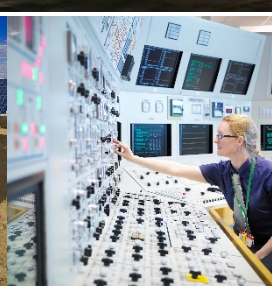
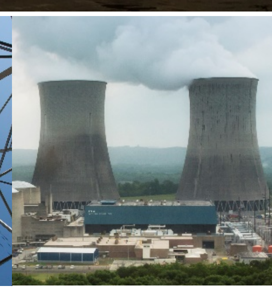
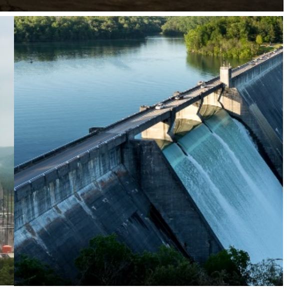
2019 Integrated Resource Plan

SCOPING REPORT







TENNESSEE VALLEY AUTHORITY

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Scoping Report Executive Summary

The Tennessee Valley Authority (TVA) began work in February 2018 on its 2019 Integrated Resource Plan (IRP), a long-term plan that provides direction on how TVA can best meet future electricity demand. The IRP will consider many views of the future to help determine how TVA can continue to provide safe, reliable energy at the lowest feasible cost; support environmental stewardship; and foster economic development in the Valley over the next 20 years. As required by the National Environmental Policy Act (NEPA), TVA also has initiated the preparation of a programmatic environmental impact statement (EIS) to assess the natural, cultural and socioeconomic impacts associated with the implementation of the updated IRP.

NEPA requires federal agencies to consider the potential environmental consequences of proposed actions. The NEPA review process is intended to help federal agencies make decisions that are based on an understanding of the action's impacts and, if necessary, to take actions that protect, restore and enhance the environment. NEPA also requires that federal agencies provide opportunities for public involvement in the decision-making process. One of those opportunities is through public scoping.

TVA initiated a 60-day public scoping period on February 14, 2018, when it published a Notice of Intent in the Federal Register announcing its plan to prepare an EIS. During the scoping period, from February 14, 2018, to April 16, 2018, the public provided input to help TVA identify issues that are important to the public and to help lay the foundation for development of the IRP and the EIS. This Scoping Report captures comments that were made during public scoping meetings, submitted online or by mail, as well as information on how the IRP and EIS are being developed.

As you will read in the report, during the EIS scoping period, TVA received a total of 87 scoping comments from the seven states within the TVA power service area as well as from nine other states. Comments about the IRP process were related to the planning process, energy resource options, planning scenarios, planning strategies/alternatives and portfolio evaluation metrics. Comments about the EIS process were related to the scope of the EIS, air quality, greenhouse gas emissions/climate change, and water resources. The Scoping Report also includes information about NEPA, applicable federal laws and executive orders, and environmental documents and reviews that are relevant to the IRP and EIS.

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Symbols, Acronyms, and Abbreviations

BRF	Bull Run Fossil
BTU	British thermal unit
CCR	Coal combustion residuals
CFR	Code of Federal Regulations
DER	Distributed energy resources
EA	Environmental Assessment
EE	Energy efficiency
EIS	Environmental Impact Statement
GHG	Greenhouse gas
IRP	Integrated Resource Plan
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LPC	Local power company
NEPA	National Environmental Policy Act
NOI	Notice of Intent
PPA	Power purchase agreement
PV	Photovoltaic
SMR	Small modular reactor
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority

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Scoping Report

The Tennessee Valley Authority (TVA) has begun a study of its energy resources to determine how TVA can best meet future electricity demand. The resulting 2019 Integrated Resource Plan (IRP) will update and replace TVA's 2015 IRP. TVA is initiating the preparation of an environmental impact statement (EIS) pursuant to the National Environmental Policy Act (NEPA) to assess the environmental impacts of adopting and implementing a new 2019 IRP.

1 Background

TVA develops an IRP to identify the most effective energy resource strategies that will meet TVA's mission and serve the people of the Tennessee Valley region over a 20 year period. In 2015, TVA completed an IRP and associated Supplemental EIS. The recommended Target Power Supply Mix described in the 2015 IRP was formally approved by the TVA Board of Directors in August 2015 and has guided TVA energy resource decisions since then. Several recent industrywide changes have led TVA to begin development of the new 2019 IRP and associated EIS ahead of the five-year cycle identified in the 2015 IRP. Natural gas supplies are abundant and are projected to remain available at lower cost. The electric system load is expected to be flat, or even declining slightly, over the next 10 years. The price of renewable resources, particularly solar, continues to decline. Consumer demand for renewable and distributed energy resources (DER) (including distributed generation, storage, demand response, energy services and energy efficiency programs) is growing.

2 Purpose and Need

Like other utilities, TVA develops power supply plans that provide direction on how to best meet future electricity demand. Due to several changes within the utility marketplace, both regionally and nationally, TVA is developing this new 2019 IRP and associated EIS to proactively address those changes. When completed, the new 2019 IRP will update and replace the 2015 IRP. The purpose of the IRP and EIS processes is to evaluate TVA's current energy resource portfolio and alternative future portfolios that meet the future electrical energy needs of the TVA region on a least-cost, system-wide basis while taking into account TVA's mission of energy, environmental stewardship and economic development.

3 Resource Planning Process

TVA employs a scenario planning approach when developing an IRP. The major steps in this approach include identifying the future need for power, developing scenarios (things outside of TVA control) and strategies (things TVA can control), determining potential supply-side and demand-side energy resource options, developing portfolios associated with the strategies, and ranking strategies and portfolios. Each strategy represents an alternative resource plan that is evaluated against each scenario to determine the most robust long-term plan.

3.1 Scenario Development

TVA initially developed a set of 12 potential scenarios, including the current outlook, to be used in evaluating the performance of the resource strategies against potential future conditions. These conditions (uncertainties) address a range of economic, financial, regulatory and legislative conditions as well as social trends and adoption of technological innovations. The 12 uncertainties used in defining each scenario are described in Table 1.

Table 1. Uncertainties

Uncertainty	Description
Electricity Demand	The customer energy requirements (in gigawatt hours) for the TVA service territory, including losses; it represents the load to be served by TVA
Market Power Price	The hourly price of energy ($/megawatt hour) at the TVA boundary: used as a proxy for market price of power
Natural Gas Prices	The price ($/million BTUs) of natural gas, including transportation
Coal Prices	The price ($/million BTUs) of coal, including transportation
Solar Prices	The price ($/megawatt hour) of solar power purchase agreements delivered to TVA
Storage Prices	The price ($/kW) of storage new builds
Regulations	All regulatory and legislative actions, including applicable codes and standards, that impact the operation of electric utilities, excluding CO_2 regulations
CO2 Regulation/Price	The cost of compliance with possible CO_2 related regulation and/or the price of cap-and-trade legislation, represented as a $/Ton value
Distributed Generation Penetration	National trending of distributed generation resources and potential regional activity by customers or third-party developers (not TVA)
National Energy Efficiency (EE) Adoption	An estimate of the adoption of EE measures by customers nationally; a measure of interest/commitment of customers in general to adopt EE initiatives, recognizing the impacts of both technology affordability and electricity price on willingness to adopt efficiency measures
Electrification	An estimate of the adoption of electric end-use technologies displacing other commercial energy forms and providing new services
Economic Outlook (National/Regional)	All aspects of the regional and national economy, including general inflation, financing considerations, population growth, GDP and other factors that drive the overall economy

Based on overlapping characteristics, the 12 potential scenarios were grouped into the categories of current outlook, declining economy, economic growth, stringent environmental, changing paradigm and emerging technology. After review of the scoping comments, suggestions from members of the IRP Working Group (see Section 5), and further analysis, TVA selected the six unique scenarios summarized in Table 2. These six scenarios include the Current Outlook scenario based on TVA's current assumptions about future conditions.

Table 2. Attributes of the Six Scenarios

Scenario	Description and Attributes
The Current Outlook	TVA's reference assumptions for the selected uncertainties
Economic Downturn	• Prolonged, stagnant economy results in weak growth and delayed expansion of new generation • Ballooning budget deficits and rising public debt hits record levels constraining Federal economic policy options • More tariffs on imports are followed by retaliatory tariff on exports • Stringent environmental regulations are delayed due to concerns of adding further pressure to the economy • Weaker demand lowers cost of new plant construction
Valley Load Growth	• Technology-driven investment in automation and artificial intelligence raise electricity use, boosting labor productivity and economic growth while lowering inflation • Rapid economic growth, driven by migration into the Valley and growth in emerging markets and developing economies, translates into higher energy sales • Lower battery prices due to economies of scale drive Increased electrification of transportation, magnifying growth • Preference for lower emissions, DER and EE drives lower demand for emitting generation, translating into lower gas and coal prices
Decarbonization	• Increasing climate-driven effects create strong federal push to curb greenhouse gas (GHG) emissions, increasing CO_2 emission penalties for the utility industry and incentives for non-emitting technologies • Compliance with new rules increases energy prices and US-based industry becomes less competitive, resulting in lagging economic growth that fails to rebound to trend levels • Fracking regulations never materialize, but gas demand is impacted by the CO_2 penalty • New expansion units are necessary to replace existing CO_2 -emitting fleet
No Nuclear Extensions	• Driven by aging assets and desire for national energy security and resiliency, there is a regulatory challenge to relicensing of existing, and construction of new, large scale nuclear plants. This results in the emergence of technologies that are more secure, modular, and flexible • National energy policy drives carbon regulation or legislation and promotes small modular reactor (SMR) technology through subsidies to drive SMR technology breakthrough and improved economics
Rapid DER Adoption	• Growing consumer awareness of and preference for energy choice, coupled with rapid advances in energy technologies, drive high penetration of distributed generation, storage, and energy management • Utilities are no longer the sole source of generation and multiple options are available to consumers • Market shift results in lower loads, decreased need for supply-side generation, but potential impacts to transmission and distribution planning and infrastructure

3.2 Strategy Development

After review of the scoping comments, five distinct alternative planning strategies were developed by TVA in coordination with the IRP Working Group. The five strategies shown in Table 3 differ in the amount of purchased power, EE and demand response efforts, renewable energy resources, distributed energy resources, nuclear generating capacity, natural gas-fired generating capacity, and coal-fired generating capacity. The five strategies include the Base Case, which represents the continued implementation of the 2015 IRP in accordance with least-cost optimization and reliability constraints. For purposes of the EIS, the Base Case represents the No Action alternative and the four other strategies represent action alternatives.

The strategies differ in, among other things, whether or not they include incentives for particular resources. In this context, an incentive is the mechanism to promote additional penetration of a resource and is equal to the difference between the cost of a resource in the Base Case and the cost to achieve the targeted level of penetration in the other four strategies. The alternative strategies are being analyzed in the context of six different scenarios described in Table 2. The alternative strategies considered but eliminated from further consideration will be described in the EIS. Any changes made to the scenarios and strategies being evaluated will be reflected in the Draft IRP and EIS that TVA publishes for public review.

Table 3. Attributes of the Planning Strategies

Strategies	Description and Attributes
Base Case	• Continued implementation of the 2015 IRP in accordance with least-cost optimization and reliability constraints.
Promote DER	• DER is incentivized to achieve high-end of long-term penetration levels. • New coal is excluded. All other technologies are available while EE, demand response, distributed generation and storage are promoted.
Promote Resiliency	• Add small, agile capacity to maximize flexibility and promote resiliency to be able to respond to short-term disruptions on the power system. • All technologies are available while nuclear additions (SMRs), gas additions (aeroderivative turbines, reciprocating engines), demand response, storage and distributed generation are promoted. • Combinations of storage and distributed generation could be installed as microgrids. • Flexible loads and DERs are aggregated to provide synthetic reserves to the grid to promote resiliency.
Promote Efficient Energy Usage	• Incentivize targeted electrification, demand and energy management to minimize peaks and troughs across a daily load shape and promote efficient energy usage. • All technologies are available but those that minimize load swings are promoted (e.g., EE, demand response, storage, distributed generation). • Expansion of programs targeting low-income customers.
Promote Renewables	• Incentivize renewables at all scales to meet growing prospective or existing customer demands for renewable energy. • New coal is excluded. All other technologies are available while renewables are promoted.

4 Environmental Review Process

NEPA requires federal agencies to consider and study the potential environmental consequences of proposed actions. Actions, in this context, can include new and continuing activities that are conducted, financed, assisted, regulated or approved by federal agencies, as well as new or revised plans, policies or procedures. The NEPA review process is intended to help federal agencies make decisions that are based on an understanding of the action's impacts and, if necessary, to take actions that protect, restore and enhance the environment (40 Code of Federal Regulations [CFR] 1500.1(c)). NEPA also requires that federal agencies provide opportunities for public involvement in the decision-making process.

TVA is initiating the preparation of an EIS to assess the environmental impacts of the proposed action. TVA is using the input from the scoping period, summarized below, in developing the Draft EIS and the Draft IRP. The Draft IRP and EIS will be distributed to interested individuals; groups; and, federal, state and local agencies for their review and comment. During the public comment period of the Draft EIS and IRP, TVA plans to conduct public meetings throughout the Tennessee Valley region. Following the public comment period, TVA will respond to the comments received on the Draft IRP and EIS and incorporate any necessary changes into the Final IRP and EIS. TVA will make a final decision regarding the proposed action after the Final EIS and IRP are published.

The completed Final EIS will be placed on TVA's website, and notices of its availability will be sent to those who received the Draft EIS or submitted comments on the Draft EIS. TVA also will send the Final IRP and EIS to the Environmental Protection Agency, which will publish a notice of its availability in the Federal Register. TVA will then issue a Record of Decision, which will include (1) the decision; (2) the rationale for the decision; (3) alternatives that were considered; (4) the alternative that was considered environmentally preferable; and (5) associated mitigation measures and monitoring, and enforcement requirements.

TVA intends to publish the Draft EIS and IRP in early 2019 and publish the Final EIS and IRP during the summer of 2019. The TVA Board of Directors will make the final decision on the IRP no sooner than 30 days after the publication of the Federal Register notice of the filing of the Final EIS and IRP. The TVA Board of Directors will consider the analyses in the EIS and IRP when it selects the resource plan to be implemented.

4.1 Applicable Federal Laws and Executive Orders

In addition to Section 113 of the Energy Policy Act of 1992 (now the least-cost, system-wide planning provision of the TVA Act), several federal laws and executive orders are relevant to TVA's integrated resource planning. Those that are specific to the natural, cultural and socioeconomic resources potentially affected by the TVA power system are described below.

4.1.1 National Environmental Policy Act

This EIS has been prepared by TVA in accordance with the NEPA of 1969 (42 United States Code [U.S.C] §§ 4321 et seq.), regulations implementing NEPA promulgated by the Council on Environmental Quality (40 CFR Parts 1500 to 1508), and TVA NEPA procedures. For major federal actions with significant environmental impacts, NEPA requires that an EIS be prepared. This process must include public involvement and analysis of a reasonable range of alternatives.

According to Council of Environmental Quality regulations, a programmatic EIS is appropriate when a decision involves a policy or program or a series of related actions by an agency over a broad geographic area. Due to the comprehensive nature of the IRP, this EIS meets that criterion. The environmental impacts of the alternative actions are, therefore, addressed at a regional level, with some extending to a national or global level. The more site-specific effects of actions that are later proposed to implement the IRP will be addressed in subsequent tiered environmental reviews.

4.1.2 Other Laws and Executive Orders

Several other laws and executive orders are relevant to the construction and operation of TVA's electric power system (Table 4). These laws and orders may affect the environmental consequences of an alternative plan, or measures needed during its implementation. Most of these laws also have associated implementing regulations. The Draft EIS will describe the regulatory setting for each resource in more detail.

Table 4. Laws and Executive Orders Relevant to the Environmental Effects of Power System Planning, Construction and Operation

Environmental Resource Area	Law / Executive Order
Water Quality	Clean Water Act
Groundwater	Safe Drinking Water Act Resource Conservation and Recovery Act
Air Quality	Clean Air Act
Wetlands and Waters	Clean Water Act Executive Order 11990 – Protection of Wetlands Executive Order 13778 – Restoring the Rule of Law, Federalism, and Economic Growth by Reviewing the "Waters of the United States" Rule
Floodplains	Executive Order 11988 – Floodplain Management
Endangered and Threatened Species	Endangered Species Act
Cultural Resources	National Historic Preservation Act Archaeological Resource Protection Act Native American Graves Protection and Repatriation Act
Environmental Justice	Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations
Land Use	Farmland Protection Policy Act
Coal Mining	Surface Mining Control and Reclamation Act
Waste Management	Resource Conservation and Recovery Act Comprehensive Environmental Response, Compensation, and Liability Act Toxic Substances Control Act

4.3 Environmental Resources to Be Considered in EIS

Based on internal and public scoping, identification of applicable laws, regulations, executive orders, and policies, TVA identified the resource areas listed below as requiring analysis within the EIS:

- Air quality
- Climate and greenhouse gases
- Water resources
  - Groundwater
  - Water quality
  - Water supply
  - Aquatic life
- Land resources
  - Geology
  - Vegetation and wildlife
  - Endangered and threatened species
  - Wetlands
  - Parks, managed areas, and ecologically significant sites
  - Land use
  - Cultural resources
- Availability of renewable energy resources
- Solid and hazardous wastes
- Socioeconomics
- Environmental Justice

The current status and, where applicable, recent trends in each of these resources will be described for the TVA region as a whole as well as for TVA's current generating facilities. The analysis of the potential environmental impacts of the alternative strategies will focus on system-wide changes in emissions of air pollutants, including GHGs, water use and consumption, fuel consumption, coal combustion residuals and spend nuclear fuel production, employment and per capita income, and disproportionate impacts to minority and low-income populations. Because of their location-specific nature, potential impacts to land resources will be described through the use of a land metric based on the land area required to construct and operate any new generating facilities.

Due to the location- and facility-specific nature of the potential effects related to public and occupational health and safety, transportation, and visual resources, these effects are not amenable to being addressed at a programmatic level and will be addressed in subsequent environmental analyses of individual actions taken to implement the 2019 IRP. These analyses will tier from the programmatic EIS. These subsequent tiered environmental analyses will address the location- and facility-specific effects on the other resource areas listed above.

5 Public Outreach during Scoping Period

On February 14, 2018, TVA published a Notice of Intent (NOI) in the Federal Register announcing that it planned to prepare an EIS to address the potential environmental effects associated with the implementation of the updated IRP (Appendix A). The NOI initiated a 60-day public scoping period, which concluded on April 16, 2018. The NOI included five scoping questions for consideration.

1. How do you think energy usage will change in the next 20 years in the Tennessee Valley region?
2. Should the diversity of the current power generation mix (e.g., coal, nuclear, power, natural gas, hydro, renewable resources) change? If so, how?
3. How should distributed energy resources (DER) be considered in TVA planning?
4. How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?
5. How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?

In addition to the NOI in the Federal Register, TVA sent notification of the NOI to local and state government entities and federal agencies; issued a news release to media; and posted the news release on the TVA website (Appendix B). TVA sent 2,500 scoping notices via email and/or mail to agencies, organizations and the public, including those on the

2015 IRP mailing list and people who registered for additional information on the TVA IRP website.

TVA published notices regarding the NOI in local newspapers, including the following cities and associated newspapers:

- Chattanooga, TN – Chattanooga Times Free Press
- Huntsville, AL – The Huntsville Times
- Memphis, TN – The Commercial Appeal
- Nashville, TN – The Tennessean
- Knoxville, TN – Knoxville News Sentinel
- Paducah, KY – The Paducah Sun
- Bowling Green, KY – Bowling Green Daily News

TVA provided the following opportunities for public involvement:

- February 21, 2018: Webinar
- February 27, 2018: Educational open house at The Westin Chattanooga, 801 Pine St., Chattanooga, TN.
- March 5, 2018: Educational open house at Memphis Light, Gas and Water Auditorium, 220 S. Main St., Memphis, TN.

Copies of scoping meeting and webinar materials are included in Appendix C and D, respectively. The purpose of the scoping period and meeting were to present TVA's project objectives and initial alternatives for input from the public and interested stakeholders.

To gain additional input, TVA established an IRP Working Group to more actively engage stakeholders throughout the development of the IRP. The group consists of 20 external stakeholders representing 20 organizations. There are eight members representing the interests of entities purchasing power from TVA:

- Three local power companies (LPCs)
- Three industrial customers
- Two organizations representing LPCs and industrial customers

The 12 other representatives are:

- Three from energy and environmental non-governmental organizations
- Three from research and academia with expertise in DERs
- Two from state government
- Two from economic development organizations
- Two from community and sustainability interests

TVA maintains an IRP contact list of more than 2,000 individual stakeholders that is regularly updated with contact information from those who commented during the scoping period, registrations on the TVA IRP website, and attendance at webinars and meetings.

6 Summary of Public Scoping Comments

TVA received a total of 87 comments. Comments were received from all seven states within the TVA power service area, with approximately 40 percent from the state of Tennessee. Comments also were received from nine states outside of the TVA power service area.

Of the 87 submissions, 30 comments were received from individuals, 28 comments were from businesses, 23 comments were from civic or non-governmental organizations, 4 comments were from government agencies, and 2 comments were from educational institutions. Comment submissions are included in Appendix E and summarized by topic below.

TVA used scoping comments to develop a list of Frequently Asked Questions, which has been posted onto the TVA IRP website.

6.1 Integrated Resource Planning

6.1.1 The Planning Process

General

- Consider the approach used by the Northwest Power Conservation Council in its recent power plan (including Bonneville Power Administration) to extend the "block" approach TVA used in 2015 for modeling EE. The Northwest Power Plan also provides a

model for load forecasting methodologies.
- Given the increasingly interconnected nature of generation, transmission and distribution, address grid resiliency and cybersecurity strategies in the IRP.
- Indicate which Public Utility Regulatory Policy Act standards are relevant to the IRP process and how they are being addressed.
- Neither TVA nor the area LPCs have engaged in the distribution resource planning necessary to evaluate demand-side resources in a consistent and integrated manner.
- Rather than spending money on developing the IRP, spend the money to better manage TVA reservoirs and public lands.
- Rather than spending the money on developing the IRP, spend it on preparing for the sale of TVA resources.
- TVA, as the largest public utility, should be a national leader in promoting the advanced energy (cleaner, safer, more efficient) industry and its associated economic development opportunities.
- What are TVA's messages and communication strategies to involve minority and low-income populations in the planning process?
- TVA's stated objectives for the IRP contradict its recent portfolio decisions. The effort to increase nuclear to 40 percent of the portfolio, for example, decreases portfolio diversity by its overrepresentation. Gas generation is also overrepresented. The most diverse portfolio would consist of approximately equal proportions of energy resource types. Similarly, the goal of low cost is contradicted by TVA's reliance on high cost coal and gas.

Model Inputs

- Consider the range of services storage provides when assigning costs to and designing storage resources.
- Due to the complexities and time span associated with the recent solar import tariffs and evolving nature of the steel and aluminum tariffs, the tariffs should not be included in the model inputs. Their impacts can be modeled through the use of real world examples described in the Southern Alliance for Clean Energy comment letter.
- Include ancillary and other grid reliability services in modeling of utility-scale photovoltaic (PV) facilities, as recently demonstrated in 2017 NREL study, as well as power ramping, voltage regulation control and frequency response.
- Include sub-hourly modeling to better capture the benefits of storage.
- Include the cost of coal sludge cleanups and remediation in the cost of coal generation.
- Incorporate current cost metrics and PV production profiles, including those TVA received in its recent RFI and RFP for renewable energy to capture recent technology and production improvements.
- Model utility-scale PV at scales of at least 50 MW_{AC} as well as in multiples of 50 MW in fixed-tile and single-axis tracking configuration to capture economies of scale.
- Model utility-scale PV with battery storage.
- Provide levelized cost of energy benchmarks for all energy resources. Values should be similar to Lazard Associates' and National Renewable Energy Laboratory Annual Technology Baseline values.
- Use National Renewable Energy Laboratory Annual Technology Baseline "low values" for multiple wind energy resources.
- Use planning capacity values that incorporate the latest operating experience and technological advances, as well as the ability of storage resources to smooth dips and peaks in solar and wind resources.
- Use resource-, geography-, and seasonal-specific capacity values for renewable energy resources.

Need for Power Forecast

- TVA's long-term load projection of little to no increase is contrary to population and industrial growth in the region.
- TVA's current reserve margin is too small and TVA needs more major generating assets.

6.1.2 Energy Resource Options

General

- Facilitate direct procurement of renewable energy and energy storage by large customers.
- Promote adoption of electric vehicles and their infrastructure.
- Promote the increased use of clean energy by accelerating the retirement of fossil plants and shifting to non-emitting sources, including increased wind and solar energy.

- Return to the mission of producing cheap electricity using hydroelectric, coal and nuclear.
- Explore the use of treated wastewater for thermal cooling, especially where municipal water systems rely almost exclusively on groundwater.

Coal

- Additional coal plant retirements will unacceptably reduce the resiliency and reliability of the TVA system during extreme weather events. The resulting rate increases will also cause a disproportionate energy tax and adverse health and welfare impacts on low-income customers.
- The Red Hills generation facility should continue to be part of TVA's generation portfolio due to its reliability, fuel security, area economic benefits, etc. It should also be dispatched as a baseload facility.

Demand Response

- Promote programs that facilitate consumers to shift energy use to non-peak times.

Distributed Energy Resources

- DERs are feasible, provided they are connected to the 161-kV transmission system and within 5 miles of a breakered station.
- Incentivize homeowners and small businesses to use combined solar and battery storage to levelize grid loads by reducing peak demand.
- Increase the incentives for and promote the adoption of DER, including residential solar.
- Increase the program caps on Green Power Providers and Distributed Solar Solutions for LPCs.
- Modify Green Power Providers program to use a bi-directional net-metering model with price parity between kWh produced and kWh consumed.

Energy Efficiency

- Increase EE efforts.

Natural Gas

- Prioritize new combined cycle gas plants over new combustion turbine gas plants.
- TVA is becoming too dependent on natural gas, which has climate and other negative impacts.
- Upgrade combustion turbine gas plants to combined cycle plants for more efficient, lower-cost generation.

Nuclear

- Increase nuclear generation.
- No new nuclear generation.

Storage

- Add utility-scale energy storage, pumped hydro, battery, and thermal storage.
- Adopt distributed, grid-tied storage.

Renewable Energy – Biomass

- Consider biomass-fueled power plants and biomass cofiring. The recent closure of large paper mills in the Valley has increased the supply of wood waste and low quality hardwoods for fuel.

Renewable Energy – Solar

- Promote community solar; it is a good business model for the TVA region.

Renewable Energy – Acquisition

- Move quickly to implement PPAs for wind and utility-scale solar generation to take advantage of the production and investment tax credits, meet increasing demand for renewable generation from corporations. Note the 4-year window from beginning of construction to completion for qualifying for tax credits.

6.1.3 Planning Scenarios

- Evaluate a carbon tax with a variety of ranges, including starting at $50/metric ton and increasing to $400/metric ton by mid-century.
- Evaluate contingencies resulting from constricted supplies of all non-renewable fuels.
- Evaluate Renewable Energy, Carbon Policy, and Electrification scenarios, as described in detail in Southern Alliance for Clean Energy scoping letter.
- Incorporate the repeal of the Clean Power Plan and effluent limitation guidelines for power plants, revision of coal combustion residuals (CCR) disposal rules, and retention of current NAAQS for NO_2.

6.1.4 Planning Strategies / Alternatives

- As the largest public utility in the country, TVA should be a leader in meeting the goals of the Paris Climate Accord and/or otherwise rapidly reducing GHG emissions and mitigating the effects of climate change.
- Consider Green Mountain Power in Vermont as a forward-thinking model when designing the strategies.
- Evaluate a range of alternatives that reduce fossil fuel use as soon as possible and meet customer demand with a combination of aggressive EE initiatives and centralized and distributed renewable energy. Within these alternatives, evaluate options to a) maximize DER and b) attain a 100 percent renewable energy mix by 2050.
- Evaluate Renewable Energy, EE, Greenhouse Gas Targets, Electric Vehicle, and Utility of the Future strategies, as described in detail in Southern Alliance for Clean Energy scoping letter.
- Evaluate the benefits to customers from halting SMR investments and redirecting the funds to EE, renewable energy and storage resources
- In addition to end user-related EE measures, the alternatives should include measures related to increasing the EE of the TVA transmission system and other TVA operations.
- Pilot “economic development energy zones” in low-income areas to develop community-scaled renewables and storage that would allow the aggregated demand to warrant the same rate structure as TVA’s B, C, and D industrial and commercial customers including available interruptible power credits.

6.1.5 Portfolio Evaluation Metrics

- Consider environmental metrics beyond CO_2 emissions, water usage and waste generation, such as the wildlife and recreational benefits that have resulted from reclamation at the Red Hills lignite mine. Such additional metrics would align with the TVA Act’s mandate to provide for reforestation, the proper use of marginal lands in the Tennessee Valley, and agricultural and industrial development.
- Expand the evaluation of flexibility beyond the single metric used in 2015 to include additional measures that keep the grid resilient, such as resiliency, long-term fuel security (including, for example, long-term drought effects), capabilities of distributed storage and provision of regulation services.
- Incorporate metrics specific to the impacts on minority and low-income customers, including on the equity of the proposed plans. See the Environmental Toolkit developed by the Metro Washington Council of Governments for examples.
- Incorporate projected changes in temperature, precipitation, and extreme weather events and the ability of the strategies to mitigate or adapt to their impacts on the TVA system into the modeling.

6.2 Environmental Impact Statement

6.2.1 Scope of the EIS

- Analyze the cumulative effects of both DERs and large-scale generating facilities on wildlife, important habitats, listed species, invasive species and aquatic resources.
- Conduct a detailed evaluation of the impacts of the scenario/strategy combinations on minority and low-income populations, including communities of color, with consideration of their high energy burden and the effects of TVA’s proposed rate change on their household income. See the Environmental Toolkit developed by the Metro Washington Council of Governments for evaluation methods.
- Per NEPA case law, TVA must consider every significant aspect of the environmental impact of a proposed action. This includes the totality of TVA operations resulting from the implementation of the proposed IRP, including ongoing operational effects in addition to the effects of the proposed changes.
- The EIS must examine the full life-cycle impacts on listed species, their habitats and other resources of TVA operations, including the extraction, processing, and transport of fuel and the disposal of combustion residuals and spent fuel. TVA should initiate and/or reinitiate consultation with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act to address the impacts of its operations on listed species and to proactively address these impacts on species petitioned for listing.
- The EIS should describe the beneficial impacts of the various energy resource options. For example, reclamation of the

surface mine providing coal to the Red Hills Power Project can result in improved soil conditions, with some reclaimed soils now having the characteristics of prime farmland soils.

- Utilize all available biological resource information in the future evaluations of site-specific actions to implement the IRP.

6.2.2 Air Quality

- TVA's 2018 rate change will suppress the adoption of DERs and their potential to offset generation by air pollutant-emitting fossil fuels. This will result in a different emissions baseline under the no action alternative (the 2015 plan) with increased emissions due to the suppression of DER. This emissions increase must be quantified.

6.2.3 Greenhouse Gas Emissions / Climate Change

- In the discussion of greenhouse gases and climate change, discuss the flaws and shortcomings of the cited climate models and the lack of correlation between recent observed and predicted temperature and precipitation trends.
- In addition to addressing reductions in CO_2 emissions, address the increase in methane emissions resulting from increased natural gas use.

6.2.4 Water Resources

- Evaluate the impacts of drought, projected climate change, and cooling water availability and withdrawals on water resources, including public water systems and aquatic life, by river basin and sub-basin.

6.3 Response to TVA Scoping Questions

As described above in Section 5, TVA asked scoping participants to respond to five questions that the IRP will begin to answer. Few scoping participants responded directly to these questions. Following are the questions and the responses.

How do you think energy usage will change in the next 20 years in the Tennessee Valley region?

- Load growth will return as low-hanging conservation measures are implemented and population and industrial growth (e.g., automotive industry) continue.
- Continued rapid growth in solar capacity with transition from legacy infrastructure to a distributed system.
- Prepare for increased load from electric vehicles and dramatic improvements in energy storage.

Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?

- Continue the current trajectory.
- Continue the reduction in coal and increase in solar.
- A diverse portfolio is not by itself a measure of reliability, and instead TVA should focus on attributes necessary to integrate the increasing amounts of intermittent renewable power and DER. These attributes include reliability, dispatchability, security of fuel supply, start times and ramp times, inertia and frequency response capability, reactive power capability, minimum load level, black start capability, storage capability, and proximity to load. These attributes are best met by natural gas and impoundment-based hydro. Additional examples include combined heat and power, waste heat recovery, and fuel cells.
- In evaluating resource diversity, consider upgrades to existing hydro plants, the rapid evolution of solar plus storage (now at grid parity in some markets), and development of utility-scale renewable projects, in part to meet corporate demands for renewable energy.

How should distributed energy resources be considered in TVA planning?

- DER should smooth peak and off-peak load shapes and reduce need for peaking units while placing additional value on base and intermediate type generation, particularly combined cycle natural gas plants.
- Comprehensively with integration of solar,

smart inverter technology, advanced forecasting, communication, and control technology, with increased management of resources by LPCs and relief from all-requirements contracts.

- Using a neutral approach regarding fuel and technology.
- As shown elsewhere, DER can improve reliability and resiliency and reduce GHG emissions at a facility or campus level. Explore strategies which emphasize DER and its associated benefits as well as various ownership models.
- Anticipate increased demand for distributed generation, including solar and combined heat and power, for customers with high reliability needs, aggressive GHG reduction and sustainability targets, and/or to reduce peak load and demand charges. These projects can contribute to demand response programs and reduce the need for oil-based standby generation.

How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?

- They will flatten load growth in near-term but will not prevent the long-term need for additional generation.
- As the first resource option for TVA and LPCs.
- Consider innovative methods for reaching renters and low-income populations. These ratepayers have little ability to pay for EE measures yet receive a higher cost-benefit from them.

How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?

- A diverse portfolio supported by adequate baseload generation is necessary for a reliable and cost-effective power supply. Natural gas generation is necessary to address intermittent and non-dispatchable renewable energy and DER.
- Modern photovoltaic systems with plant control systems would deliver power ramping, voltage regulation control and frequency response.
- Natural gas provides all these attributes for the TVA region.

7 Relevant Environmental Documents and Reviews

Several environmental documents and reviews are relevant to TVA's IRP and are briefly discussed in the sections below.

7.1 Programs, Plans and Policies

Diesel-fueled Generation in TVA Demand Response Program (February 2017)
This environmental assessment (EA) evaluated the potential use of diesel-fueled generators by participants in TVA demand response programs to provide backup generation during certain demand response events.

TVA Solar Photovoltaic Projects (September 2014)
This programmatic EA evaluated the potential impacts of constructing and operating small solar PV systems providing power for the TVA system.

7.2 Power Generation – Coal and Gas

Ash Impoundment Closure (June 2016)
This programmatic EIS evaluated the closure of ash impoundments containing coal combustion residuals (CCR) at fossil fuel plants across the Tennessee Valley to support the implementation of TVA's goal to eliminate all wet CCR storage at its coal plants.

Bull Run Fossil Plant Ash Impoundment Closure Project (October 2017)
This EA tiers from the 2016 Ash Impoundment Closure Programmatic EIS, which evaluated the closure of the Bull Run Fossil (BRF) Plant Sluice Channel and Fly Ash Impoundment. TVA expanded the closure area at BRF and determined a long-term

need for wastewater treatment at BRF. The new proposed action included a plan to repurpose the Stilling Impoundment and possibly a portion of the Fly Ash Impoundment to be used as part of wastewater treatment at BRF.

Bull Run Fossil Plant Landfill (November 2016)
This EIS addressed the continued disposal of CCR from the BRF by proposing to construct and operate a new landfill for storage of CCR on TVA property adjacent to BRF.

Colbert Fossil Plant Decontamination and Deconstruction (November 2016)
This EA evaluated the future disposition of the retired coal-fired plant, including the powerhouse, coal handling facilities, and support buildings.

Cumberland Fossil Plant Borrow Areas and Access Road (August 2017)
This EA evaluated the development of a new access road and onsite borrow sites at the Cumberland Fossil Plant to support ongoing operations, including partial closure of the fly ash and gypsum stacks in accordance with Tennessee Department of Environment and Conservation (TDEC) regulations.

Cumberland Fossil Plant Coal Combustion Residuals Management Operations (April 2018)
This EIS evaluated the construction and operation of a bottom ash dewatering facility, an onsite CCR landfill, and process water basins at the Cumberland Fossil Plant.

Flue Gas Desulfurization System at Kingston Fossil Plant (February 2018)
This EA supplemented a 2006 EA to evaluate changes to the proposed construction support areas and environmental conditions within the area of the Phase 2 part of the landfill.

Gallatin Fossil Plant Bottom Ash Process Dewatering Facility (July 2017)
This EA evaluated the construction of a bottom ash process dewatering facility at Gallatin Fossil Plant, which also included a recirculation system to recycle sluice water back into the powerhouse for future sluicing operations.

Johnsonville Cogeneration Plant (June 2015)
This EA evaluated the addition of a heat recovery steam generator to an existing combustion turbine at the Johnsonville Fossil Plant. The steam generator would provide steam to an adjacent industrial customer that was previously provided by now-retired coal-fired units.

Paradise Coal Combustion Residuals Management Operations (June 2017)
This EA evaluated the implementation of projects proposed to support dry storage and CCR Rule compliance at Paradise Fossil Plant, including the construction and operation of a gypsum dewatering facility, a dry fly ash handling system, and an onsite CCR landfill. Also included are the closure of the gypsum disposal area, slag impoundment 2A/2B and stilling impoundment 2C, and the Peabody ash impoundment.

Widows Creek Fossil Plant Deconstruction (June 2016)
This EA evaluated the future disposition of the physical structures associated with the retired coal-fired plant, including the powerhouse, coal handling facilities and surrounding support buildings.

7.3 Power Generation – Nuclear

Production of Tritium in a Commercial Light Water Reactor (March 2016)
This Supplemental EIS addressed the production of tritium in TVA reactors using tritium-producing burnable absorber rods. Due to changes in the estimate of tritium needs for national security, the preferred alternative changed to Alternative 6, which would enable irradiating a total of up to 5,000 absorber rods at the Watts Bar and Sequoyah Nuclear Plants.

Watts Bar Nuclear Plant Unit 2 Replacement of Steam Generators (December 2017)
This EA evaluated the replacement of steam generators in Watts Bar Nuclear Plant Unit 2, which would allow TVA to operate the plant more efficiently and maintain the generating capacity of Unit 2.

7.4 Power Generation – Solar and Other Renewables

Cumberland Solar Project (January 2018)
This EA evaluated the construction and operation of a proposed 20-megawatt (MW) solar photovoltaic (PV) facility on approximately 140 acres in Limestone County, Alabama. This solar facility would connect to the existing adjacent 161-kilovolt (kV) TVA Ardmore Substation. TVA proposed to enter into a power purchase agreement (PPA) with Cumberland Land Holdings LLC to purchase the electric power generated by the solar facility.

Haywood Solar Farm (March 2017)
This EA evaluated the construction and operation of a 3.9 MW solar PV facility on approximately 27.6 acres near Brownsville, Tennessee. This solar facility would connect to the Brownsville Energy Authority distribution network at the Dupree Substation, which would transmit the power to the TVA network. TVA proposed to enter into a PPA with Hayward Solar LLC.

Houston, Mississippi Solar Farms (June 2016)
This EA evaluated the construction and operation of two proposed solar PV facilities near the town of Houston, Mississippi (a 3.9 MW solar PV facility and a 1 MW solar PV facility) on approximately 21 acres. The facilities would be connected to the Natchez Trace Electric Power Association distribution network, which would transmit the power to the TVA network. TVA proposes to enter into PPAs with SR Houston LLC and Chickasaw Solar, LLC.

Jonesborough Solar Site (October 2017)
This EA evaluated the construction and operation of a proposed 5 MW solar PV facility on approximately 42.5 acres in Washington County, Tennessee. The facility would connect to the Johnson City Power Board distribution network, which would transmit the power to the TVA network. TVA proposes to enter into a PPA with SR Jonesborough LLC.

Latitude Solar Center Project (August 2016)
This EA evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres near Whiteville, Tennessee. The facility would connect to the TVA transmission system through a power line to an existing nearby Bolivar Electric Authority substation. TVA proposes to enter into a PPA with Latitude Solar Center LLC.

Millington Solar Project (December 2017)
This EA evaluated the construction and operation of a proposed 53 MW solar PV facility on approximately 390 acres in Millington, Tennessee. The facility would connect to the TVA electrical transmission network via a new onsite substation and a new TVA 161-kV transmission line. TVA proposes to enter into a PPA with SR Millington LLC.

Naval Air Station Meridian Solar Farm (April 2017)
This EA evaluated the construction and operation of a proposed 6 MW solar PV facility on approximately 45 acres on Naval Air Station Meridian in Lauderdale County, Mississippi. The facility would connect to the existing substation located approximately one mile away, which would transmit the power to the TVA network. TVA proposes to enter into a PPA with SR Meridian LLC.

Providence Solar Center (March 2016)
This EA evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 118 acres in Madison County, Tennessee. The facility would tie into a nearby Southwest Tennessee Electric Membership Corporation substation. TVA proposes to enter into a PPA with Providence Solar Center LLC.

Selmer North I Solar Project (October 2016)
This EA evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 99 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby Pickwick Electric Power Cooperative power line which would be rebuilt. TVA proposes to enter into a PPA with Selmer North I LLC.

Selmer North II Solar Project (July 2016)
This EA evaluated the construction and operation of a proposed 10 MW solar PV facility on approximately 73 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby

Pickwick Electric Cooperative power line. TVA proposes to enter into a PPA with Selmer North II, LLC.

Wildberry Solar Center Project (June 2016)
This EA evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres in Fayette County, Tennessee. The facility would tie into an existing nearby Chickasaw Electric Cooperative substation. TVA proposes to enter into a PPA with Wildberry Solar Center LLC.

8 Potential Mitigation Measures

TVA's siting processes for generation and transmission facilities, as well as practices for modifying these facilities, are designed to avoid and/or minimize potential adverse environmental impacts. Potential impacts also are reduced through pollution prevention measures and environmental controls such as air pollution control systems, wastewater treatment systems and thermal generating plant cooling systems. Other potentially adverse impacts can be mitigated by measures such as compensatory wetlands mitigation, payments to in-lieu stream mitigation programs and related conservation initiatives, enhanced management of other properties, documentation and recovery of cultural resources, and infrastructure improvement assistance to local communities. However, these mitigation measures would be considered and implemented during site specific reviews of future generation or transmission facilities or modifications to existing facilities in a tiered NEPA analysis.

During scoping, commenters suggested the following potential mitigation measures as part of the Draft EIS.

- Promote the siting of new energy facilities on previously disturbed lands.
- Require monitoring of impacts on listed species and their habitats for new energy projects.
- Research and incorporate best management practices such as the U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines, wind turbine cut-in speed modifications, and wind turbine collision avoidance technology.

A

Appendix A – Federal Register Notice of Intent

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• Chapter 17 of the United States-Morocco Free Trade Agreement; and
• Final Environmental Review of the United States–Morocco Free Trade Agreement.

These documents are available at: *http://www.state.gov/e/oes/eqt/trade/morocco/index.htm.*

Robert Wing,

Acting Director, Office of Environmental Quality and Transboundary Issues, Department of State.

[FR Doc. 2018–03117 Filed 2–13–18; 8:45 am]

BILLING CODE 4710–09–P

TENNESSEE VALLEY AUTHORITY

Environmental Impact Statement for 2019 Update to the Integrated Resource Plan

AGENCY: Tennessee Valley Authority.

ACTION: Notice of intent.

SUMMARY: The Tennessee Valley Authority (TVA) is conducting a study of its energy resources in order to update and replace the Integrated Resource Plan (IRP) and the associated Supplemental Environmental Impact Statement (EIS) that it completed in 2015. The IRP is a comprehensive study of how TVA will meet the demand for electricity in its service territory over the next 20 years. The 2015 IRP is being updated in response to major changes in electrical utility industry trends since 2015, including flat to slightly declining load growth, advances in the development of distributed energy resources and the integration of those resources in the electric grid. As part of the study, TVA intends to prepare a programmatic EIS to assess the impacts associated with the implementation of the updated IRP. TVA will use the EIS process to elicit and prioritize the values and concerns of stakeholders; identify issues, trends, events, and tradeoffs affecting TVA's policies; formulate, evaluate and compare alternative portfolios of energy resource options; provide opportunities for public review and comment; and ensure that TVA's evaluation of alternative energy resource strategies reflects a full range of stakeholder input. Public comment is invited concerning both the scope of the EIS and environmental issues that should be addressed as a part of this EIS.

DATES: To ensure consideration, comments on the scope and environmental issues must be postmarked, emailed or submitted online no later than April 16, 2018. To facilitate the scoping process, TVA will hold public scoping meetings; see *http://www.tva.gov/irp* for more information on the meetings.

ADDRESSES: Written comments should be sent to Ashley Pilakowski, NEPA Compliance Specialist, 400 West Summit Hill Dr., WT 11D, Knoxville, TN 37902–1499. Comments may also be submitted online at: *www.tva.gov/irp,* or by email at *IRP@tva.gov.*

FOR FURTHER INFORMATION CONTACT: For general information about the NEPA process, please contact Ashley Pilakowski at the address above, by email at *aapilakowski@tva.gov.* For general information on the IRP process, contact Hunter Hydas, Tennessee Valley Authority, 1101 Market Street, MR 3M–C, Chattanooga, TN 37402 or by email at *jhhydas@tva.gov.*

SUPPLEMENTARY INFORMATION: This notice is provided in accordance with the Council on Environmental Quality's Regulations (40 CFR parts 1500 to 1508) and TVA's procedures for implementing the National Environmental Policy Act (NEPA). TVA is an agency and instrumentality of the United States, established by an act of Congress in 1933, to foster the social and economic welfare of the people of the Tennessee Valley region and to promote the proper use and conservation of the region's natural resources. One component of this mission is the generation, transmission, and sale of reliable and affordable electric energy.

TVA Power System

TVA operates the nation's largest public power system, providing electricity to about 9 million people in an 80,000-square mile area comprised of most of Tennessee and parts of Virginia, North Carolina, Georgia, Alabama, Mississippi, and Kentucky. It provides wholesale power to 154 independent local power companies and 56 directly served large industries and federal facilities. The TVA Act requires the TVA power system to be self-supporting and operated on a nonprofit basis and directs TVA to sell power at rates as low as are feasible.

Dependable generating capability on the TVA power system is approximately 37,000 megawatts. TVA generates most of the power it distributes with 3 nuclear plants, 7 coal-fired plants, 9 simple-cycle combustion turbine plants, 7 combined-cycle combustion turbine plants, 29 hydroelectric dams, a pumped-storage facility, a methane-gas cofiring facility, a diesel-fired facility, and 16 small solar photovoltaic facilities. A portion of delivered power is provided through long-term power purchase agreements. In 2017, 25 percent of TVA's power supply was from coal; 38 percent from nuclear; 16 percent from natural gas; 9 percent from non-renewable purchases; 7 percent from hydro; and 5 percent from renewable power purchase agreements. TVA transmits electricity from these facilities over 16,000 circuit miles of transmission lines. Like other utility systems, TVA has power interchange agreements with utilities surrounding its region and purchases and sells power on an economic basis almost daily.

Resource Planning

TVA develops an Integrated Resource Plan to identify the most effective energy resource strategies that will meet TVA's mission and serve the people of the Valley for the next 20 years. In 2015, TVA completed the Integrated Resource Plan and associated Supplemental EIS. Since 2015, several industry-wide changes have led TVA to begin development of the new IRP and associated EIS ahead of the 5-year cycle identified in the 2015 IRP. Natural gas supplies are abundant and are projected to remain available at lower cost. The electric system load is expected to be flat, or even declining slightly, over the next ten years. The price of renewable resources, particularly solar, continues to decline. Consumer demand for renewable and distributed energy resources (including distributed generation, storage, demand response, energy services, and energy efficiency programs) is growing.

Proposed Issues To Be Addressed

Based on discussions with both internal and external stakeholders, TVA anticipates that the scope of the IRP EIS will include the cost and reliability of power, the availability and use of renewable and distributed energy resources, the effectiveness and implementation of demand side management options, the effect of energy efficiency programs, and the relationship of the economy to all of these options. The IRP EIS will address the effects of power production on the environment, including climate change, the effects of climate change on the Valley, and the waste and byproducts of TVA's power operations.

Because of its nature as a planning document, the IRP will not identify specific locations for new resource options. Site-specific environmental effects of new resource options will be addressed in later site-specific assessments tiered off this programmatic EIS. Therefore, in this programmatic environmental impact statement, TVA anticipates that the environmental effects examined will primarily be those at a regional level with some extending to a national or global level. Preliminary issues identified by TVA that will be reviewed in this analysis include:

- Emissions of greenhouse gases,
- fuel consumption,
- air quality,
- water quality and quantity,
- waste generation and disposal,
- land use,
- ecological,
- cultural resources,
- socioeconomic impacts and environmental justice.

TVA invites suggestions concerning the list of issues which should be addressed. TVA also invites specific comments on the questions that will begin to be answered by this IRP:

- How do you think energy usage will change in the next 20 years in the Tennessee Valley region?
- Should the diversity of the current power generation mix (*e.g.,* coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?
- How should distributed energy resources be considered in TVA planning?
- How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?
- And how will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?

Analytical Approach

TVA employs a scenario planning approach when developing an IRP. The major steps in this approach include identifying the future need for power, developing scenarios and strategies, determining potential supply-side and demand-side energy resource options, developing portfolios associated with the strategies and ranking strategies and portfolios. The 2015 IRP, developed with extensive public involvement, evaluated six alternative energy resource strategies which differed in the amount of purchased power, energy efficiency and demand response efforts, renewable energy resources, nuclear generating capacity additions, and coal-fired generation. The alternative strategies were analyzed in the context of five different scenarios that described plausible future economic, financial, regulatory and legislated conditions, as well as social trends and adoption of technological innovations. TVA then developed a preferred alternative, the Target Power Supply Mix, based on guideline ranges for key energy resources. In developing the Target Power Supply Mix, TVA took into account its least-cost planning requirement and customer priorities of power cost and reliability, as well as other comments it received during the public comment periods. The Target Power Supply Mix established ranges, in MW, for coal plant retirements and additions of nuclear, hydroelectric, demand response, energy efficiency, solar, wind, and natural gas capacity. TVA anticipates using an analytical approach similar to that of the 2015 IRP/EIS described above. The number of alternative energy resource strategies and scenarios to be evaluated may differ from the 2015 IRP/EIS and will be determined after the completion of scoping.

Scoping Process

Scoping, which is integral to the process for implementing NEPA, provides an early and open process to ensure that (1) issues are identified early and properly studied; (2) issues of little significance do not consume substantial time and effort; (3) the draft EIS is thorough and balanced; and (4) delays caused by an inadequate EIS are avoided.

With the help of the public, TVA will identify the most effective energy resource strategy that will meet TVA's mission and serve the people of the Valley for the next 20 years. To ensure that the full range of issues and a comprehensive portfolio of energy resources are addressed, TVA invites members of the public as well as Federal, state, and local agencies and Indian tribes to comment on the scope of the IRP EIS. As part of the IRP process and in addition to other public engagement opportunities, TVA is assembling representatives from key stakeholders to participate in a working group that will discuss tradeoffs associated with different resource options and assist TVA in developing an optimal energy resource strategy.

Comments on the scope of this IRP EIS should be submitted no later than the date given under the **DATES** section of this notice. Any comments received, including names and addresses, will become part of the administrative record and will be available for public inspection.

After consideration of the comments received during this scoping period, TVA will summarize public and agency comments, identify the issues and alternatives to be addressed in the EIS, and identify the schedule for completing the EIS process. Following analysis of the issues, TVA will prepare a draft EIS for public review and comment. Notice of availability of the draft EIS will be published by the U.S. Environmental Protection Agency in the **Federal Register**. TVA will solicit written comments on the draft IRP and EIS and also hold public meetings for this purpose. TVA expects to release the draft IRP and EIS in late 2018. TVA anticipates issuing the final IRP and EIS in 2019.

Dated: February 8, 2018.

M. Susan Smelley,

Director, Environmental Compliance and Operations.

[FR Doc. 2018–03027 Filed 2–13–18; 8:45 am]

BILLING CODE 8120–08–P

TENNESSEE VALLEY AUTHORITY

Sunshine Act Meeting Notice

Meeting No. 18–01

The TVA Board of Directors will hold a public meeting on February 16, 2018, in the Missionary Ridge Auditorium of the Chattanooga Office Complex, 1101 Market Street, Chattanooga, Tennessee. The public may comment on any agenda item or subject at a *public listening session* which begins at 9:30 a.m. (ET). Following the end of the public listening session, the meeting will be called to order to consider the agenda items listed below. On-site registration will be available until 15 minutes before the public listening session begins at 9:30 a.m. (ET). Preregistered speakers will address the Board first. TVA management will answer questions from the news media following the Board meeting.

STATUS: Open.

Agenda

Chair's Welcome

Discussion of committee membership

Old Business

Approval of minutes of the November 9, 2017, Board Meeting

New Business

1. Report from President and CEO
2. Report of the Finance, Rates, and Portfolio Committee
3. Report of the Audit, Risk, and Regulation Committee
4. Report of the Nuclear Oversight Committee
5. Report of the External Relations Committee

A. FACA Charter Renewals

6. Report of the People and Performance Committee
7. Information Items

A. Conveyance of Power System Assets to a Customer

B. Committee Membership

For more information: Please call TVA Media Relations at (865) 632–6000, Knoxville, Tennessee. People who plan

B

Appendix B – Transmittal Letter, Meeting Notice, Newspaper Advertisements, and Media Release

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Wade, Blair

From: Integrated Resource Plan <irp@tva.gov>
Sent: Thursday, February 15, 2018 12:47 PM
To: Integrated Resource Plan
Subject: 2019 Integrated Resource Plan - Notice of Intent

The Tennessee Valley Authority (TVA) is beginning work on the 2019 Integrated Resource Plan (IRP), a comprehensive study that provides direction on how to best meet future electricity demand in the region. Building upon the work done in prior plans, TVA's 2019 IRP will proactively address the changing energy marketplace and to better understand the impact and benefit of system flexibility with increasing renewable and dispersed energy resources.

TVA has issued a Notice of Intent (NOI) to prepare a programmatic Environmental Impact Statement (EIS) to address the potential environmental effects associated with updating its 2015 IRP. You can view the Federal Register notice here (PDF).

The release of the NOI begins a 60-day public scoping period which will run from Feb. 15 through Apr. 16, 2018. You can provide input at our IRP website www.tva.gov/irp. Comments and questions may also be submitted by email at IRP@tva.gov, or by mail to Ashley Pilakowski, NEPA Project Manager, 400 W. Summit Hill Dr., WT 11D, Knoxville, TN 37902.

Public comment is invited concerning both the scope of the IRP/EIS and the its associated environmental issues. A number of opportunities are available to learn more about the IRP process and directly interact with staff members, including:

Public Involvement Meeting Calendar

- **February 21, from 10:00 a.m. to noon EST**: Webinar; please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329
- **February 27, 5:30 to 7:00p.m. EST:** Educational open house at the Westin Hotel, 801 Pine St., Chattanooga, Tenn.
- **March 5, 5:30 to 7:00p.m. CST:** Educational open house at Memphis Light Gas & Water's 1st Floor Auditorium, 220 S. Main St., Memphis, Tenn. (validated parking provided at garage across from building).

Written comments will be collected at both open houses. Please share this information with others who have an interest in TVA's energy resources.

Those who have special needs who wish to attend the meeting need to contact TVA at least a week in advance at (865) 632-6113

TVA

N E W S   R E L E A S E

TVA Opens Public Comment Period on Scope of Integrated Resource Plan Update

KNOXVILLE, Tenn. - The Tennessee Valley Authority kicked off a public comment period on February 15, related to the initial process phase for updating its Integrated Resource Plan (IRP), the agency's long-term energy resource strategy.

To ensure that the full range of issues and a comprehensive portfolio of energy resources are addressed, TVA invites members of the public, customers, businesses, employees, environmental organizations and community leaders, as well as federal, state and local agencies, to comment on the scope of the IRP and the associated programmatic Environmental Impact Statement.

The public comment period will run 60 days, closing on April 16.

"We strongly believe in a transparent and public-friendly process in developing our Integrated Resource Plan because it impacts every Tennessee Valley resident we serve," said Laura Campbell, vice president of Enterprise Planning.

"The diverse perspectives and opinions we gain make our plans stronger, so it's important that those who want to share their thoughts with us have the opportunity to do so."

The updated IRP will assess the previous planning direction presented in the 2015 IRP and reflect significant changes in the energy industry over the past three years, including flat to declining load growth, advances in the development of renewable and distributed energy resources, and the integration of those resources in the electric grid.

TVA anticipates the major issues to be addressed in the IRP study and the associated EIS will include the cost and reliability of energy resources, the availability and use of renewable and distributed resources, the effect of energy efficiency programs, and the relationship of costs and the economy to all of these options.

To gain greater public participation, a number of opportunities have been scheduled to learn more about the IRP process and directly interact with staff members, including:

- Feb. 21, 11 a.m. – noon EST: Webinar. Please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329.

- Feb. 27, 5:30 – 7p.m. EST: Educational open house at the Westin, 801 Pine St., Chattanooga, Tenn.

- March 5, 5:30 – 7 p.m. CST: Educational open house at Memphis Light Gas & Water's 1st Floor Auditorium, 220 S. Main St, Memphis, Tenn. (Validated parking provided at garage across the street.)

NOTE: Those with special needs who wish to attend either open house should contact TVA at least a week in advance at 1-865-632-6113.

Written comments should be sent to Ashley Pilakowski, Tennessee Valley Authority, 400 West Summit Hill Drive, WT 11D, Knoxville, TN 37902. Comments also may be submitted on the project website at http://www.tva.gov/irp, or by email at IRP@tva.gov.

The Tennessee Valley Authority is a corporate agency of the United States that provides electricity for business customers and local power companies serving more than 9 million people in parts of seven southeastern states. TVA receives no taxpayer funding, deriving virtually all of its revenues from sales of electricity. In addition to operating and investing its revenues in its electric system, TVA provides flood control, navigation and land management for the Tennessee River system and assists local power companies and state and local governments with economic development and job creation.

# # #

Media Contact: Jim Hopson, Knoxville, 865-632-8860
TVA Public Relations, Knoxville, 865-632-6000
www.tva.com/news
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(Distributed: Feb. 20, 2018)

7605 18-1878

Help Wanted

Business Ventures

Help Wanted

Help Wanted

Truck, Trailer, Van

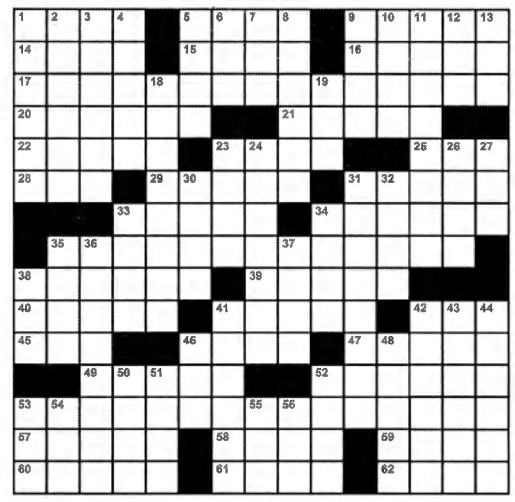
Autos

Auto Parts

Motorcycles

Daily CROSSWORD/UNIVERSAL SYNDICATE

STRAITLACED
By Timothy E. Parker



ACROSS
1 Age unit
5 Not fooled by
9 Philatelist's necessity
14 Quaint preposition
15 Go-getter
16 Beer barrel dance
17 Laundering anchor's aid?
20 Simple boats
21 Kinds
22 Gulf of Guinea city
23 Get up?
25 Indian honorific
28 Poker action
29 Connect logically
31 Moshe of Israel
33 Non-jittery java
34 Paul and Carly
35 Why some have no limit?
38 Calyx parts
39 Cuttings and pastings
40 Not worth the trouble
41 Crinkled fabric
42 Cigar refuse
45 Singer DiFranco
46 Box score L
47 Musically too much
49 American dogwood
52 Paper holder
53 Loan officers?
57 Be of help to
58 Give off
59 Road section
60 Shoulder muscles, briefly
61 Tsk alternatives
62 First grandchild

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2 Interweave strings
3 "ASAP!"
4 Copter's spinner
5 Some poem forms
6 Some answers
7 Aviv header
8 Prayer
9 Imitator
10 Barn section
11 God's sneeze follower?
12 Island inst.
13 Insane
18 Hot way to argue
19 At this moment
23 Equipment
24 Ransackers, essentially
26 Have a verbal fit
27 "Outs" partners
30 Cold "Italian" treats
31 Lo-cal, sugar-free, e.g.
32 Singer Tori
33 "Aw shucks!" kin
34 Make paper dolls
35 "___ there, done ..."
36 Not mandatory
37 "... the ___ of March!"
38 Relaxing "asp" anagram
41 Trumpet relative
42 Condor variety
43 Fuel jelly
44 Some ride providers
46 Island garland
48 Oft-twisted joint
50 Quick comedy routine
51 Woes
52 Baseball items
53 Michael Jackson hit
54 "Ciao, Caesar"
55 Down Under fowl
56 Boring tool

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Public Notice

TVA

Tennessee Valley Authority 2019 Integrated Resource Plan

TVA is beginning work on the 2019 Integrated Resource Plan (IRP) – a comprehensive study that provides direction on how to best meet future electricity demand in the region. Building upon the work done in prior plans, TVA is starting the 2019 IRP to proactively address the changing energy marketplace and to better understand the impact and benefit of system flexibility with increased renewable and distributed (dispersed) energy resources.

The IRP will consider a variety of future conditions to determine how TVA can continue to fulfill its commitment to provide low-cost, reliable energy; environmental stewardship; and regional economic development over the next 20 years. TVA will analyze the potential social-economic and natural environmental effects of the energy scenarios under consideration in a programmatic environmental impact statement (EIS).

Engagement with customers and stakeholders is a vital part of developing the IRP and EIS. As in the 2015 IRP, TVA will host multiple public engagement opportunities, as well as collaborate with an IRP working group and the TVA Regional Energy Resource Council.

Public comment is invited concerning both the scope of the IRP/EIS and environmental issues that should be addressed.

A 60-day public scoping period runs from Feb. 15, to April 16, 2018. You can provide input at our IRP website www.tva.gov/irp, email or post comments to the addresses below, or submit comments in writing at the scoping meetings.

Public Involvement Meeting Calendar

February 21, 11 a.m.-noon EST. Webinar. If attending, please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329.

February 27, 5:30-7 p.m. EST. Educational open house at the Westin, Chattanooga, Tennessee.

March 5, 5:30-7 p.m. CST. Educational open house, Memphis Light Gas & Water Auditorium, 220 S. Main St., Memphis, Tennessee. (Validated parking provided at garage across the street.)

Those who have special needs who wish to attend the meetings need to contact TVA at least a week in advance at 1-865-632-6113.

For more information about the IRP study contact:

Hunter Hydas
Enterprise Planning
1101 Market St.
Chattanooga, TN 37402

Ashley Pilakowski
NEPA Project Manager
400 W. Summit Hill Drive, WT 11D
Knoxville, TN 37902

Amy Henry
Enterprise Relations and Innovation
400 West Summit Hill Drive, WT 9D
Knoxville, TN 37902

IRP@tva.gov

Legals

or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 12TH day of FEBRUARY, 2018.

ESTATE OF JOHN ROBINSON BOSSON

PERSONAL REPRESENTATIVE (S)
ELIZABETH ANN BOSSON; EXECUTRIX
5433 MALONEYVILLE ROAD
CORRYTON, TN. 37721

PHILIP CRYE, JR.
ATTORNEY AT LAW
125 NORTH MAIN STREET
CLINTON, TN. 37716
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF JUNE C KISER
DOCKET NUMBER 79873-3

Notice is hereby given that on the 12TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

JUNE C KISER

Who died Dec 19, 2017, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 12TH day of FEBRUARY, 2018.

ESTATE OF JUNE C KISER

PERSONAL REPRESENTATIVE (S)
DAVID M KISER; EXECUTOR
5634 HARRIET LANE
LUDINGTON, MI 49431
February 15 & 22, 2018

Legals

NOTICE TO CREDITORS
ESTATE OF KARL HANS MELVIN BARTH
DOCKET NUMBER 79925-1

Notice is hereby given that on the 9TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

KARL HANS MELVIN BARTH

Who died Jan 21, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 9TH day of FEBRUARY, 2018.

ESTATE OF KARL HANS MELVIN BARTH

PERSONAL REPRESENTATIVE (S)
ANNINA TOWNES; EXECUTRIX
8151 ROBINS NEST LANE
KNOXVILLE, TN. 37919
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF KERRY JANE RADER
DOCKET NUMBER 79893-2

Notice is hereby given that on the 8TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

KERRY JANE RADER

Who died Jan 3, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

Legals

(2) Twelve (12) months from the decedent's date of death.
This the 8TH day of FEBRUARY, 2018.

ESTATE OF KERRY JANE RADER

PERSONAL REPRESENTATIVE (S)
TANDA SHAWN PAINE; EXECUTRIX
3710 GUNNISON WAY
KNOXVILLE, TN. 37921

THOMAS R. RAMSEY, III
ATTORNEY AT LAW
550 W. MAIN ST STE 310
KNOXVILLE, TN. 37902
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF MARY NELL MINTON
DOCKET NUMBER 79918-3

Notice is hereby given that on the 8TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

MARY NELL MINTON

Who died Dec 22, 2017, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 8TH day of FEBRUARY, 2018.

ESTATE OF MARY NELL MINTON

PERSONAL REPRESENTATIVE (S)
SANDRA RENEE BROUGHTON; EXECUTRIX
1105 MANLEY ROAD
RUTLEDGE, TN. 37861

BEN T. NORRIS
ATTORNEY AT LAW
P.O. BOX 397
KNOXVILLE, TN. 37871
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF MICHAEL J DELEONARDIS
DOCKET NUMBER 79921-3

Notice is hereby given that on the 8TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

MICHAEL J DELEONARDIS

Who died Dec 19, 2017, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims,

Public Notices

Public Notice

TVA

Tennessee Valley Authority 2019 Integrated Resource Plan

TVA is beginning work on the 2019 Integrated Resource Plan (IRP) – a comprehensive study that provides direction on how to best meet future electricity demand in the region. Building upon the work done in prior plans, TVA is starting the 2019 IRP to proactively address the changing energy marketplace and to better understand the impact and benefit of system flexibility with increased renewable and distributed (dispersed) energy resources.

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Engagement with customers and stakeholders is a vital part of developing the IRP and EIS. As in the 2015 IRP, TVA will host multiple public engagement opportunities, as well as collaborate with an IRP working group and the TVA Regional Energy Resource Council.

Public comment is invited concerning both the scope of the IRP/EIS and environmental issues that should be addressed.

A 60-day public scoping period runs from Feb. 15, to April 16, 2018. You can provide input at our IRP website www.tva.gov/irp, email or post comments to the addresses below, or submit comments in writing at the scoping meetings.

Public Involvement Meeting Calendar

February 21, 11 a.m.-noon EST. Webinar. If attending, please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329.

February 27, 5:30-7 p.m. EST. Educational open house at the Westin, Chattanooga, Tennessee.

March 5, 5:30-7 p.m. CST. Educational open house, Memphis Light Gas &

Legals

matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 8TH day of FEBRUARY, 2018.

ESTATE OF MICHAEL J DELEONARDIS

PERSONAL REPRESENTATIVE (S)
WILLIAM M DELEONARDIS; EXECUTOR
3001 RIVER TOWN WAY 41502
KNOXVILLE, TN. 37920

STEVEN L WILLIAMS
ATTORNEY AT LAW
329 ELLIS AVENUE
MARYVILLE, TN. 37804
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF MIOKO YOSHIDA OLIVER
DOCKET NUMBER 79926-2

Notice is hereby given that on the 9TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

MIOKO YOSHIDA OLIVER

Who died Jan 22, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 9TH day of FEBRUARY, 2018.

ESTATE OF MIOKO YOSHIDA OLIVER

PERSONAL REPRESENTATIVE (S)
ROBERT M OLIVER; EXECUTOR
2805 AQUA LANE
KNOXVILLE, TN. 37931
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF CATHERINE A SUMMERS
DOCKET NUMBER 79904-1

Notice is hereby given that on the 6TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

CATHERINE A SUMMERS

Who died Jan 7, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 6TH day of FEBRUARY, 2018.

ESTATE OF CATHERINE A SUMMERS

PERSONAL REPRESENTATIVE (S)
ASHLEY SUMMERS; EXECUTOR
7129 RUGGLES FERRY PIKE
KNOXVILLE, TN. 37924

GAIL F WORTLEY
ATTORNEY AT LAW
3715 POWERS STREET
KNOXVILLE, TN. 37917
February 8 & 15, 2018

NOTICE TO CREDITORS
ESTATE OF JOHN D ARNETT, JR.
DOCKET NUMBER 79872-2

Notice is hereby given that on the 6TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

JOHN D ARNETT, JR.

Who died Oct 27, 2017, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less

Legals

forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 13TH day of FEBRUARY, 2018.

ESTATE OF REBECCA W. ADDINGTON

PERSONAL REPRESENTATIVE (S)
JENNIFER A DUNSMORE; EXECUTRIX
1326 ASTORIA DRIVE
KNOXVILLE, TN. 37918

JOHN W ROUTH
ATTORNEY AT LAW
3214 TAZEWELL PIKE, SUITE 105
KNOXVILLE, TN. 37918
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF ROBERT D KENNEY
DOCKET NUMBER 79931-1

Notice is hereby given that on the 12TH day of FEBRUARY, 2018, letters administration in respect of the Estate of

ROBERT D KENNEY

Who died Jan 6, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 12TH day of FEBRUARY, 2018.

ESTATE OF ROBERT D KENNEY

PERSONAL REPRESENTATIVE (S)
GAIL LOWERY; ADMINISTRATRIX
7930 INTERVALE WAY
POWELL, TN. 37849
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF SHANNEN DENISE ROBINSON
DOCKET NUMBER 79934-1

Notice is hereby given that on the 13TH day of FEBRUARY, 2018, letters administration in respect of the Estate of

SHANNEN DENISE ROBINSON

Who died Oct 23, 2017, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1) (A); or

(2) Twelve (12) months from the decedent's date of death.
This the 13TH day of FEBRUARY, 2018.

ESTATE OF SHANNEN DENISE ROBINSON

PERSONAL REPRESENTATIVE (S)
ROSLYN W ROBINSON; ADMINISTRATRIX
8915 ORMAND LANE
KNOXVILLE, TN. 37923
February 15 & 22, 2018

NOTICE TO CREDITORS
ESTATE OF VIRGINIA S TINDELL
DOCKET NUMBER 79922-1

Notice is hereby given that on the 9TH day of FEBRUARY, 2018, letters testamentary in respect of the Estate of

VIRGINIA S TINDELL

Who died Jan 10, 2018, were issued the undersigned by the Clerk and Master of the Chancery Court of Knox County, Tennessee. All persons, resident and non-resident, having claims, matured or unmatured, against his or her estate are required to file the same with the Clerk and Master of the above named court on or before the earlier of the dates prescribed in (1) or (2) otherwise their claims will be forever barred:

(1) (A) Four (4) months from the date of the first date of the publication of this notice if the creditor received an actual copy of this notice to creditors at least sixty (60) days before the date that is (4) months from the date of the first publication: or

(B) Sixty (60) days from the date the creditor received an actual copy of the notice to creditors if the creditor received the copy of the notice less than sixty (60) days prior to the date that is (4) months from the date of first publication as described in (1)

Miscellaneous Notice

In KNOX NEWS SENTINEL, a newspaper published in KNOXVILLE, KNOX COUNTY, TENNESSEE requiring the above listed defendant, **ZACHARY DREW TOLLIVER**, appear before the clerk of said Court on or before thirty days after the last publication hereof and make defense to the bill filed in the above cause, which seeks TERMINATION OF PARENTAL RIGHTS AND ADOPTION or otherwise said bill be taken for confessed and cause proceeded with exparte.

This the 7th day of February, 2018.
John A. W. Bratcher,
Clerk & Master, Chancery Court.
By: Lori Finch, Deputy Clerk & Master.
Solicitors for Plaintiff: Robert D. Tuke
February 15, 22, March 1 & 8, 2018

Notice Of Foreclosure

NOTICE OF TRUSTEE'S SALE

THAT WHEREAS, by Deed of Trust dated August 8, 2014, of record in the Register's Office of Jefferson County, Tennessee, and recorded in Record Book 1236, at page 643, Ronald Holmes and Lisa Holmes, did convey in Trust to Dennis Michael Robertson, Trustee, the tract of land hereinafter described to secure the payment of a promissory note in the original amount of $85,000.00, same being payable as set out in said Deed of Trust, being incorporated by reference, and recorded in the Jefferson County Register's Office, and,

WHEREAS, Commercial Bank is the owner and holder of the note aforesaid secured by the Deed of Trust aforesaid, and

WHEREAS, said Deed of Trust provides that in the event of default in the payment of said note when due, the entire indebtedness shall become due and payable, and,

WHEREAS, default has been made in the payment of said note and the holder has declared the entire amount due and payable and has instructed the trustee to foreclose on said Deed of Trust.

NOW, THEREFORE, by virtue of authority to me vested as trustee of said instrument, I will on the 13th day of March, 2018, offer for sale, and sell in front of the Jefferson County Courthouse Door, in Dandridge, Tennessee, at the hour of 10:30 a.m., to the last, highest, and the best bidder for cash in hand, and in bar of the equity of redemption, the following described tract of land:

Situated in the First Civil District of Jefferson County, Tennessee, to wit:

Being all of Lot No. 5 of Franklin Ridge Development, as shown by plat of record in Plat Cabinet F, Slide 229, in the Register's Office for Jefferson County, Tennessee, to which map specific reference is hereby made for a more particular description of said lot.

The above referenced property has been improved with a manufactured dwelling bearing the following description; 2001 Fleetwood Home, Serial #TNGL127A25415AV12

For reference see Warranty Deed Book 1236, page 680.

Property address: 112 Danielle Drive, Dandridge, Tennessee 37725.

MAP 058 OA, PARCEL 005.00.

The creditor has certified to the Trustee that the provisions of Public Chapter No. 834 of the Public Acts of 2010 for the State of Tennessee are not applicable or have been complied with.

This notice is published in accordance with said Deed of Trust on the 15th , and the 22nd day of February, and 1st day of March 2018, in the Knoxville News Sentinel.

Dated: February 9, 2018.
Dennis Michael Robertson, Trustee
P.O. Box 678
Harrogate, Tennessee 37752
(423) 869-0520

SUBSTITUTE TRUSTEE'S NOTICE OF SALE

Thomas H. Dickenson, Substitute Trustee under a Deed of Trust dated June 14, 2012, executed by Jeff McHaha and Kristen McGaha, and recorded in Book G-30, Page 563, in the Register's Office for Monroe County, Tennessee, will **sell for cash**, at a foreclosure sale requested by Y-12 Federal Credit Union, the real property described below. The sale will be at the front door of the Monroe County Courthouse, 103 College Street S, Madisonville, Tennessee, on the 2nd day of March, 2018, at 10:15 a.m., prevailing time.

Property Description: Situated in the Third Civil District of Monroe County, Tennessee, within the corporate limits of the city of Madisonville, Tennessee, and being more particularly described as follows: **Beginning** at the Northwest corner of Walnut Street and Magill Street, thence following along Walnut Street, North 90 deg. 00 min. 00 sec. West, 75.00 feet to an iron pin set (5/8 inch rebar w/cap) corner to Charles Parris (Deed Book 275, Page 683); thence, following along property of Parris, North 02 deg. 06 min. 44 sec. East, 56.84 feet to an iron pin set (5/8 inch rebar w/ cap) corner to BS Ent. (Deed Book 263, Page 678); thence, following along BS Ent., South 87 deg. 15 min. 11 sec. East, 74.95 feet to an iron pin set (5/8 inch rebar w/cap) corner to Magill Street; thence following along Magill Street, South 02 deg. 06 min. 44 sec. West, 53.25 feet to the point of beginning, according to the survey of Michael D. Lowe, RLS NO. 2212. **Subject** to all applicable easements, restrictions, and permissive use agreements of record in the Register's Office. **See also**, deed of record in Deed Book 323, Page 441, Register's Office of Monroe County, Tennessee.

Property Address: Believed to be 200 Magill Street, Madisonville, Tennessee 37354

Tax Parcel I.D.: 067DF020.00

Other Interested Parties: City of Madisonville; CU Revest, LLC

The above-described property will be sold **AS IS, WHERE IS**, and subject to unpaid taxes, prior deeds of trust, all easements and restrictions, the rights of tenants in possession of said premises, if any, prior claims, or other matters of record with priority over the deed of trust described herein. The proceeds of the sale will be applied as required by the deed of

+6025
18-1878

THE COMMERCIAL APPEAL
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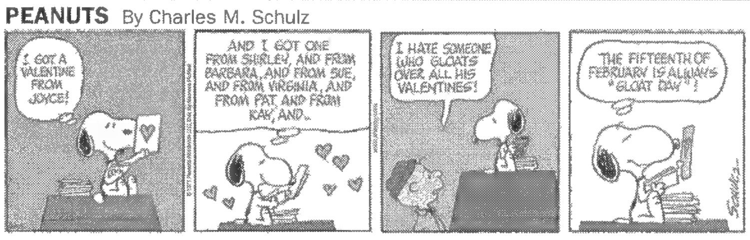
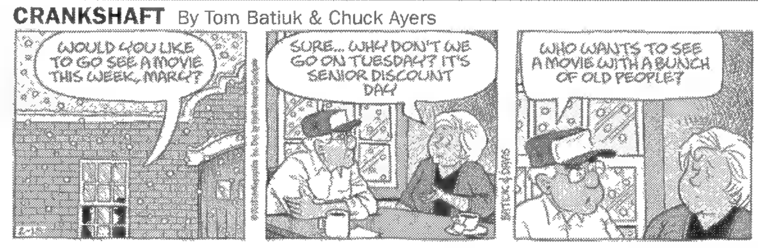
Announcements | Garage Sales | Real Estate Commercial | Training and Education
Employment | Legals | Real Estate Rentals | Transportation
Farmer's Market Trading Post | Merchandise | Real Estate Sales | Services Offered
Financial | Pets | Recreation

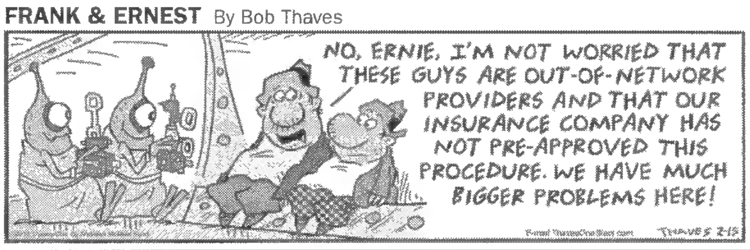
PEANUTS By Charles M. Schulz



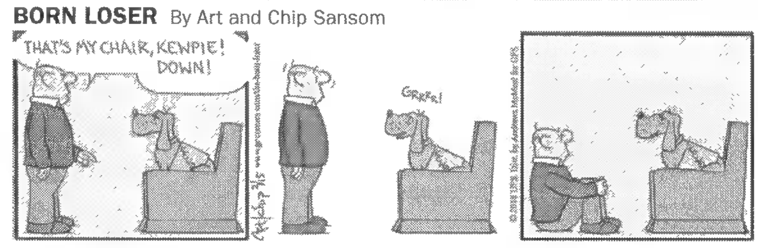
CRANKSHAFT By Tom Batiuk & Chuck Ayers



FRANK & ERNEST By Bob Thaves



BORN LOSER By Art and Chip Sansom



Announcements

Personals

Adopting your newborn is our dream.
Secure life and love awaits. Call Lorraine & Danny 1-866-997-7171 expenses paid.

Employment

Employment Wanted

AAA CAREGIVER - FOR ELDERLY IN HOME/FACILITY 18 yrs. exper. Excel. references. Reasonable rates. Avail. all hours, weekends & holidays. Familiar w/Kashrut Values. Please call: **901-503-1818**

ARE YOU IN NEED of an Eldercare Provider
Days, Evenings and Overnight.
24 hrs. Excellent references
901-496-2429 901-846-2267

Farmer's Mkt/ Trading Post

Wanted to Buy

FREON R12 WANTED -
Freon R12 WANTED: Certified buyer will pickup and pay CASH for cylinders of R12.
312-291-9169

Financial

Business Opportunities

Building Supplies

Legals

Legal Notices

INVITATION TO BID
F & F Construction Co., Inc. is soliciting bids from DOT-Certified Disadvantaged Business Enterprise (DBE) Contractors for the Airfield Maintenance & Operations Support Facility project at the Memphis International Airport. If you would like to bid on this project, please contact Kathy Bell at our office via email (kathy@fandfconstruction.com) as soon as possible.

NOTICE OF FILING OF COMPLAINT SEEKING EXONERATION FROM OR LIMITATION OF LIABILITY
Notice is hereby given that Wepfer Marine, Inc. ("Wepfer"), as owner pro hac vice of the M/V RICKY ROBINSON, Official No. 572484 (the "towboat"), has filed a Complaint for Exoneration From or Limitation of Liability pursuant to Title 46 U.S.C. § 30501, et seq., of the United States Code.
You are further notified that Wepfer by filing such Complaint seeks an order exonerating it from all liability for claims, losses, and damages arising out of an incident which occurred on or about December 8, 2017, when the towboat sank at or about Mile 733.2, L.M.R., in Shelby County, Tennessee (the "sinking").
All firms, persons, and corporations having claims arising out of the sinking must file them in the form prescribed by Rule F of the Supplemental Rules for Certain Admiralty and Maritime Claims of the Federal Rules of Civil Procedure, with the Clerk of the United States District Court for the Western District of Tennessee, Eastern Division, on or before Friday, March 2, 2018.
Any such claimant desiring to contest Wepfer's and/or the M/V RICKY ROBINSON's right to exonerate must file an answer to said Complaint within the time prescribed above.
You are notified that failure to timely file a claim and/or or answer in proper form, within the time prescribed above, will operate to bar the subsequent filing of a claim, suit, or answer arising out of the sinking against the towboat and/or Wepfer, its officers, directors, stockholders, agents, representatives, servants, employees, and parent or affiliated companies, and any other person or entity whatsoever for whom Wepfer may be responsible, arising out of or attributable to the sinking.
A true and correct copy of any claim or answer filed in accordance with the foregoing must be mailed to Frank J. Dantone, Henderson Dantone, P.A., P.O. Box 778, Greenville, Mississippi 38702, the attorney for Wepfer Marine, Inc.
SO NOTICED, this the 8th day of January, 2018.
CLERK, U. S. DISTRICT COURT
By: s/Judy Easley
Deputy Clerk

NOTICE OF SUBSTITUTE TRUSTEE S SALE WHEREAS, default has occurred in the performance of the covenants, terms and conditions of a Deed of Trust dated September 28, 2007, executed by Alfred Robinson, conveying certain real property therein described to PRLAP, INC., as Trustee, as same appears of record in the Register's Office of Shelby County, Tennessee recorded October 4, 2007, at Instrument Number 07153376; and WHEREAS, the beneficial interest of said Deed of Trust was last transferred and assigned to BANK OF AMERICA, N.A. who is now the owner of said debt; andWHEREAS, the undersigned,Rubin Lublin TN, PLLC, having been appointed as Substitute Trustee by instrument to be filed for record in the Register's Office of Shelby County, Tennessee. NOW, THEREFORE, notice is hereby given that the entire indebtedness has been declared due and payable, and that the undersigned, Rubin Lublin TN, PLLC, as Substitute Trustee or his duly appointed agent, by virtue of the power, duty and authority vested and imposed upon said Substitute Trustee will, on **March 1, 2018 at 12:00 PM** at the Shelby County Courthouse, 140 Adams Avenue, Memphis, TN, located in Memphis, Tennessee, proceed to sell at public outcry to the highest and best bidder for cash or certified funds ONLY, the following described property situated in Shelby County, Tennessee, to wit:LOT 108, SECTION A, SECOND ADDITION, WHITEHAVEN VIEW SUBDIVISION, AS SHOWN ON PLAT OF RECORD IN PLAT BOOK 22, PAGE 76, IN THE REGISTER`S OFFICE OF SHELBY COUNTY, TENNESSEE, TO WHICH PLAT REFERENCE IS HEREBY MADE FOR AMORE PARTICULAR DESCRIPTION OF SAID PROPERTY.Parcel ID: 07910400023PROPERTY ADDRESS: The street address of the property is believed to be **5144 Lexie Drive, Memphis, TN 38116.** In the event of any discrepancy between this street address and the legal description of the property, the legal description shall control. CURRENT OWNER(S): Alfred RobinsonOTHER INTERESTED PARTIES: Cavalry SPV 1 LLCThe sale of the above-described property shall be subject to all matters shown on any recorded plat; any unpaid taxes; any restrictive covenants, easements or set-back lines that may be applicable; any prior liens or encumbrances as well as any priority created by a fixture filing; and to any matter that an accurate survey of the premises might disclose. This property is being sold with the express reservation that it is subject to confirmation by the lender or Substitute Trustee. This sale may be rescinded at any time. The right is reserved to adjourn the day of the sale to another day, time, and place certain without further publication, upon announcement at the time and place for the sale set forth above. All right and equity of redemption, statutory or otherwise, homestead, and dower are expressly waived in said Deed of Trust, and the title is believed to be good, but the undersigned will sell and convey only as Substitute Trustee. The Property is sold as is, where is, without representations or warranties of any kind, including fitness for a particular use or purpose. THIS LAW FIRM IS ATTEMPTING TO COLLECT A DEBT. ANY INFORMATION OBTAINED WILL BE USED FOR THAT PURPOSE. Rubin Lublin TN, PLLC, Substitute Trustee119 S. Main Street, Suite 500Memphis, TN 38103 www.rubinlublin.com/property-listings.php Tel: (877) 813-0992Fax: (404) 601-5846 Ad #130669 02/01/2018, 02/08/2018, 02/15/2018

NOTICE OF SUBSTITUTE TRUSTEE S SALE WHEREAS, default has occurred in the performance of the covenants, terms and conditions of a Deed of Trust dated June 20, 2005, executed by KEITH D FISHER And TARA FISHER, conveying certain real property therein described to WALTER H. NEILSEN, as Trustee, as same appears of record in the Register's Office of Shelby County, Tennessee recorded July 5, 2005, at Instrument Number 05104580; and WHEREAS, the beneficial interest of said Deed of Trust was last transferred and assigned to Deutsche Bank National Trust Company, as indenture trustee for the Encore Credit Receivables Trust 2005-3 who is now the owner of said debt; andWHEREAS, the undersigned,Rubin Lublin TN, PLLC, having been appointed as Substitute Trustee by instrument to be filed for record in the Register's Office of Shelby County, Tennessee. NOW, THEREFORE, notice is hereby given that the entire indebtedness has been declared due and payable, and that the undersigned, Rubin Lublin TN, PLLC, as Substitute Trustee or his duly appointed agent, by virtue of the power, duty and authority vested and imposed upon said Substitute Trustee will, on **March 15, 2018 at 10:00 AM** at the Front Entrance Steps of the Shelby County Courthouse, Memphis, Tennessee, proceed to sell at public outcry to the highest and best bidder for cash or certified funds ONLY, the following described property situated in Shelby County, Tennessee, to wit:LOT 196, SECTION "A", VALLYWOOD SUBDIVISION, AS SHOWN ON PLAT OF RECORD IN PLAT BOOK 46, PAGE 60, IN THE REGISTER`S OFFICE OF SHELBY COUNTY, TENNESSEE, TO WHICH PLAT REFERENCE IS HEREBY MADE FOR A MORE PARTICULAR DESCRIPTION OF SAID PROPERTY.Parcel ID: 0790610A000200PROPERTY ADDRESS: The street address of the property is believed to be **4895 WHITWORTH RD, MEMPHIS, TN 38116.** In the event of any discrepancy between this street address and the legal description of the property, the legal

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LEGALS

ADEM
1400 Coliseum Blvd.
[Mailing address: PO Box 301463;
Zip 36130-1463]
Montgomery, Alabama 36110-2400
(334) 271-7714
Persons wishing to comment may do so, in writing, to the Department's named contact above within 45 days of the publication date of this notice. To affect final decisions, comments must offer technically substantial information that is applicable to the proposed permit modification.
A written request for a public hearing may also be filed within the 45-day period and must state the nature of the issues proposed to be raised in the hearing. The Director shall hold a public hearing upon receipt of a significant number of technical requests.
After consideration of all written comments, review of any public hearing record, and consideration of the requirements of the AHWMMA, the federal Resource, Conservation and Recovery Act (RCRA) and applicable regulations, the Department will make a final determination. The Department will develop a response to comments, which will become part of the public record and will be available to persons upon request. Information will be sent to any person requesting notice of the final action.
The Department maintains a list of interested individuals who are mailed legal notices regarding proposed permits. If you wish to receive such notices, contact the Permits & Services Division via telephone (334-271-7714), e-mail (permitsmail@adem.alabama.gov), or postal service (P.O. Box 301463 Montgomery, AL 36130-1463).
The Department does not discriminate on the basis of race, color, national origin, sex, religion, age or disability in the administration of its programs.
This notice is hereby given this 16th day of February, 2018, by authorization of the Alabama Department of Environmental Management.
Lance R. LeFleur
Director
The Department does not discriminate on the basis of race, color, national origin, sex, religion, age or disability in the administration of its programs.
Huntsville Times: February 16, 2018

IN THE JUVENILE COURT OF
MADISON COUNTY, ALABAMA

IN THE MATTER OF
JETER MIKAH

CASE NO.: JU-2016-000976.02

PUBLICATION ORDER

TO: Jazmine Jeter and/or any other person claiming to be the natural father of Mikah Jeter.

A petition having been filed in this Court by the Madison County Department of Human Resources requesting the Court to terminate the parental rights of the parents of said children and grant permanent legal custody of the child known as Mikah Jeter, a child born March 17, 2009, to the State of Alabama Department of Human Resources, for the purpose of adoptive planning, and the Court having set a hearing on the merits of said petition for the 11th day of June, 2018, at 9:00 o'clock a.m. in the courtroom of the undersigned judge, Madison County Courthouse, 100 North Side Square, Huntsville, Alabama, you are hereby notified that at said time and place you may appear and show cause, if any, why the permanent legal custody of said child should not be given to the State of Alabama Department of Human Resources as requested in said petition. Inquiry may be made as to this matter by contacting, Robin Wolfe, attorney for the Madison County Department of Human Resources, or this Court prior to the hearing.

DONE this 5th day of February, 2018.

/s/ PATRICIA DUNN DEMOS
JUVENILE JUDGE

Huntsville Times: February 16, 23, March 2, 9, 2018

IN THE JUVENILE COURT OF
MADISON COUNTY, ALABAMA

IN THE MATTER OF
PLYLAR MALIA

CASE NO.: JU-2014-000314.03

AMENDED PUBLICATION ORDER

TO: Molly Plylar and David Ross and/or any other person claiming to be the natural father of Malia Plylar.

A petition having been filed in this Court by the Madison County Department of Human Resources requesting the Court to terminate the parental rights of the parents of said children and grant permanent legal custody of the child known as Malia Plylar, a child born October 21, 2011, to the State of Alabama Department of Human Resources, for the purpose of adoptive planning, and the Court having set a hearing on the merits of said petition for the 14th day of June, 2018, at 9:00 o'clock a.m. in the courtroom of the undersigned judge, Madison County Courthouse, 100 North Side Square, Huntsville, Alabama, you are hereby notified that at said time and place you may appear and show cause, if any, why the permanent legal custody of said child should not be given to the State of Alabama Department of Human Resources as requested in said petition. Inquiry may be made as to this matter by contacting, Robin Wolfe, attorney for the Madison County Department of Human Resources, or this Court prior to the hearing.

DONE this 7th day of February, 2018.

/s/ PATRICIA DUNN DEMOS
JUVENILE JUDGE

Huntsville Times: February 9, 16, 23, March 2, 2018

INVITATION FOR BIDS

Sealed proposals for the FOLEY TO DAPHNE FIBER LINE PROJECT # ELE 6724. The proposals will be received by Riviera Utilities at the office of same at 413 East Laurel Avenue, Foley Alabama 36535 until Friday, March 2, 2018 at 10:00 A.M. Local time at which time and place the received proposals will be publicly opened and read aloud.
The MANDATORY pre-bid meeting is scheduled for: Friday, February 23rd, 2018 at 10:00 AM local time. Bidders shall meet in the Riviera Utilities 2nd floor main conference room, 413 East Laurel Ave, Foley, AL 36535. Please RSVP by calling (251) 943-5001. Written requests for interpretation received by Wednesday, February 21st, 2018 shall be answered in the form of addenda to these contract documents at this meeting. All bidders are required to attend the pre-bid meeting and submit the completed Bidder's Work Experience Form. Attendance at the pre-bid meeting is MANDATORY for bid consideration.
Contract Documents will be available for inspection and may be obtained from the office of Riviera Utilities, Located at 413 East Laurel Avenue Foley, Alabama 36535 upon receipt of a $65.00 per set. Contract forms are also available in electronic form at no charge.
The work consists principally of the following:
INSTALLATION OF APPROXIMATELY A 25.6 MILE ROUTE OF ALL DIELECTRIC SELF-SUPPORTING (ADSS) FIBER OPTIC CABLE. THIS WILL BE A COMBINATION OF A 24.66 MILE ROUTE OF ADSS FIBER OPTIC CABLE INSTALLED ON OVERHEAD UTILITY POLE INFRASTRUCTURE AS WELL AS A 0.94 MILE ROUTE OF ADSS FIBER OPTIC CABLE INSTALLED UNDERGROUND IN CONDUIT. INCLUDING INSTALLATION OF ALL ATTACHMENTS, U/G BOXES, SLACK STORAGE, SPLICE BOXES, & TERMINATIONS NEEDED TO COMPLETE THE INSTALLATION FROM THE MDF IN DAPHNE TO THE MDF LOCATED IN FOLEY. INCLUDING ALL LABOR, ASSOCIATED EQUIPMENT & INCIDENTAL MATERIALS TO COMPLETE THE INSTALLATION OF THE NEW LINE LOCATED IN BALDWIN COUNTY, ALABAMA.
As a proposal guaranty, a BID BOND or CERTIFIED CHECK must accompany PROPOSALS in an amount equal to five (5) percent of the proposal or $10,000, whichever is less. The successful Bidder will be required to furnish a performance bond and a bond for payment for labor and materials in an amount equal to one hundred percent (100%) of the contract price, said bonds to remain in full force and effect for a period of one (1) year after the completed Work has been accepted by the owner.
All bidders must comply with the Contractor's Licensing Laws of the State of Alabama (Ala. Code 1975, Title 34, Chapter 8), and must be certified for the type of work involved. It is also noted that any subcontractor performing Work in excess of $50,000.00 must also be licensed as a general contractor in the State of Alabama.
Submission of a proposal by any person, firm, or corporation shall be prima facie evidence that he, she, or they have carefully examined the site of Work and the contract documents; that he or they have judged for, and satisfied themselves as to the conditions that will be encountered, as to the character and nature of the Work to be performed, and materials to be furnished and as to the requirements of the contract documents, and as to the contingencies. Such submission shall further be prima facie evidence that the submitting person is familiar with and shall comply with all requirements of all Federal, State and Local Laws and Ordinances which may directly or indirectly affect the Work, and materials or equipment used in the Work.
The Board reserves the right to reject any and all proposals, to waive formalities and technicalities in the proposals, and to delay an award of contract for a period of Thirty (30) days after the date for receiving proposals (or such other time period provided for in the Special Provisions). No proposal shall be accepted, however, without the Experience Form completed and attached. Riviera Utilities reserves the right to refuse or reject any bid for any reason authorized by applicable law.
Sealed Bids shall be marked and addressed as follows:
Attn: Michael Siladi
Riviera Utilities
413 East Laurel Avenue
Foley, Alabama 36535
Mark the following clearly on the outside of the sealed envelope:
BID DOCUMENTS
DO NOT OPEN until March 2, 2018 at 10:00 A.M.
Bid For: Foley to Daphne Fiber Line – ELE 6724
Name and Address of Contractor
Contractor's State of Alabama License Number
Huntsville Times: February 16, 2018

LEGAL NOTICE

Notice is hereby given the undersigned will sell for cash at public auction March 1, 2018, starting at 10:30 AM. The following property will be sold:
Unit # 76
Joseph Fleming
1928 Bo Bo Section Rd.
Hazel Green, AL 35750
Contents: Household goods
Best Mini Storage
7242 Governors West
Huntsville, Al 35806
We reserve the right to refuse any or all bids.
Huntsville Times: February 16, 23, 2018

MORTGAGE FORECLOSURE NOTICE

Default having been made in the terms of that certain Mortgage, executed on 10/21/2009, by Donald Webster, an unmarried man , as Mortgagor, to Mortgage Electronic Registration Systems, Inc as nominee for First Federal Bank as Mortgagee, which said Mortgage is recorded in the Office of the Judge of Probate, Madison County, Alabama, in instrument number 20091026000674430 on 10/26/2009, and subsequently assigned to Carrington Mortgage Services, LLC and default having continued under the terms of said Mortgage, and by virtue of Alabama Code Section 35-10-3 and 35-10-2, the following described real property will be sold at public outcry, for cash, to the highest bidder, in front of the Courthouse door of said County, during the legal hours of sale, on 2/22/2018.
Lot 10, block 7, according to the map of survey of Kingwood Hills Subdivision, as recorded in the Office of the Judge of Probate of Madison County, Alabama, in plat book 3, page 101.
Subject to all easements, restrictions and reservations appearing of record. Said sale will also be made subject to any Federal Tax Liens and/or Special Assessments of any nature, if any, which might adversely affect the title to the property.
Alabama law gives some persons who have an interest in property the right to redeem the property under certain circumstances. Programs may also exist that help persons avoid or delay the foreclosure process. An attorney should be consulted to help you understand these rights and programs as a part of the foreclosure process.
The property is being sold "as is, where is". Said property is sold without warranty or recourse, expressed or implied as to title, use or enjoyment.
This sale is made for the purpose of paying the indebtedness secured by said mortgage, as well as the expenses of foreclosure.
KENT D. MCPHAIL
DUMAS & MCPHAIL, L.L.C.
Attorney for Mortgage Holder
126 Government Street
Mobile, AL 36602
251-438-2333
Huntsville Times: February 2, 9, 16, 2018

MORTGAGE FORECLOSURE SALE

Default having been made in the payment of the indebtedness secured by that certain mortgage executed by Dorothy Edwards, a single person, originally in favor of Wells Fargo Financial Alabama, Inc., on the 26th day of October, 2006, said mortgage recorded in the Office of the Judge of Probate of Madison County, Alabama, in Instrument Number 20070110000021860; the undersigned U.S. Bank Trust, N.A., as Trustee for LSF9 Master Participation Trust, as Mortgagee/Transferee, under and by virtue of the power of sale contained in said mortgage, will sell at public outcry to the highest bidder for cash, in front of the main entrance of the Courthouse at Huntsville, Madison County, Alabama, on March 23, 2018, during the legal hours of sale, all of its right, title, and interest in and to the following described real estate, situated in Madison County, Alabama, to-wit:
Lot 34, Block 1, according to the Map of Survey of Ortega Heights, Huntsville, Alabama, as same appears of record in the Office of the Judge of Probate of Madison County, Alabama, in Plat Book 3, Page 113.
Property street address for informational purposes: 5128 Ortega Cir, Huntsville, AL 35810
THIS PROPERTY WILL BE SOLD ON AN "AS IS, WHERE IS" BASIS, SUBJECT TO ANY EASEMENTS, ENCUMBRANCES, AND EXCEPTIONS REFLECTED IN THE MORTGAGE AND THOSE CONTAINED IN THE RECORDS OF THE OFFICE OF THE JUDGE OF PROBATE OF THE COUNTY WHERE THE ABOVE-DESCRIBED PROPERTY IS SITUATED. THIS PROPERTY WILL BE SOLD WITHOUT WARRANTY OR RECOURSE, EXPRESSED OR IMPLIED AS TO TITLE, USE AND/OR ENJOYMENT AND WILL BE SOLD SUBJECT TO THE RIGHT OF REDEMPTION OF ALL PARTIES ENTITLED THERETO.
Alabama law gives some persons who have an interest in property the right to redeem the property under certain circumstances. Programs may also exist that help persons avoid or delay the foreclosure process. An attorney should be consulted to help you understand these rights and programs as a part of the foreclosure process.
This sale is made for the purpose of paying the indebtedness secured by said mortgage, as well as the expenses of foreclosure.
The successful bidder must tender a non-refundable deposit of Five Thousand Dollars ($5,000.00) in certified funds made payable to Sirote & Permutt, P.C. at the time and place of the sale. The balance of the purchase price must be paid in certified funds by noon the next business day at the Law Office of Sirote & Permutt, P.C. at the address indicated below. Sirote & Permutt, P.C. reserves the right to award the bid to the next highest bidder should the highest bidder fail to timely tender the total amount due.
The Mortgagee/Transferee reserves the right to bid for and purchase the real estate and to credit its purchase price against the expenses of sale and the indebtedness secured by the real estate.
This sale is subject to postponement or cancellation.
U.S. Bank Trust, N.A., as Trustee for LSF9 Master Participation Trust,
Mortgagee/Transferee
Elizabeth Loefgren
SIROTE & PERMUTT, P.C.
P. O. Box 55727
Birmingham, AL 35255-5727
Attorney for Mortgagee/Transferee
www.sirote.com/foreclosures
399252
Huntsville Times: February 9, 16, 23, 2018

MORTGAGE FORECLOSURE SALE

Default having been made in the payment of the indebtedness secured by that certain mortgage executed by Juan R. Garcia and Ofelia Garcia, husband and wife, originally in favor of Mortgage Electronic Registration Systems, Inc., as nominee for Cherry Creek Mortgage Co., Inc., on the 19th day of August, 2003, said mortgage recorded in the Office of the Judge of Probate of Madison County, Alabama, in Book 3468 Page 0935; the undersigned Bank of America, N.A., as Mortgagee/Transferee, under and by virtue of the power of sale contained in said mortgage, will sell at public outcry to the highest bidder for cash, in front of the main entrance of the Courthouse at Huntsville, Madison County, Alabama, on April 13, 2018, during the legal hours of sale, all of its right, title, and interest in and to the following described real estate, situated in Madison County, Alabama, to-wit:
Lot 5, Block 1, according to the Map of Survey of Quail Ridge, Huntsville, Alabama, as recorded in Plat Book 31, at Page 21, in the Office of Judge of Probate of Madison County, Alabama.
Property street address for informational purposes: 2515 Quail Ridge Ln Sw , Huntsville, AL 35803
THIS PROPERTY WILL BE SOLD ON AN "AS IS, WHERE IS" BASIS, SUBJECT TO ANY EASEMENTS, ENCUMBRANCES, AND EXCEPTIONS REFLECTED IN THE MORTGAGE AND THOSE CONTAINED IN THE RECORDS OF THE OFFICE OF THE JUDGE OF PROBATE OF THE COUNTY WHERE THE ABOVE-DESCRIBED PROPERTY IS SITUATED. THIS PROPERTY WILL BE SOLD WITHOUT WARRANTY OR RECOURSE, EXPRESSED OR IMPLIED AS TO TITLE, USE AND/OR ENJOYMENT AND WILL BE SOLD SUBJECT TO THE RIGHT OF REDEMPTION OF ALL PARTIES ENTITLED THERETO.
Alabama law gives some persons who have an interest in property the right to redeem the property under certain circumstances. Programs may also exist that help persons avoid or delay the foreclosure process. An attorney should be consulted to help you understand these rights and programs as a part of the foreclosure process.
This sale is made for the purpose of paying the indebtedness secured by said mortgage, as well as the expenses of foreclosure.
The successful bidder must tender a non-refundable deposit of Five Thousand Dollars ($5,000.00) in certified funds made payable to Sirote & Permutt, P.C. at the time and place of the sale. The balance of the purchase price must be paid in certified funds by noon the next business day at the Law Office of Sirote & Permutt, P.C. at the address indicated below. Sirote & Permutt, P.C reserves the right to award the bid to the next highest bidder should the highest bidder fail to timely tender the total amount due.
The Mortgagee/Transferee reserves the right to bid for and purchase the real estate and to credit its purchase price against the expenses of sale and the indebtedness secured by the real estate.
This sale is subject to postponement or cancellation.
Bank of America, N.A.,
Mortgagee/Transferee
Pam King
SIROTE & PERMUTT, P.C.
P. O. Box 55727
Birmingham, AL 35255-5727
Attorney for Mortgagee/Transferee
www.sirote.com/foreclosures
429422
Huntsville Times: February 2, 9, 16, 2018

MORTGAGE FORECLOSURE SALE

Default having been made in the payment of the indebtedness secured by that certain mortgage executed by Robert G. Benton and Tiril D. Benton, married, originally in favor of Wachovia Bank, National Association, on the 23rd day of May, 2005, said mortgage recorded in the Office of the Judge of Probate of Madison County, Alabama, in Instrument Number 20050624000410730; the undersigned Wells Fargo Bank, N.A., successor by merger to Wachovia Bank, N.A., as Mortgagee/Transferee, under and by virtue of the power of sale contained in said mortgage, will sell at public outcry to the highest bidder for cash, in front of the main entrance of the Courthouse at Huntsville, Madison County, Alabama, on March 23, 2018, during the legal hours of sale, all of its right, title, and interest in and to the following described real estate, situated in Madison County, Alabama, to-wit:
All that certain property situated in the City of Huntsville in the County of Madison and State of Alabama and being described in a Deed Dated 01/17/2001 and Recorded 01/18/2001 in Book 986 Page among the Land Records If the County and State set forth above and referenced as follows: Planned Unit Development: Timber Ridge Recorded Date: 08/21/1987 Book: 700 Page: 802 Parcel ID Number: 23-0-5-16-2-002-017.000
Property street address for informational purposes: 1305 Ryefield Pl, Huntsville, AL 35803
THIS PROPERTY WILL BE SOLD ON AN "AS IS, WHERE IS" BASIS, SUBJECT TO ANY EASEMENTS, ENCUMBRANCES, AND EXCEPTIONS REFLECTED IN THE MORTGAGE AND THOSE CONTAINED IN THE RECORDS OF THE OFFICE OF THE JUDGE OF PROBATE OF THE COUNTY WHERE THE ABOVE-DESCRIBED PROPERTY IS SITUATED. THIS PROPERTY WILL BE SOLD WITHOUT WARRANTY OR RECOURSE, EXPRESSED OR IMPLIED AS TO TITLE, USE AND/OR ENJOYMENT AND WILL BE SOLD SUBJECT TO THE RIGHT OF REDEMPTION OF ALL PARTIES ENTITLED THERETO.
Alabama law gives some persons who have an interest in property the right to redeem the property under certain circumstances. Programs may also exist that help persons avoid or delay the foreclosure process. An attorney should be consulted to help you understand these rights and programs as a part of the foreclosure process.
This sale is made for the purpose of paying the indebtedness secured by said mortgage, as well as the expenses of foreclosure.
The successful bidder must tender a non-refundable deposit of Five Thousand Dollars ($5,000.00) in certified funds made payable to Sirote & Permutt, P.C. at the time and place of the sale. The balance of the purchase price must be paid in certified funds by noon the next business day at the Law Office of Sirote & Permutt, P.C. at the address indicated below. Sirote & Permutt, P.C. reserves the right to award the bid to the next highest bidder should the highest bidder fail to timely tender the total amount due.
The Mortgagee/Transferee reserves the right to bid for and purchase the real estate and to credit its purchase price against the expenses of sale and the indebtedness secured by the real estate.
This sale is subject to postponement or cancellation.
Wells Fargo Bank, N.A., successor by merger to Wachovia Bank, N.A.,
Mortgagee/Transferee
Ginny Rutledge
SIROTE & PERMUTT, P.C.
P. O. Box 55727
Birmingham, AL 35255-5727
Attorney for Mortgagee/Transferee
www.sirote.com/foreclosures
428076
Huntsville Times: February 9, 16, 23, 2018

MORTGAGE FORECLOSURE SALE

Default having been made in the payment of the indebtedness secured by that certain mortgage executed by Rosemarie Hilson, an unmarried woman, originally in favor of Mortgage Electronic Registration systems, Inc., as nominee for Residential Finance Corporation, on the 30th day of June, 2010, said mortgage recorded in the Office of the Judge of Probate of Madison County, Alabama, in Instrument Number 20100713000382340; the undersigned Wells Fargo Bank, N.A., as Mortgagee/Transferee, under and by virtue of the power of sale contained in said mortgage, will sell at public outcry to the highest bidder for cash, in front of the main entrance of the Courthouse at Huntsville, Madison County, Alabama, on April 13, 2018, during the legal hours of sale, all of its right, title, and interest in and to the following described real estate, situated in Madison County, Alabama, to-wit:
Lot 205, according to the Plat of Survey of Bainbridge Phase Three, a resubdivision of Tract B1, Phase Two (Recorded in Document No. 20051220000852700), a resubdivision of Tract B of Bainbridge Phase One (Recorded in Document Number 20041015000438130), as recorded in Document Number 20070316000189600, in the Office of the Judge of Probate of Madison County, Alabama.
Property street address for informational purposes: 145 Olympia Dr, Meridianville, AL 35759
THIS PROPERTY WILL BE SOLD ON AN "AS IS, WHERE IS" BASIS, SUBJECT TO ANY EASEMENTS, ENCUMBRANCES, AND EXCEPTIONS REFLECTED IN THE MORTGAGE AND THOSE CONTAINED IN THE RECORDS OF THE OFFICE OF THE JUDGE OF PROBATE OF THE COUNTY WHERE THE ABOVE-DESCRIBED PROPERTY IS SITUATED. THIS PROPERTY WILL BE SOLD WITHOUT WARRANTY OR RECOURSE, EXPRESSED OR IMPLIED AS TO TITLE, USE AND/OR ENJOYMENT AND WILL BE SOLD SUBJECT TO THE RIGHT OF REDEMPTION OF ALL PARTIES ENTITLED THERETO.
Alabama law gives some persons who have an interest in property the right to redeem the property under certain circumstances. Programs may also exist that help persons avoid or delay the foreclosure process. An attorney should be consulted to help you understand these rights and programs as a part of the foreclosure process.
This sale is made for the purpose of paying the indebtedness secured by said mortgage, as well as the expenses of foreclosure.
The successful bidder must tender a non-refundable deposit of Five Thousand Dollars ($5,000.00) in certified funds made payable to Sirote & Permutt, P.C. at the time and place of the sale. The balance of the purchase price must be paid in certified funds by noon the next business day at the Law Office of Sirote & Permutt, P.C. at the address indicated below. Sirote & Permutt, P.C. reserves the right to award the bid to the next highest bidder should the highest bidder fail to timely tender the total amount due.
The Mortgagee/Transferee reserves the right to bid for and purchase the real estate and to credit its purchase price against the expenses of sale and the indebtedness secured by the real estate.
This sale is subject to postponement or cancellation.
Wells Fargo Bank, N.A.,
Mortgagee/Transferee
Ginny Rutledge
SIROTE & PERMUTT, P.C.
P. O. Box 55727
Birmingham, AL 35255-5727
Attorney for Mortgagee/Transferee
www.sirote.com/foreclosures
429303
Huntsville Times: February 2, 9, 16, 2018

MORTGAGE FORECLOSURE SALE

Default having been made in the payment of the indebtedness secured by that certain mortgage executed by Stuart F. Trapp, a single man, originally in favor of Chase Manhattan Mortgage Corporation, on the 20th day of August, 2004, said mortgage recorded in the Office of the Judge of Probate of Madison County, Alabama, in Instrument Number 20040825000325390; the undersigned U.S. Bank National Association, as Trustee For J.P. Morgan Mortgage Trust 2004-S2, Mortgage Pass-Through Certificates, as Mortgagee/Transferee, under and by virtue of the power of sale contained in said mortgage, will sell at public outcry to the highest bidder for cash, in front of the main entrance of the Courthouse at Huntsville, Madison County, Alabama, on March 9, 2018, during the legal hours of sale, all of its right, title, and interest in and to the following described real estate, situated in Madison County, Alabama, to-wit:
Lot 10, Block 2, Sunset Cove, 4th Addition, according to the plat of said subdivision recorded in the Office of the Judge of Probate of Madison County, Alabama, in Plat Book 3, Page 71.
Property street address for informational purposes: 9302 Grandfield Ln Se , Huntsville, AL 35803
THIS PROPERTY WILL BE SOLD ON AN "AS IS, WHERE IS" BASIS, SUBJECT TO ANY EASEMENTS, ENCUMBRANCES, AND EXCEPTIONS REFLECTED IN THE MORTGAGE AND THOSE CONTAINED IN THE RECORDS OF THE OFFICE OF THE JUDGE OF PROBATE OF THE COUNTY WHERE THE ABOVE-DESCRIBED PROPERTY IS SITUATED. THIS PROPERTY WILL BE SOLD WITHOUT WARRANTY OR RECOURSE, EXPRESSED OR IMPLIED AS TO TITLE, USE AND/OR ENJOYMENT AND WILL BE SOLD SUBJECT TO THE RIGHT OF REDEMPTION OF ALL PARTIES ENTITLED THERETO.

LEGALS LEGALS LEGALS

Public Notice

TVA

Tennessee Valley Authority 2019 Integrated Resource Plan

TVA is beginning work on the 2019 Integrated Resource Plan (IRP) – a comprehensive study that provides direction on how to best meet future electricity demand in the region. Building upon the work done in prior plans, TVA is starting the 2019 IRP to proactively address the changing energy marketplace and to better understand the impact and benefit of system flexibility with increased renewable and distributed (dispersed) energy resources.

The IRP will consider a variety of future conditions to determine how TVA can continue to fulfill its commitment to provide low-cost, reliable energy; environmental stewardship; and regional economic development over the next 20 years. TVA will analyze the potential social-economic and natural environmental effects of the energy scenarios under consideration in a programmatic environmental impact statement (EIS).

Engagement with customers and stakeholders is a vital part of developing the IRP and EIS. As in the 2015 IRP, TVA will host multiple public engagement opportunities, as well as collaborate with an IRP working group and the TVA Regional Energy Resource Council.

Public comment is invited concerning both the scope of the IRP/EIS and environmental issues that should be addressed.

A 60-day public scoping period runs from Feb. 15, to April 16, 2018. You can provide input at our IRP website www.tva.gov/irp, email or post comments to the addresses below, or submit comments in writing at the scoping meetings.

Public Involvement Meeting Calendar

February 21, 11 a.m.-noon EST. Webinar. If attending, please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329.

February 27, 5:30-7 p.m. EST. Educational open house at the Westin, Chattanooga, Tennessee.

March 5, 5:30-7 p.m. CST. Educational open house, Memphis Light Gas & Water Auditorium, 220 S. Main St., Memphis, Tennessee. (Validated parking provided at garage across the street.)

Those who have special needs who wish to attend the meetings need to contact TVA at least a week in advance at 1-865-632-6113.

For more information about the IRP study contact:

Hunter Hydas
Enterprise Planning
1101 Market St.
Chattanooga, TN 37402

Ashley Pilakowski
NEPA Project Manager
400 W. Summit Hill Drive, WT 11D
Knoxville, TN 37902

Amy Henry
Enterprise Relations and Innovation
400 West Summit Hill Drive, WT 9D
Knoxville, TN 37902

IRP@tva.gov

7605 18-1878

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Chattanooga, TN 37402

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NEPA Project Manager
400 W. Summit Hill Drive, WT 11D
Knoxville, TN 37902

Amy Henry
Enterprise Relations and Innovation
400 West Summit Hill Drive, WT 9D
Knoxville, TN 37902

IRP@tva.gov

90149-1

JOB OPENING!!! PILGRIM'S PRIDE

Lookout Valley, TN

Feed Mill Supervisor 2nd Shift

GENERAL SUMMARY

Oversee all activities and maintenance of a feed mill facility.

- Monitor feed sampling
- Monitor preventive maintenance activities to ensure equipment and machinery are functioning properly
- Complete all paperwork and reports associated with mill
- Match feed delivery tickets

BASIC SKILLS & QUALIFICATIONS:

- 2 or more years of previous Supervisory experience.
- Poultry or food industry experiences a plus.
- Previous leadership skills with 20 or more employees.
- Must have basic computer knowledge.

EDUCATIONAL REQUIREMENTS:

High School Diploma/GED; College Degree in related field preferred.

For more information and to apply visit
http://pilgrims.com/contact-us/careers.aspx and go to careers.

EOE/M/F/Vet/Disabled

Pilgrim's

90081-1

ANTIQUES

TN Department of Mental Health & Substance Abuse Services

MOCCASIN BEND MENTAL HEALTH INSTITUTE

If you are looking for a dynamic work environment where employees are valued and encouraged to grow, then MBMHI is the right place for you!

- PSYCH TECHS
- PSYCHIATRIC SOCIAL WORKER I & II
- REGISTERED NURSE II
- LICENSED PRACTICAL NURSE II
- NURSE PRACTITIONER
- RECREATIONAL THERAPIST
- CUSTODIAL WORKER
- FOOD SERVICE WORKER
- HOUSEKEEPING

Apply in person Monday - Friday 10am-4pm at
100 Moccasin Bend Rd., Chattanooga,
Call Human Resources at 423-265-2271 or
apply on-line 24/7 at www.moccasinbendmhijobs.com

The State of Tennessee is an Equal Opportunity, Equal Access, and Affirmative Action Employer.
An Accredited Psychiatric Facility.

89697-1

APPLIANCES

STOVES AND REFRIGERATORS: Washer & Dryer $199 set.All Guaranteed. Call 423-432-4581.

WASHER: Very good shape. $100. Call 423-531-0596.

WASHERS & DRYER: Whirlpool works perfect. Can deliver. $95 each. Call 423-227-1518.

BABY ITEMS

BABY BED: new Mattress cover, good cond. $45. Call 706-375-3285.

BABY STROLLER: Grayco, like brand new, $50. Call 423-596-1874.

BUILDING MATERIAL

OFFICE CUBICLES: 9 lockable fitted units, by Herman Miller. Convert vacant space into 9 lockable offices. Cost $85K. $14,750. 423-899-4257.

POLE BARN: 24x36 10' ceiling height, Wood trusses, metal roof. $4200. Other sizes and close in options available. Call 423-595-2079.

PORCELAIN TILE: 320 sq. ft. $100. 8ft. Shelving, oak finish, $9.95 per sheet. Call 423-718-4629.

CLOTHING

LADIES CLOTHES: Blouses, sweaters, jackets, M/L/XL. $4/up. 596-1874.

SWEATSHIRTS: Green Bay, Heavy, $89. Call 423-400-7376.

WEDDING DRESS: Off White, size 6-8, $45 obo. Call 423-284-3044.

COINS-JEWELRY

BEAUTIFUL FINE JEWELRY: at discount prices. No interest layaway plan. Olde Towne Antiques 3973 Hixson Pike, . Call 423-886-1611

COLLECTIBLES

CA$H FOR COMICS: murfcomics@hotmail.com. $1, Call 423-838-9289

MISTER MIRACLE #1 FINE: 1971 **HOT COMIC**. $55, 423-838-9289

PLAYBOY MAGAZINES: 2002 thru 2016. $150, OBO Call 954-347-4677

ZAP COMIX #0,1,2,3 +3MORE: **RARE**. $75, OBO 423-838-9289

COMPUTERS

LAPTOP: Lenovo Or Dell WIN 10. $125, OBO Call 423-802-9130

USED OFFICE EQUIPMENT: Conference Table, 6 drawer file-Dell computers. Commercial copy/fax. Metal Desks.. OBO Call 423-421-4846

FLEA MARKETS

I-24 FLEA MARKET:
Sat.-Sun. Exit 134 on I-24.
Monteagle, TN. 931-235-6354.

I-59 INDOOR FLEA MARKET:
Exit 231, Sat & Sun, 8am-3pm CST. We buy Estate Sales. Mini Storage 10x20 $45 per month.
See Facebook.
Call 256-638-5907

FURNITURE

BOOKCASES : Two tall. 4 & 5 shelves. Both for. $75, 423-305-5691

BUNK BED: Futon as bottom bunk. $75,

FURNACES / FIREWOOD

NATURAL GAS HEATER: 80,000 btu w/blower, $75 obo. Call 423-718-3206.

GARAGE/YARD SALES

HIXSON, TN: 5808 Lake Resort Dr., Garage Sale. Sat. 2/17 9am-2pm. Hshld. items, furniture, patio set, baby equip., childrens & womens clothing. Also 2012 Toyota 4Runner.

MISCELLANEOUS

BEDSPREAD: Cannon, full size, pillow shams, $40 cash only. 706-937-3085.

BOOKS: Shuptrine, Jericho: The South Beheld/Home To Jericho . $80, OBO Call 423-886-1433

CHERISHED TEDDY COLLEC.: New in box.Cost $1000, . $135, 423-838-2226

CLOTHING FIXTURES: Slatwall Accessories, Hang Rail, . Call 423-505-7538

EASY CHAIR $40. Exercise Chair $40. Rollator $15. Toaster oven $10. Call 423-875-3957.

FIREPLACE DOORS: Glass NIB, 24" x 42". $125, OBO Call 954-347-4677

FORD TRACTOR MODEL 800: w/tiller & equip. . $4,000, OBO 423-332-2407

FREE CHERRY TREE: You remove. Call 423-400-7376.

FREE FIREWOOD:
Call 423-892-3196.

HEPPA AIR CLEANES: (2), $30 each. Call 706-891-6931.

MILITARY RELICS: German, Japanese, & American World War I&II. Pay top $$. Call 423-842-6020.

PEDAL CAR: JEFF GORDON good Condition. $125, OBO 954-347-4677

PIANO-UPRIGHT GRAND: Lovely! Rich Tone. $300, Call 423-356-4353

POSTER: Bill Fulmer. $100 obo. Call 423-400-7376.

QUILT: Handmade, patchwork, queen. $30 cash only. 706-937-3085.

QUILT: Twin/Full size. $20 cash only. Call 706-937-3085.

QUILTS: Fall & Christmas, full-queen, with shams, $35 each. 706-891-6931

SNOW BOARD/SLED: New, 4ft x 18in. Tags still on it.. $25, Call 423-838-2226

TANNING BED: Suntanner Pastport, 16 bulb, $150 obo. Call 423-413-3273.

RESTAURANT EQUIPMENT

PIZZA OVEN & ACCESSORIES : 2-3 Door Cooler, . Call 423-505-7538

SPORTS EQUIPMENT

AIRDYNE EXERCISE BIKE : Schwinn,Like NEW. $365, Call 423-838-2226

BOWFLEX TREADCLIMBER TC10: Like New. $300, Call 423-356-4353

ELECTRONICS

PA SYSTEM: Mackie 808M, 800w, w/ spkrs. $450, OBO Call 423-802-9130

SLIDE PROJECTOR: Kodak Ektagraphic AF-2, $75, 423-802-9130

SOUND EQUIPMENT: Yamaha 12 channel mixing board; mics; monitors; speakers. Asking $2400 for all or will separate. Call 423-667-4489.

WANTED TO BUY

MISTER BASEBALL: Buying sports cards and memorabilia. 203-557-0856; Cell: 203-767-2407.

SM XTRA CAB TRUCK: Must be Automatic. Call 423-436-9049

THE TN JUNK MAN: We will pick up your unwanted appliances. We will haul off any scrap metal. More than one appliance or scrap metal no charge. $10 for all single pickups. 256-504-7754; 423-400-7472.

We pay
$ CASH $

PETS

GOLDEN DOODLE PUPPIES. F1B, Adorable bundles of fur. Only 2 left out of a litter of 9. Vet checked, shots up to date. A must see for that special Valentine. Call 423-733-9252

Poodle: CKC, Purebred, cafe-au-lait, Female, 6 weeks, Adorable Female Purebred Poodle Puppy for sale. Registered, mama is 7# and papa is 10#. Born in our home, not a puppy farm. Avail immediately. Text for photos or video. $700. Contact me at jcraigsmith@epbfi.com or Call 423-645-2046

SHIHTZU PUPPIES-AKC, Beautiful colors. Shots UTD. $700 Warranty. 423-618-8038; 423-775-4016

YORKIE PUPS Full blooded. UTD on shots, no papers. $250/up each. Great gift for Valentine's Day. 423-582-2814

Yorkies CKC Reg. $800. Labradoodles. $500; Golden Retrievers, $800. AKC Reg. 931-319-0000

Yorkies. Tiny Tea Cups, 2lbs. M/F $650 each. Call 256-202-0341

FEED/SEED/PLANTS

HAY FOR SALE: Premium quality Timothy Hay plastic banded, 25"x17"x17" double compressed 60 lb square bales. Analysis & delivery available. Call for more information. Jarrot Moser 865-776-6031 or Ty Hodges 865-210-1775.

Find out all the latest real estate transactions in the Times Free Press classifieds.

LEGAL NOTICES

ABANDONED VEHICLE

To sell for fees owed. Sale date: March 2, 2018 @ 8:30 AM. To be held at 6714 Middle Valley Rd., Hixson, TN.
2004 Chevrolet Impala
VIN: 2G1WF52E649125698
Vehicle: 1992 Ford F-150
VIN: 1FTEX15N3NKA11744
Vehicle: 1996 Mercedes C220
VIN: WDBHA22E8TF340873

ADVERTISEMENT FOR BIDS

Project No. 15122
Town of Tracy City (Owner)

Separate sealed bids for Contract 118 (ECD) South Cumberland Learning Center Renovations for Building Renovations, including electrical, mechanical, plumbing, etc. will be received by Town of Tracy City at the office of Tracy City Town Hall, 50 Main Street, Tracy City, TN 37387 until 2:00 o'clock P.M., local time March 8, 2018, and then at said office publicly opened and read aloud.

The Information for Bidders, Form of Bid, Form of Contract, Plans, Specifications, and Forms of Bid Bond, Performance and Payment Bond, and other contract documents may be examined electronically at www.jchengr.com or at the following:

James C. Hailey & Company, 7518 Highway 70 South, Suite 100, Nashville, TN 37221

Tracy City Hall, 50 Main Street, Tracy City, TN 37387

If you choose to bid, CONTRACT BID DOCUMENTS may be obtained at the office of JAMES C. HAILEY & COMPANY, 7518 Highway 70 South, Suite 100, Nashville, TN 37221 upon a non-refundable payment of $50.00.

Paper copies of the PLANS and SPECIFICATIONS may be obtained upon a non-refundable payment of $200.00 per each set.

The owner reserves the right to waive any informalities or to reject any or all bids.

Each bidder must deposit with his bid, security in the amount, form and subject to the conditions provided in the Information for Bidders.

All bidders must be licensed General Contractors as required by the Contractor's Licensing Act of 1994 of the General Assembly of the State of Tennessee, and qualified for the type of construction being bid upon.

Attention of bidders is particularly called to the requirements as to conditions of employment to be observed and minimum wage rates to be paid under the contract, Section 3, Segregated Facility, Section 109 and E.O. 11246.

No bidder may withdraw his bid within 60 days after the actual date of the opening thereof.

Town of Tracy City is an equal opportunity provider and employer does not discriminate against or exclude any Bidder with respect to race, color, national origin, sex, age, or disability.

January 2018 (Date)
Larry Phipps, Mayor

INVITATION TO BID

Sealed Bids in Duplicate will be received

7605 18-1878

Continued from last column

and to J. PHILLIP JONES AND/OR JESSICA D. BINKLEY, either of whom may act, appointed as Substitute Trustee in an instrument of record in the Register's Office for DAVIDSON County, Tennessee, to secure the indebtedness described; the entire indebtedness having been declared due and payable by REGIONS BANK D/B/A REGIONS MORTGAGE, being the present owner/holder or authorized agent, designee or servicer of the holder/owner of said indebtedness, has requested foreclosure proceedings to be instituted; and as provided in said Deed of Trust, I, J. PHILLIP JONES/ JESSICA D. BINKLEY, will by virtue of the power and authority vested in me as Substitute Trustee, on THURSDAY, MARCH 15, 2018 AT 10:00 A.M., LOCAL TIME AT THE FRONT ENTRANCE OF THE HISTORIC DAVIDSON COUNTY COURTHOUSE, ONE PUBLIC SQUARE, NASHVILLE, DAVIDSON COUNTY, TENNESSEE, sell to the highest bidder for cash, free from the equity of redemption, homestead, and dower, and all other exemptions which are expressly waived, and subject to any unpaid taxes, if any, the following described property in DAVIDSON County, Tennessee, to wit:

PROPERTY LOCATED IN THE COUNTY OF DAVIDSON, TENNESSEE:

LAND IN DAVIDSON COUNTY, TENNESSEE, BEING LOT NO. 2, RESUBDIVISION OF LOT NO. 20 ON THE PLAN OF FAIRLANE PARK SUBDIVISION, OF RECORD IN PLAT BOOK 6900, PAGE 472, REGISTER'S OFFICE FOR DAVIDSON COUNTY, TENNESSEE, TO WHICH PLAN REFERENCE IS HEREBY MADE FOR A MORE COMPLETE DESCRIPTION THEREOF.

BEING THE SAME PROPERTY CONVEYED TO THE GRANTORS HEREIN BY DEED OF RECORD IN INSTRUMENT NO. 20161110-0119196, SAID REGISTER'S OFFICE.

ALSO BEING THE SAME PROPERTY CONVEYED TO JOSHUA COOLEY AND JESSICA NIXON, HUSBAND AND WIFE BY WARRANTY DEED DATED NOVEMBER 8, 2016, OF RECORD IN INSTRUMENT NO. 20161110-0119196

Continued from last column

THEM, AND THE SALE WILL BE SUBJECT TO ALL APPLICABLE GOVERNMENTAL ENTITIES RIGHT TO REDEEM THE PROPERTY, ALL AS REQUIRED BY 26 U.S.C. 7425, T.C.A. 67-1-1433, AND 28 U.S.C. 2410 (C). THE NOTICE REQUIREMENTS OF T.C.A. 35-5-101 ET SEQ. HAVE BEEN MET.

THE RIGHT IS RESERVED TO ADJOURN THE DAY OF THE SALE TO ANOTHER DAY, TIME AND PLACE CERTAIN WITHOUT FURTHER PUBLICATION, UPON ANNOUNCEMENT AT THE TIME AND PLACE FOR THE SALE SET FORTH ABOVE. THE TRUSTEE/SUBSTITUTE TRUSTEE RESERVES THE RIGHT TO RESCIND THE SALE

IF YOU PURCHASE A PROPERTY AT THE FORECLOSURE SALE, THE ENTIRE PURCHASE PRICE IS DUE AND PAYABLE AT THE CONCLUSION OF THE AUCTION IN THE FORM OF A CERTIFIED/BANK CHECK MADE PAYABLE TO OR ENDORSED TO LAW OFFICE OF J. PHILLIP JONES. NO PERSONAL CHECKS WILL BE ACCEPTED. TO THIS END, YOU MUST BRING SUFFICIENT FUNDS TO OUTBID THE LENDER AND ANY OTHER BIDDERS. INSUFFICIENT FUNDS WILL NOT BE ACCEPTED. AMOUNTS RECEIVED IN EXCESS OF THE WINNING BID WILL BE REFUNDED TO THE SUCCESSFUL PURCHASER AT THE TIME THE FORECLOSURE DEED IS DELIVERED.

OTHER INTERESTED PARTIES: NONE OF RECORD

THIS IS AN ATTEMPT TO COLLECT A DEBT AND ANY INFORMATION OBTAINED WILL BE USED FOR THAT PURPOSE.

This is improved property known as 349 STRASSER DRIVE, NASHVILLE, TN 37211.

J. PHILLIP JONES/ JESSICA D. BINKLEY, Substitute Trustee
1800 HAYES STREET
NASHVILLE, TN 37203
(615) 254-4430
www.phillipjoneslaw.com
www.auction.com
F18-0005
Run Dates: February 15, 22; March 1, 2018

Public Notices | Public Notices | Public Notices

Public Notice

TVA

Tennessee Valley Authority 2019 Integrated Resource Plan

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A 60-day public scoping period runs from Feb. 15, to April 16, 2018. You can provide input at our IRP website www.tva.gov/irp, email or post comments to the addresses below, or submit comments in writing at the scoping meetings.

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February 27, 5:30-7 p.m. EST. Educational open house at the Westin,

WE WANT TO HEAR FROM YOU

The Tennessee Valley Authority is kicking off its 2019 Integrated Resource Plan. It starts with us hearing what you want to make sure we include when assessing the region's energy future. The IRP is a comprehensive study that provides direction on how to best meet future electricity demand over the next 20 years – and includes an associated programmatic environmental impact statement.

Hearing from customers, residents and businesses is a vital part of developing the IRP. TVA is particularly interested in hearing from you!

A 60-day public scoping period runs from

Feb. 15 – Apr. 16, 2018.

Please join us at one of the following events:

- **February 21, 11 a.m. – noon EST.** Webinar. If attending, please register in advance of the meeting at https://attendee.gotowebinar.com/register/5507415649105603329.
- **February 27, 5:30 – 7 p.m. EST.** Educational open house at the Westin, Chattanooga, TN.
- **March 5, 5:30 – 7 p.m. CST.** Educational open house, Memphis Light Gas & Water Auditorium, 220 S. Main Street., Memphis, TN. (Validated parking provided at garage across the street.)

Those who have special needs who wish to attend the meeting need to contact TVA at least a week in advance at 1-865-632-6113.

Or

Provide input at the IRP website **www.tva.gov/irp**. Email **irp@tva.gov**.

Send comments to the address below:

Ashley Pilakowski, NEPA Project Manager, 400 West Summit Hill Dr., WT 11D Knoxville, TN 37902

TVA

18-1878 0218

Tennessee Valley Authority
400 West Summit Hill Dr. – WT 11D
Knoxville, TN 37902

C

Appendix C – Scoping Meeting Materials

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2019 INTEGRATED RESOURCE PLAN

Open House
February 27, 2018

About Today's Open House

- Welcome
- Brief Presentation at 5:45
- Open House for Conversation and to Provide Your Comments
- Concluding Remarks at 7

TVA

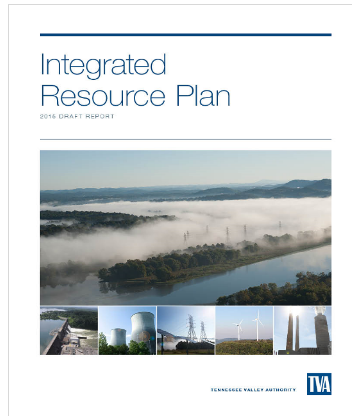
Welcome

Laura Campbell
Vice President, TVA Enterprise Planning

TVA's Integrated Resource Plan

The IRP is a study of how TVA could meet customer demands across a variety of future environments.

A programmatic Environmental Impact Statement (EIS) accompanies the IRP to analyze the impacts associated with an updated IRP to the Valley.



Utility Marketplace Is Changing Rapidly

An updated Integrated Resource Plan is needed:

- Proactively plan for the future
- Inform next long-range financial plan
- How might TVA continue to:
  - Provide low-cost, reliable electricity
  - Support environmental stewardship
  - Spur economic development

What Is Public Scoping?

- TVA periodically updates its power generation strategy. The first step is to understand the environment we're planning in. We call this scoping.
- We ask the general public, our customers, our partners and regulators about their concerns regarding the sources we use to generate power, how we manage demand and how we deliver power.
- With this information, we develop candidate resource plans that are evaluated for viability, socioeconomic and environmental impact.

IRP is a public process – stakeholder engagement is important

- IRP Working Group
- Regional Energy Resource Council
- Public meetings, webinars, listening sessions

2019 IRP Objective & Purpose

Brian Child
Enterprise Planning

Integrated Resource Planning

- Collaboration with stakeholders to envision the generation needs of the future
- Based on least-cost planning foundation
- Provides foundation for developing long-range financial plans
- Considers a number of potential futures to help predict changes in the marketplace

The IRP functions like a compass, not a GPS

Goals for an Optimal Resource Plan

- Low Cost
- Risk Informed
- Environmentally Responsible
- Reliable
- Diverse
- Flexible

Resource Planning Is About Solving Puzzles

By asking a lot of questions, like …

How much energy will our customers use in the future?

What alternatives do we have to meet our resource needs?

Are there strategic considerations that will limit the alternatives we can consider?

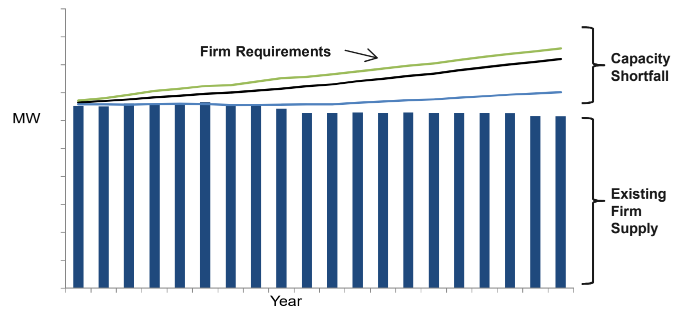
How do we properly evaluate these resource alternatives?

How do we find the best solution?

Resource Planning Addresses Future Capacity Needs

Resource planning is about optimizing the mix of future capacity.

Projections of capacity needed are filled by the most cost-effective resource.

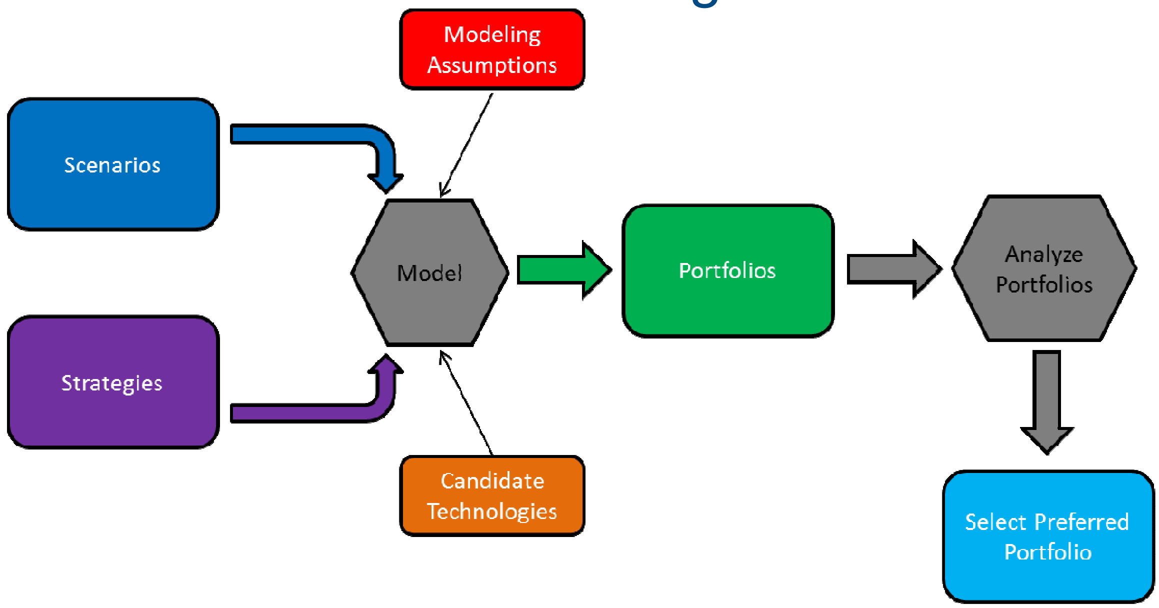


The TVA Resource Planning Process

Resource Planning is a common tool in the utility industry to identify the least cost solution to meet customer demand over a long horizon (usually 20 years)

- **Develop Load Forecast** – Project customer demand for electricity in the future
- **Define Existing Resources** – Define the resources currently available to meet customer demand and how that will change in the future
- **Establish Need for Resources** – Compare future customer demand with existing resources
- **Identify Resource Options** – Identify all resources (supply- and demand-side) that will be considered to meet future need
- **Analyze Portfolios** – Test different resource combinations (portfolios) to evaluate performance
- **Select Preferred Portfolio** – Select the preferred combination of resources

How the Resource Planning Process Works

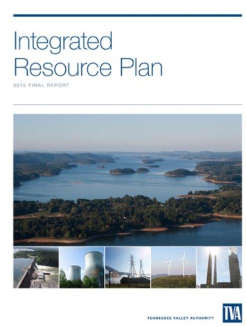


2015 IRP Recommendation

More . . .

- Energy efficiency & demand response
- Natural gas
- Renewables
- Nuclear uprates

- Less coal
- No new base load in the planning horizon after Watt Bar Unit 2 and nuclear uprates



TVA will provide reliable, affordable and sustainable power & strive for economic growth in the Valley

2019 IRP Focus Areas

- Distributed energy resources (DER)
- System flexibility
- Portfolio diversity

Defining the IRP

The IRP Will:

- Use least-cost planning criteria
- Incorporate resource capital and operating costs, fuel costs
- Include Valley economics as key criteria to evaluate strategies
- Evaluate socioeconomic impacts of alternative strategies
- Attempt to understand the speed of DER penetration in the Valley

The IRP Will Not:

- Establish wholesale or retail electricity rates
- Identify specific sites for new resources
- Be a Distributed Integrated Resource Plan (DIRP)

2019 IRP Schedule: Schedule & Milestones

The 2019 IRP Study Approach is intended to ensure transparency & enable stakeholder involvement

Winter/Spring 2018	*Spring 2018*	*Summer/Fall 2018*	*Winter/Spring 2019*	*Spring/Summer 2019*	*Summer 2019*
Scoping **	Develop Inputs & Framework	Analyze & Evaluate	Present Initial Results **	Incorporate Input	Identify Preferred Plan/Direction

(** indicates timing of Valley-wide public meetings)

Key Tasks/Milestones in this study timeline include:

- Establish stakeholder group and hold first meeting (Feb 2018)
- Initial modeling (June 2018)
- Publish draft EIS and IRP (Feb 2019)
- Complete public meetings (April 2019)
- Board approval and final publication of EIS and IRP (expected Summer 2019)

TVA

IRP Programmatic Environmental Impact Statement (EIS)

Ashley Pilakowski
NEPA Program

IRP Environmental Impact Statement - Purpose and Approach

- Determine environmental impacts system-wide
- Inform decision makers of potential impacts
- Provide public involvement

Analyze Key Environmental Factors

- The EIS will assess broad system-wide impacts of a new IRP on environmental factors such as:
  - Air quality
  - Water resources
  - Fuel requirements
  - Waste production
  - Land requirements
  - Socioeconomics

EIS Process

Winter/Spring 2018	Summer/Fall 2018	Winter/Spring 2019	Spring/Summer 2019	Summer 2019	Summer 2019
Public Scoping	Prepare Draft EIS	**Public Review Draft EIS**	Prepare Final EIS	Issue Final EIS	Issue Record of Decision

Open House

TVA representatives are available for questions.

Please provide comments electronicall or by writing on comment cards.

Wrap-Up

Jo Anne Lavender

We Want Your Input

How you can comment on the IRP Scoping:

- In person at any of the public open houses
- Use the online IRP comment form at www.tva.gov/irp
- Email your comment to irp@tva.gov
- Mail written comments to:

  Ashley Pilakowski
  400 W Summit Hill Dr., WT 11D
  Knoxville, TN 37902

Opportunities to Stay Involved

- Submit comments during the scoping period, which ends April 16, 2018
- Quarterly Public Update Webinars
- TVA Website www.tva.gov/irp
- Make comments on the Draft IRP and Draft EIS, expected to be available in early 2019

For information and to comment:

www.tva.gov/irp

Provide TVA your comments on the 2019 IRP.

Tennessee Valley Authority
400 West Summit Hill Dr. – WT 11D
Knoxville, TN 37902

TVA INTEGRATED Resource Plan 2019

Public Meeting Sign-In Sheet

2019 Integrated Resource Plan and Environmental Impact Statement (EIS)

February 27, 2018
5:30-7:00 p.m.

Name	Organization	Mailing Address	Email	Add to Mailing List
Rick BENDER	KY EEC	300 Sower Blvd. Frankfort KY	rick.bender@ky.gov	
Laura Schepis	PACE	8409 Lee Hwy #2547 Merrifield VA 22116	laura@energyfairness.org	
Marcos Ayala	TVA Planning	1351 Passenger St Chatt, TN 37408	maayalazelaya@tva.gov	
William (Bill) Copeland	EPB	10. W MLK Blvd, Chatt, TN 37405	copelandwe@epb.net	✓
Paul Rund	NGEMC	1850 Cleveland Hwy Dalton	prund@ngemc.com	
Dave Flessner	Chattanooga Times Free Press	400 E. 11th St. Chattanooga	dflessner@timesfreepress.com	✓
* Michael Walton	green/spaces	63 E Main St Chattanooga TN 37408	michael@greenspaceschattanooga.org	
Susan Jacks	TVA	←	EE IX	
Al Armendariz	Sierra Club	PO Box 829, Lithia FL 33547	al.armendariz@sierraclub.org	
Randy Johnson	Johnson Energy Solutions	923 Fairway Lane Soddy Daisy, TN 37379	randy@jenergysolutions.com	

Thank you for your interest and participation!

TVA INTEGRATED Resource Plan 2019

Public Meeting Sign-in Sheet

2019 Integrated Resource Plan and
Environmental Impact Statement (EIS)

February 27, 2018
5:30-7:00 p.m.

Name	Organization	Mailing Address	Email	Add to Mailing List
Richard Holland	Tenn Paper Canal	IRP WG		

Thank you for your interest and participation!

TVA INTEGRATED Resource Plan 2019

Public Meeting Sign-in Sheet

2019 Integrated Resource Plan and Environmental Impact Statement (EIS)

March 5, 2018
5:30-7:00 p.m.

Name	Organization	Mailing Address	Email	Add to Mailing List
Angela Garrone	SACE	1735 Carruthers Pl, Mem, TN 38112	angela@cleanenergy.org	✓
[illegible]	[illegible]	220 S. [illegible] 38103	[illegible]	
Lynn Strickland	Sierra Club	lynnstricc@bellsouth.net	4728 Spottswood 38117	✓
David Lifting	North American Coal		dave.lifting@nacoal.com	
Tom Charlier	The Commercial Appeal		thomas.charlier@commercialappeal.com	
Aulton Green	TVA	50 N. Front St 38103	ajgreen@tva.gov	
SHANA WOODS	TVA		slwoods@tva.gov	
Sandra Upchurch	NAACP	sandraupchurch3gmail.com		

Thank you for your interest and participation!

TVA INTEGRATED Resource Plan 2019

Public Meeting Sign-in Sheet

2019 Integrated Resource Plan and Environmental Impact Statement (EIS)

March 5, 2018
5:30-7:00 p.m.

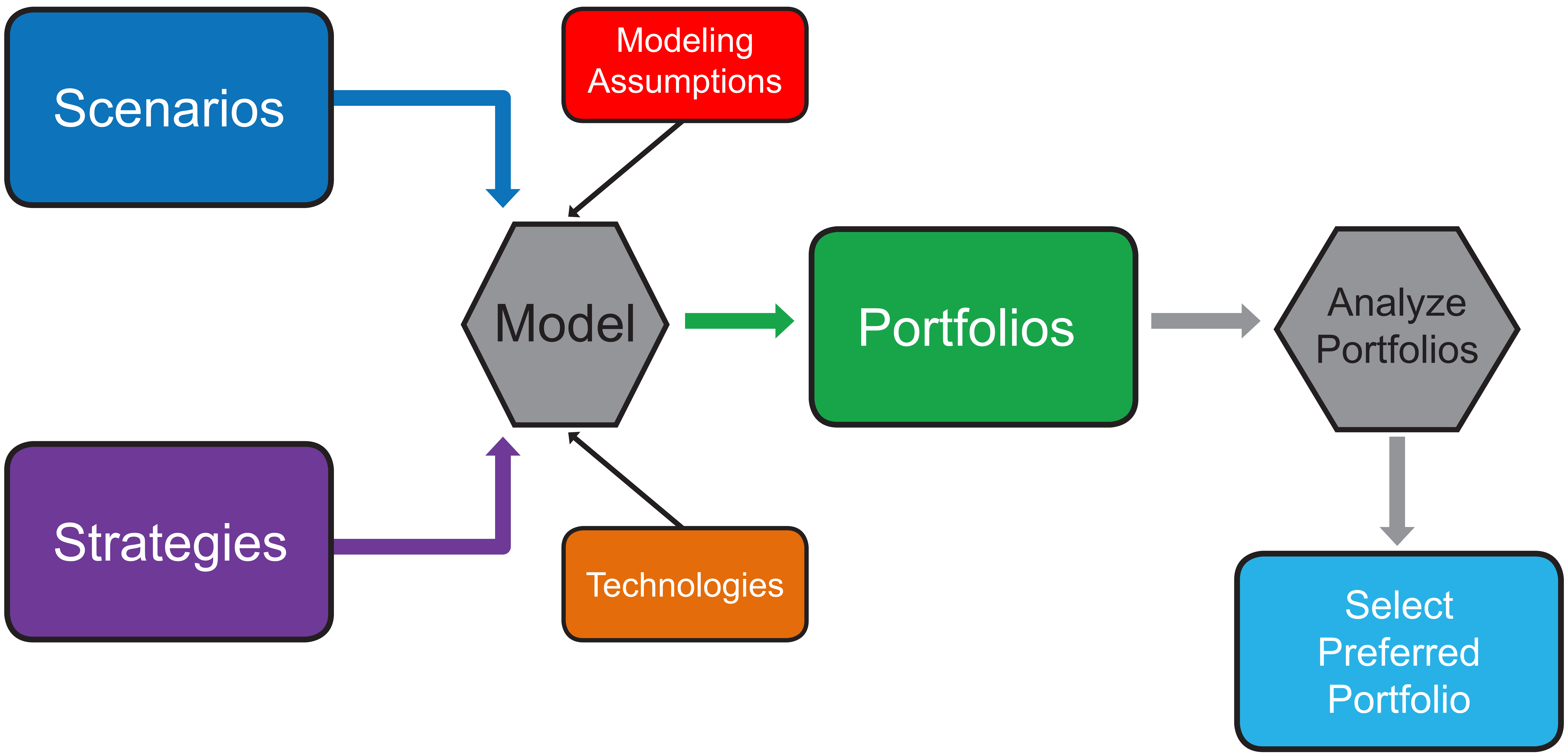
Name	Organization	Mailing Address	Email	Add to Mailing List
Alfred Dyson	DYSON ENGINEERING	3088 Mon Cherie Lane 38119	a-dyson@msn.com	✓
Chip Estes	Utilicom	P.O. Box 70 Flora, MS 39071	chipestes@gmail.com	✓
Dennis Lynch	Sierra Club			
James Stokes	Bass River Advisors		james.stokes@bassriveradvisors.com	
Abraham [illegible]	Energy Justice	3478 Barron Ave 3811[illegible]	[illegible]	✓
Suzanne C[illegible]	Innovate Memphis	516 Tennessee 82		

Thank you for your interest and participation!

Resource Plan Goals

Low Cost	Risk Informed	Environmentally Responsible
Reliable	Diverse	Flexible

How the Resource Planning Process Works



2019 IRP Focus Areas

- Distributed Energy Resources
- System Flexibility
- Portfolio Diversity

2019 IRP Schedule

The 2019 IRP Study Approach is intended to ensure transparency & enable stakeholder involvement

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Environmental Impact Statement Schedule

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D

Appendix D – Scoping Webinar Materials

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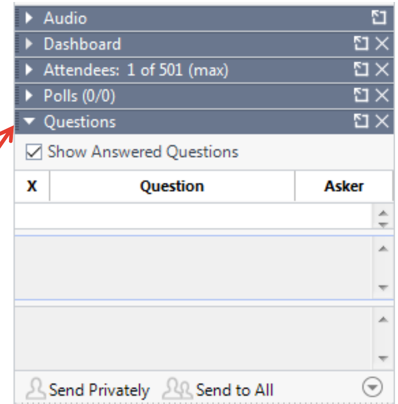
WEBINAR
Version

2019 INTEGRATED RESOURCE PLAN

Public Scoping Webinar
February 21, 2018

About Today's Meeting

- This a Webinar Meeting.
- **Participants** are in listen-only mode.
- Questions or comments **will be accepted during the webinar**; please use the question box to submit your questions or comments.
- This session is being recorded and will be available on the TVA 2019 IRP website.
- 2019 IRP website: www.tva.gov/IRP



Webinar Agenda

- **Webinar Kick Off and Logistics**
- **Welcome and Meeting Purpose**
- **Objective & Purpose of TVA's Integrated Resource Planning Study**
- **Overview of NEPA Process and about the PEIS**
- **Clarifying Questions from Audience and Comments**
- **Closing Remarks and How to Provide Comments**

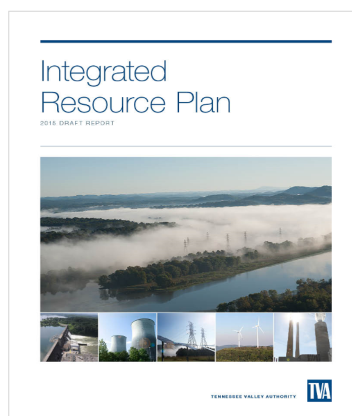
Welcome & Meeting Purpose

Laura Campbell
Vice President, TVA Enterprise Planning

TVA's Integrated Resource Plan

The IRP is a study of how TVA could meet customer demands across a variety of future environments

An Environmental Impact Statement (EIS) accompanies the IRP to address NEPA compliance



Utility Marketplace is Changing Rapidly

An updated Integrated Resource Plan is needed:

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- How might TVA continue our mission to:
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Brian Child
Enterprise Planning

Integrated Resource Planning

- Collaboration with stakeholders to envision the generation needs of the future
- Based on least-cost planning
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By asking a lot of questions, like …

How much energy will our customers use in the future?

What alternatives do we have to meet our resource needs?

Are there strategic considerations that will limit the alternatives we can consider?

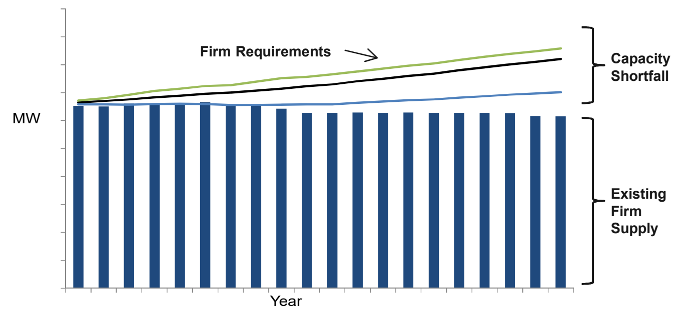
How do we properly evaluate these resource alternatives?

How do we find the best solution? Which plan (portfolio) do we select?

Resource Planning Addresses Future Capacity Needs

Resource planning is about optimizing the mix of future capacity.

Projections of capacity needed are filled by the most cost-effective resource.



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Resource Planning is a common tool in the utility industry to identify the least cost solution to meet customer demand over a long horizon (usually 20 years)

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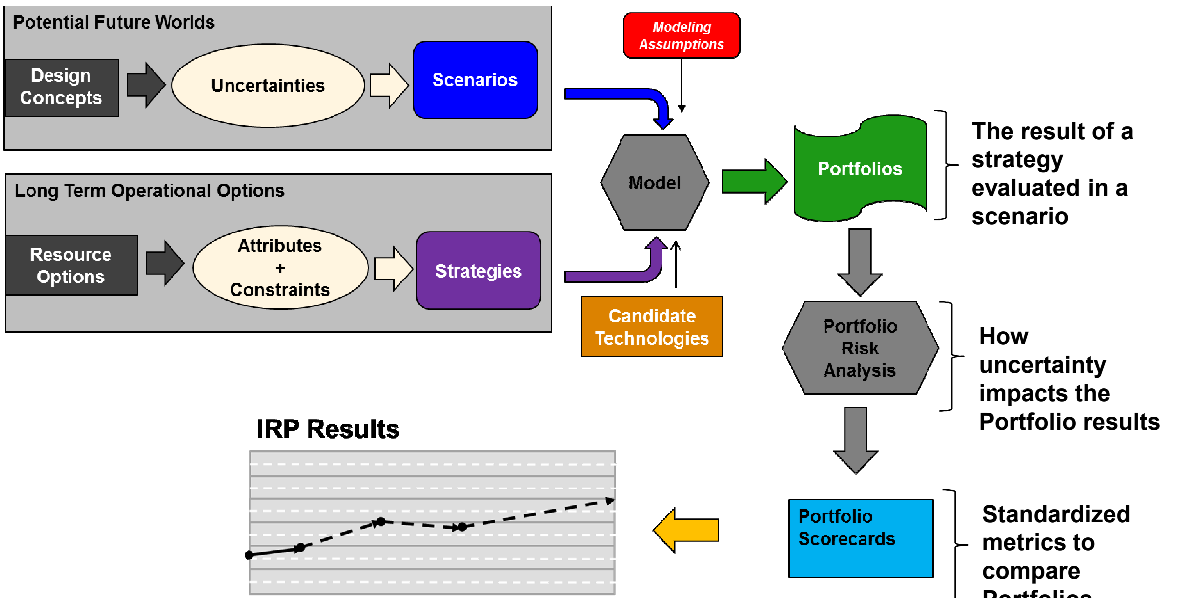
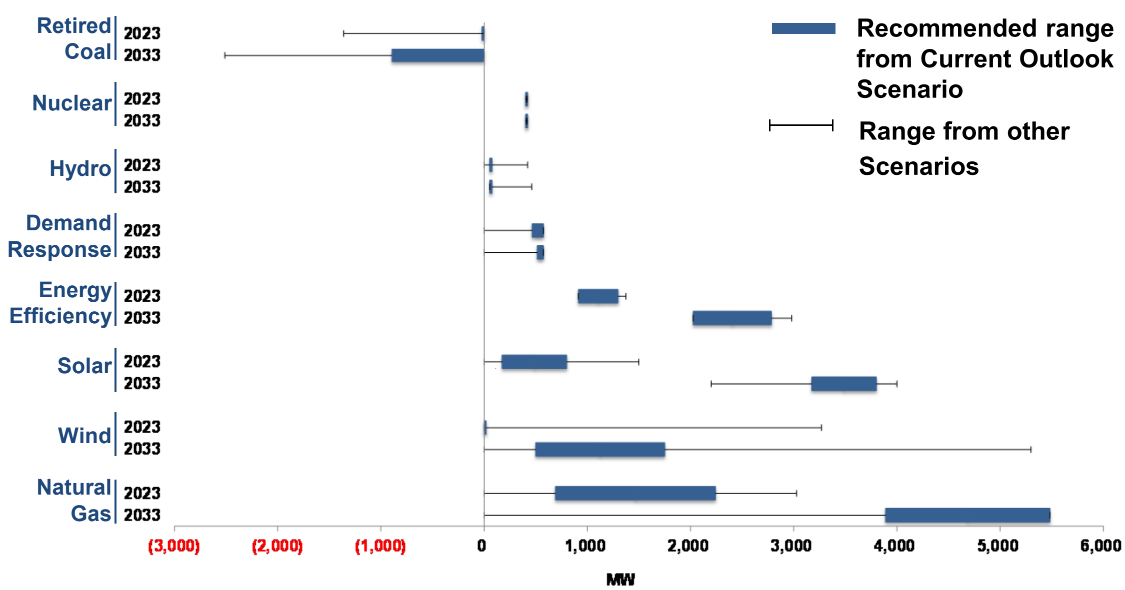
How the Resource Planning Process Works



2015 IRP Recommendation



MWs are incremental additions from 2014 forward. Board-approved coal retirements and natural gas additions as of August 2015 are excluded.

2019 IRP Focus Areas

- Distributed Energy Resources Modeling Refinement
- System flexibility with increasing DER
- Base load generation challenges

IRP Supports TVA's Long-Range Financial Plan

The IRP Will:

- Use least-cost planning criteria
- Incorporate resource capital and operating costs, fuel costs
- Include Valley economics as key criteria to evaluate strategies
- Evaluate socioeconomic impacts of alternative strategies
- Attempt to understand the speed of DER penetration in the Valley

The IRP Will Not:

- Establish wholesale or retail electricity rates
- Identify specific sites for new resources
- Be a Distribution Integrated Resource Plan (DIRP)

IRP is a public process – stakeholder engagement is important

- IRP Working Group
- Regional Energy Resource Council
- Public meetings, webinars, listening sessions

2019 IRP Schedule: Schedule & Milestones

The 2019 IRP Study Approach is intended to ensure transparency & enable stakeholder involvement

Fall 2017	*Winter/Spring 2018*	*Spring 2018*	*Summer/Fall 2018*	*Winter/Spring 2019*	*Spring/Summer 2019*	*Summer 2019*
Prep	Scoping **	Develop Inputs & Framework	Analyze & Evaluate	Present Initial Results **	Incorporate Input	Identify Preferred Plan/Direction

Public Engagement Period
(** indicates timing of Valley-wide public meetings)

Key Tasks/Milestones in this study timeline include:

- Establish stakeholder group and hold first meeting (Feb 2018)
- Complete first modeling runs (June 2018)
- Publish draft SEIS and IRP (Feb 2019)
- Complete public meetings (April 2019)
- Board approval and final publication of EIS and IRP (expected Summer 2019)

IRP Environmental Impact Statement (EIS)

Ashley Pilakowski
NEPA Specialist III

IRP EIS Purpose and Approach

- National Environmental Policy Act (NEPA)
- Decision-makers informed of environmental impacts
- Public involvement
- System-wide study of environmental impacts
- Subsequent site-specific studies

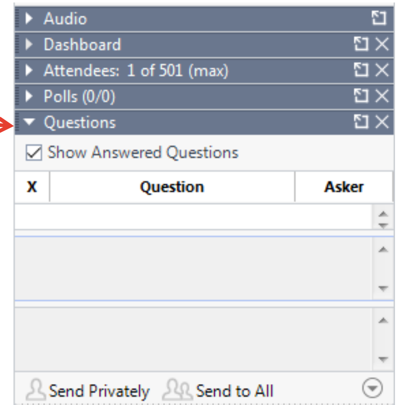
EIS Process

Analyze Key Environmental Factors

- The EIS will assess broad region-wide impacts of a new IRP on environmental factors such as:
  - Air quality
  - Water resources
  - Fuel requirements
  - Waste production
  - Land requirements
  - Socioeconomics

Clarifying Questions

- Use the ‘Question’ area of the webinar toolbar to ask clarifying questions or make comments



Wrap Up

Brian Child

Senior Manager, Long Range Financial Planning

Opportunities to Stay Involved

- Quarterly Public Update Webinars
- TVA Website www.tva.gov/irp
- Submit comments during the scoping period
- Make comments on the Draft Report, expected to be available in early 2019

TVA

Comment Period
February 15 – April 16, 2018

February 21 - Webinar, recorded version available at www.tva.gov/irp

February 27- Public Open House, 5:30pm - 7:00pm EST, Westin Hotel, Chattanooga, TN,

March 05 - Public Open House 5:30pm - 7:00pm CST, Memphis Light Gas & Water Auditorium, Memphis, TN,

TVA

We Want Your Input

How you can comment:

- Use the Question area to submit a comment during the Webinar today
- In person at any of the Public Open Houses
- Use the online IRP comment form at www.tva.gov/irp
- Email your comment to irp@tva.gov
- Mail written comments to:

  Ashley Pilakowski
  400 W Summit Hill Dr., WT 11D
  Knoxville, TN 37902

For information and to comment:

www.tva.gov/irp

Attendee Report: TVA 2019 Integrated Resource Plan Scoping Webinar

Report Generated:
2/21/18 12:14 PM EST

Webinar ID	Actual Start Date/Time	# Registered	Clicked Registration Link
969-483-611	1/18 10:29 AM E	93	212

Last Name	First Name	Registration Date/Time	Time in Session	Organization	Webinar Question 1	Webinar Question 2	Webinar Question 3	Webinar Question 4
Alexander	Bob	2/15/18 11:19 AM EST	45 minutes	NPDES Regulatory	Will the IRP or the EIS address any recommended changes to the Hydro discharges, specifically the "guaranteed" minimum reservoir flows?			
Ansary	Robbie	2/12/18 8:49 AM EST	46 minutes	TVA NE District				
Armendariz	Al	2/3/18 5:01 PM EST	49 minutes	Sierra Club				
Bailey	Brent	2/15/18 11:32 AM EST	46 minutes	25x'25 Alliance				
Baucom	Brad	2/12/18 8:07 AM EST	51 minutes	TVA				
Blank	Mike	2/21/18 11:39 AM EST	6 minutes	Peabody				
Boyd	Rodney	2/12/18 9:04 AM EST	29 minutes	McMinnville Electric System				
Brinkworth	Gary	2/21/18 8:51 AM EST	46 minutes	TVA				
Cleek	Rodney	2/21/18 8:46 AM EST	56 minutes	Memphis Light, Gas and Water Division				
Dyson	Alfred	2/15/18 12:08 PM EST	1 minute	Dyson Engineering & Technical Services				
Eckert	Steven	2/21/18 10:45 AM EST	60 minutes	Brookfield Renewable				
Emerson	Jill	2/16/18 11:57 AM EST	39 minutes	Paradoxe Corporation				
England	Brandon	2/21/18 8:47 AM EST	47 minutes	Pathway Lending				
Estes	Chip	2/14/18 1:52 AM EST	1 minute	Utilicom				
Farrell	Melanie	2/21/18 10:58 AM EST	48 minutes	TVA				
Flessner	Dave	2/20/18 9:36 PM EST	41 minutes	www.timesfreepress.com	What is the budget for the 2019 IRP?			
Gardner	Lindsay	2/21/18 10:58 AM EST	47 minutes	Mr.				
Garrett	Gary	2/10/18 10:01 AM EST	44 minutes	SSEB	Is there a representative of Georgia Interfaith Power & Light or the Southern States Energy Board involved in either the IRP Working Group or the Regional Energy Resource Council? a more general question would be how those groups are populated?			
Graham	Mike	2/20/18 6:24 PM EST	55 minutes	customer				
Greening	Lorna	2/15/18 11:18 AM EST	51 minutes	Howard Baker Center for Public Policy, University of Tennessee, Knoxville	How does TVA plan to evaluate resiliency in this IRP? How will resiliency be valued?	There is a difference between reliability and resilience. FERC is considering this question at the moment with respect to wholesale market rules.	Load forecasts by TVA have varied from increasing to declining by 13% in 2027. Is there a backcasting or verification protocol being used to improve the accuracy of your forecasts?	Your answer on considering resiliency implied you were placing the emphasis on resource adequacy. The transmission grid and the location of generation are more critical to analyzing this question. Are those issues excluded from the IRP?
Henrich	Greg	2/12/18 10:02 AM EST	20 minutes	TVA				
Higdon	Matthew	2/21/18 9:37 AM EST	24 minutes	TVA				
Hitchcock	Candyce	2/8/18 10:28 AM EST	35 minutes	TVA				
Hough	Gil	2/12/18 11:14 AM EST	46 minutes	TenneSEIA	What is the process for creating the IRP Working Group and who are the members?			
Houston	Shelby	2/12/18 3:43 PM EST	43 minutes	IPL/AES				
Jacob	Bryan	2/9/18 2:53 PM EST	53 minutes	Southern Alliance for Clean Energy				
Karnauch	Julia	2/12/18 9:46 AM EST	32 minutes	TVA				
Knisley	Brianna	2/21/18 10:59 AM EST	47 minutes	Appalachian Voices	Can you give a specific example of how public input influenced the last IRP?			
Lalley	John	2/7/18 9:08 AM EST	49 minutes	Mississippi Silicon				
Lanning	Joyce	2/18/18 10:46 PM EST	57 minutes	alternate for Energy Alabama				
Larson	Cass	2/21/18 9:33 AM EST	46 minutes	TVA				
Lee	Sharon	2/19/18 9:16 AM EST	54 minutes	Cantsink Manufacturing				
Levenshus	Jonathan	2/5/18 11:39 AM EST	47 minutes	Sierra Club				
Littlepage	Tom	2/21/18 10:25 AM EST	55 minutes	Alabama Office of Water Resources				
Mahan	Simon	2/7/18 10:19 AM EST	32 minutes	Southern Wind Energy Association	Will there be a review of how TVA has implemented the 2015 IRP?			
Mattheis	Pete	2/20/18 11:15 AM EST	50 minutes	TVIC				
Maynard	Jon	2/19/18 10:10 AM EST	50 minutes	Oxford-Lafayette County Economic				
McIntosh	JoAnn	2/16/18 5:20 PM EST	21 minutes	Sierra Club				
Minor	Wayne	2/20/18 5:45 PM EST	1 hour 1 minute	Go Green International, LLC				
Moghrabi	Amer	2/17/18 11:36 AM EST	12 minutes	Customer Delivery				
Nicholson	Charles	2/16/18 10:13 AM EST	50 minutes	HDR, Inc.				
Peek	Ray	2/16/18 8:40 AM EST	50 minutes	Individual				
Piper	Cortney	2/9/18 11:38 AM EST	49 minutes	TN Advanced Energy Business Council	How does TVA define customer?	How will comments, during this phase of the IRP process, be used? Are they used to draft the IRP?		
Pohnan	Heather	2/21/18 10:39 AM EST	1 hour 7 minutes	SACE				
Robbins	Deborah	2/20/18 3:16 PM EST	18 minutes	Piper Communications				
Roberts	Dustine	2/15/18 10:26 AM EST	21 minutes	TVA				
Ruhl	Grant	2/21/18 11:24 AM EST	22 minutes	TDEC				
Sauder	Marylee	2/20/18 8:57 AM EST	51 minutes	Sauder Ink				
Schepis	Laura	2/9/18 4:59 PM EST	46 minutes	Partnership for Affordable Clean Energy				
Schiller	Joe	2/21/18 10:59 AM EST	46 minutes	Austin Peay State University	Will the EIS consider the CO2 emmissions and global warming impacts of the various IRP scenarious. If so, how? Social Cost of carbon?	Given that diversification is an important goal of the IRP, will TVA set a standard for the relative quantity of renewables, which currently are the lowest portion of capacity, relative to natural gass and coal, which are the highest capacity?	Will distributed energy resources include small modular nucler reactors?	Will TVA revisit the issue of the "value of solar" as a strategy in the IRP in order to incentivize more DER implementation in the Valley?
Shelton	Glenn	2/20/18 6:59 PM EST	43 minutes	Lloyd's Electric Service, Inc.				

Shober	Maggie	2/13/18 9:41 AM EST	47 minutes	Navigant Consulting	What has TVA done to evaluate the resource planning processes and modeling used by other utilities across the country, and how or does that influence the process TVA plans to use for this IRP?			
Smith	Steve	2/21/18 10:59 AM EST	47 minutes	Southern Alliance for Clean Energy				
Stanton	Ryan	2/16/18 11:21 AM EST	54 minutes	Tennessee Department of Environment & Conservation	Where do electric vehicles and associated charging infrastructure fall within the IRP?			
Strickland	Lynn	2/15/18 2:10 PM EST	43 minutes	Stricckland Consulting	How will the IRP address local issues such as the Memphis acquifer?			
Stump	Kenya	2/12/18 9:01 AM EST	27 minutes	EEC				
Talley	James	2/15/18 11:33 AM EST	55 minutes	Hannah Solar				
Wade	Blair	2/21/18 10:57 AM EST	48 minutes	HDR Inc.				
Warmack	Joshua	2/21/18 9:29 AM EST	38 minutes	EnerVision, Inc.				
Weiss	Ira	2/15/18 10:42 AM EST	38 minutes	WeissAssociates				
Wiggins	Kenny	2/12/18 9:40 AM EST	1 hour 17 minutes	City of Alcoa				
Williamson	Becky	2/12/18 10:26 AM EST	56 minutes	MLGW				
Willis	Phillip	2/20/18 7:32 AM EST	54 minutes	private citizen				
Wilson	John	2/20/18 4:12 PM EST	47 minutes	Southern Alliance for Clean Energy				
Wilson	Karen	2/2/18 4:57 PM EST	47 minutes	Kentucky Energy and Environment Cabinet				
barkenbus	Jack	2/14/18 11:23 AM EST	45 minutes	Vanderbilt University				
Begic	Alma	2/19/18 7:17 PM EST	--	HDR				
Bermel	Colby	2/20/18 6:56 PM EST	--	S&P Global				
Boyles	Glenn	2/12/18 4:46 PM EST	--	Decatur Utilities				
Brown	Chuck	2/12/18 9:37 AM EST	--	TVA				
Burnette	Robert	2/21/18 6:13 AM EST	--	TDEC DSWM				
Caviness	Samuel	2/12/18 8:52 AM EST	--	CD				
Cripps	Molly	2/9/18 10:57 AM EST	--	TDEC OEP				
Dutton	Laura	2/12/18 8:16 AM EST	--	Distributed Energy Resources				
Hutchinson	Pat	2/20/18 2:40 PM EST	--	Cantsink Manufacturing				
Levy	Stephen	2/20/18 4:36 PM EST	--	Tennessee Solar Energy Association				
Martinez	Christian	2/12/18 10:59 AM EST	--	First Solar				
McCall	Betsey	2/12/18 9:14 AM EST	--	TVPPA				
Moore	Elizabeth	2/15/18 10:45 AM EST	--	TVA				
Peters	Doug	2/9/18 9:59 AM EST	--	TVPA				
Peterson	Ernest	2/12/18 9:14 AM EST	--	Customer Delivery				
Quillen	Chris	2/12/18 10:28 AM EST	--	NE Customer Delivery				
Rogers	Joanna	2/12/18 7:44 PM EST	--	TVA - Customer Delivery (Alabama)				
Schmidt	Erik	2/20/18 4:25 PM EST	--	City of Chattanooga				
Scudder	Danette	2/12/18 8:08 AM EST	--	TVPPA				
Swinford	Bonnie	2/5/18 11:59 AM EST	--	Sierra Club				
Thompson	Kiki	2/20/18 10:38 AM EST	--	TVA				
White	Andrew	2/12/18 3:58 PM EST	--	First Solar, Inc.				
holland	richard	2/21/18 9:29 AM EST	--	Tennessee Paper Council				
huss	phil	2/15/18 11:03 AM EST	--	wearwell				
m	k	2/15/18 11:02 AM EST	--	BNS				
malone	john	2/12/18 10:14 AM EST	--	TVA				
sparks	david	2/12/18 9:15 AM EST	--	TVA				

E

Appendix E – Public and Agency Comments

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From:	Matthew K. Taylor
To:	Integrated Resource Plan
Cc:	Kendra Abkowitz; Cripps, Molly
Subject:	TDEC Comment Letter on TVA Integrated Resource Plan NOI to Conduct EIS
Date:	Monday, April 16, 2018 9:29:39 PM
Attachments:	image001.png 2018-4-16--TDEC_Comments_TVA_NOI_IRP_EIS.pdf

TVA External Message. Please use caution when opening.

Dear Ms. Pilakowski,

The Tennessee Department of Environment and Conservation (TDEC) appreciates the opportunity to provide comments on the Tennessee Valley Authority (TVA) Notice of Intent (NOI) to update and replace its 2015 Integrated Resource Plan (IRP) and associated Supplemental Environmental Impact Statement (EIS). Please note that these comments are not indicative of approval or disapproval of the proposed content or updates to the 2015 TVA IRP and EIS. Please contact me should you have any questions regarding these comments.

Thank you,

TN Department of Environment & Conservation

Matt Taylor | Senior Policy Analyst
Office of Policy and Sustainable Practices, TDEC
William R. Snodgrass Tennessee Tower
312 Rosa L Parks Ave, 2nd Floor
Nashville, TN 37243
Email: Matthew.K.Taylor@tn.gov
Office: 615-532-1291
Cell: 615-979-2449

Internal Customers: We value your feedback! Please complete our customer satisfaction survey.
External Customers: We value your feedback! Please complete our customer satisfaction survey.

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
NASHVILLE, TENNESSEE 37243-0435

ROBERT J. MARTINEAU, JR.
COMMISSIONER

BILL HASLAM
GOVERNOR

April 16, 2018

<u>Via Electronic Mail to IRP@tva.gov</u>
Attn: Ashley Pilakowski, NEPA Compliance Specialist
Tennessee Valley Authority
400 West Summit Hill Drive, WT–11D
Knoxville, TN 37902

RE: TVA Notice of Intent to Conduct Environmental Impact Statement for 2019 Update to the Integrated Resource Plan

Dear Ms. Pilakowski:

The Tennessee Department of Environment and Conservation (TDEC) appreciates the opportunity to provide comments on the Tennessee Valley Authority (TVA) Notice of Intent (NOI) to update and replace its 2015 Integrated Resource Plan (IRP) and associated Supplemental Environmental Impact Statement (EIS). TVA plans to update the 2015 IRP in response to major changes in electrical utility industry trends since 2015, including flat to slightly declining load growth, advances in the development of distributed energy resources and the integration of those resources in the electric grid. As part of the study, TVA intends to prepare a programmatic EIS to assess the impacts associated with the implementation of the updated IRP. TVA will use the IRP and EIS development processes to elicit and prioritize the values and concerns of stakeholders; identify issues, trends, events, and tradeoffs affecting TVA's policies; formulate, evaluate and compare alternative portfolios of energy resource options; provide opportunities for public review and comment; and ensure that TVA's evaluation of alternative energy resource strategies reflects a full range of stakeholder input.

TDEC has reviewed the NOI and has the following comments regarding the proposed 2019 IRP and associated EIS.

General Comments

- TDEC commends TVA for maintaining one of the most reliable transmission and generation systems in the country. However, given the current and increasingly connected nature of energy generation, transmission, and distribution, TDEC recommends that TVA include discussion of grid resiliency and cybersecurity strategies in the upcoming IRP. The addition of any new generation assets and management of existing assets requires careful consideration to protect critical infrastructure from physical and cyber-attacks. TDEC recommends addressing the potential cyber risk and security benefits associated with different types of generation resources considered in the IRP. Similarly, TDEC encourages TVA to consider how projected changes in temperature, precipitation, and the occurrence of other weather events may impact TVA's generation and transmission activities and infrastructure, and the ability of various generation strategies to effectively mitigate or adapt to impacts associated with these changes and/or events. With demand projected to be flat to negative, focusing on energy generation and transmission infrastructure resiliency protects the longevity of TVA's existing critical assets and its ability to continue serving its customers throughout the Tennessee Valley.

- TDEC recommends that TVA fully consider the various costs and benefits of individual energy resources from a number of different perspectives when building out scenarios and its generation strategies for modeling. Contemplation of resource ownership, cost to TVA, cost to customer, grid reliability, ability to dispatch, net GHG emissions, social equity concerns, and air, water, and land resource impacts are all examples of critical factors to consider for resources including but not limited to energy efficiency, demand response, electric vehicles, solar, solar plus storage, customer storage, cogeneration and CHP, nuclear, natural gas combined cycle, coal, etc.

- TDEC encourages TVA to indicate which Public Utility Regulatory Policy Act (PURPA) standards are relevant to its IRP process and how they have been applied during the process.

- In revising its IRP, TDEC encourages TVA to update energy projections and clarify how these IRP projections differ from 2015 projections.

Energy Resources

- TDEC recommends that TVA consider how energy use will change in the TVA service area over the next 20 years and include these considerations in the 2019 IRP and EIS, specifically with respect to:

    - Electric Vehicles (EVs): Under certain market and infrastructure conditions, EVs could significantly increase TVA's load, offsetting flat or declining demand. As TVA's generation becomes cleaner, high deployment and utilization of EVs in lieu of gas-powered vehicles could reduce overall criteria pollutant and greenhouse gas (GHG) emissions. Electric transportation is poised to accelerate beyond light duty vehicles, with options for transit buses, class 8 semi-trucks, and delivery vans arriving quickly. Recently, the Distributed Generation – Information Exchange (DG-IX) Electric Vehicles sub-committee developed and presented various scenarios of electric vehicle deployment, including light duty vehicles, buses, class 4-7 trucks (medium duty), and class 8 semi-trucks (heavy duty).

    - Energy Storage: Dramatic improvements in energy storage, such as new battery technology and utility-scale energy storage units, which could allow TVA to store significant amounts of power for delayed consumption, should be considered in development of the IRP scenarios and strategies.

- TDEC recommends that TVA consider its current fuel mix and whether it should be further diversified, and if so, in what manner, and include these considerations in the 2019 IRP and EIS. Specifically:

    - Coal: In evaluating its use of coal-fired power plants, TDEC encourages TVA to consider potential GHG and other air emissions, coal combustion residual disposal challenges, and other relevant environmental and economic factors associated with coal-fired assets.

    - Hydropower: Upgrades to existing hydropower facilities could result in additional generation capacity which could replace older, less efficient generation assets.

    - Solar Plus Storage: Traditional solar faces difficulty with firm load requirements, but large scale, dispatchable solar generation (solar plus storage) will likely become a cost-competitive resource in the next 10 years as battery and solar technology continue to improve while their costs continue to fall. Solar plus storage is already at grid parity in certain markets within the U.S.

    - Renewables: TVA should consider development of additional utility-scale renewable energy projects. Increasingly, having significant amounts of renewable power available for purchase is a necessary requirement for green field development projects for data centers, progressive manufacturing plants, and large retail chains. These types of projects are critical economic development tools that could support TVA and its Local Power Companies' (LPCs) needs to remain relevant and competitive with regard to the recruitment, retention, and expansion of businesses and industries throughout the Tennessee Valley.

- TDEC recommends that TVA consider the following items related to distributed energy resources (DER) in the 2019 IRP and EIS. Specifically:

    - Distributed Energy Resources: DER can improve reliability and resiliency and reduce GHG emissions at a facility or campus level. Ownership models in other parts of the country have been successful when utilities partner with end users to either own or operate a DER resource or microgrid. TDEC encourages TVA to explore and consider portfolio strategies which emphasize DER and its associated benefits for LPCs across the Tennessee Valley.

    - Microgrids / Distributed Generation: TDEC encourages TVA to anticipate increased demand for distributed generation, including solar and combined heat and power (CHP) projects, particularly for customers who have:
        - high reliability needs (datacenters, hospitals, water treatment, public safety, etc.),
        - aggressive GHG reduction and sustainability targets (Fortune 500s, larger cities), and/or
        - desire to reduce peak load and demand charges.

      These projects may contribute to demand response programs and peak savings and reduce the need for oil-based, standby generation. Encouraging dual-fuel generators in these projects further increases their resiliency to supply disruptions.

- TDEC recommends that TVA consider how energy efficiency (EE) and demand response can be used in planning for future energy needs and how TVA can directly affect electricity usage by customers in the 2019 IRP and EIS. Specifically:

    - TDEC recommends TVA consider including strategies within its portfolio that emphasize EE and demand response programming. These programs represent the most reliable and cost effective solutions to utilize current generation assets more efficiently and further delay the need for any new generation. EE costs are a fraction of the costs for building new generation or retrofitting old assets. Further, it is important TVA consider innovative as well as proven methods for reaching all ratepayers such as renters and low-income populations. These segments of ratepayers often receive a proportionately higher cost benefit from EE measures, yet they often have the least ability to install such measures or purchase new, more energy efficient appliances. Electrification programs could include incentives for multi-family dwellings to make large scale replacement of appliances with new, more energy efficient ones.

Water Resources

- The NOI states that TVA will consider "climate change, the effects of climate change on the Valley…" TDEC encourages TVA to include discussion relating to drought and drought conditions in the 2019 IRP and EIS and how such conditions could affect short- and long-term generation strategies and associated reliability. Moreover, during drought and drought conditions, water withdrawals for cooling water could have a serious impact on both public water systems and aquatic life.

- TDEC recommends that TVA further explore the use of treated wastewater for cooling. Other states are requiring or encouraging the use of treated wastewater for cooling water rather than drinking-water. This is particularly a concern in areas of the state where municipal water systems rely almost exclusively on ground water.

- TDEC also encourages TVA to place priority on development of future combined cycle combustion turbine plants over simple cycle plants. Gas-fired simple cycle combustion turbine plants use "once through cooling" water, whereas gas-fired combined cycle combustion turbine plants recycle at least some of the cooling water and are much more efficient in their use of water for cooling.

- TVA must consider potential impacts of their water withdrawals (ground water or surface water) on public water systems. The Tennessee Safe Drinking Water Act and associated rules (Rule 0400-45-01-.34) require entities contemplating water withdrawals to consider the impact on existing public water supply sources. TDEC encourages TVA to consider how future construction or upgrading of facilities requiring water withdrawals may impact water systems.

Air Resources

- TDEC encourages TVA to explore use of combined cycle combustion turbine plants over simple cycle plants. Combined cycle systems tend to be more efficient in power production and the use of natural gas as a primary fuel will produce fewer air emissions.

- TDEC recommends that TVA use air quality data that reflects the current National Ambient Air Quality Standards (NAAQS), the current designations for ozone and Particulate Matter (PM) 2.5, which for Tennessee are all in attainment, and changes in TVA generation related emissions.

TDEC appreciates the opportunity to identify topics and issues that it believes should be addressed in TVA's 2019 IRP and EIS. Please note that these comments are not indicative of approval or disapproval of the proposed content or updates to the 2015 TVA IRP and EIS. Please contact me should you have any questions regarding these comments.

Sincerely,

Kendra Abkowitz, PhD
Assistant Commissioner, Office of Policy and Sustainable Practices
Tennessee Department of Environment and Conservation
Kendra.Abkowitz@tn.gov
(615) 532-8689

cc: Robert Brawner, Division of Air Pollution Control, TDEC
Molly R. Cripps, Assistant Commissioner, Office of Energy Programs, TDEC
Lacey Hardin, Division of Air Pollution Control, TDEC
Tom Moss, Division of Water Resources, TDEC

Name: Tonya Alexander

Comments: I work for a company that started in 1946. During those years, imi has used hundreds of thousands of tons of fly ash. It is a vital constituent that makes concrete stronger and better. In the last few years, this product has become extremely volatile regarding supply.

Without fly ash, material cost are higher and less effective. Tax payers will pay more for roads/buildings and these higher cost can potentially slow down growth and development.

The ideal solution is to utilize the existing fly ash fields that we have available. This is a win win for all parties!

close window

From: Wayne Ammons
To: Integrated Resource Plan
Subject: Integrated Resource Plan (IRP) Comments
Date: Friday, March 16, 2018 5:48:30 PM
Attachments: DS SSD Logo-2.png

TVA External Message. Please use caution when opening.

Although solar power generation is increasing in the Tennessee Valley, TVA trails other Southern utilities such as Georgia Power, Duke Energy and Florida Power and Light in the amount of solar-generated electricity the utilities are adding to the grid. TVA also has balked at a request from the solar power industry to revise its individual generation limits on its Green Power Providers program to help TVA meet its target for solar power.

Comparing utilities' use of the sun

TVA reported last year a total of 226 megawatts of solar generation across its seven-state region, including 145 megawatts of utility scale solar and 81 megawatts of rooftop or other small-scale solar generation.

By comparison, Georgia Power had more than 500 megawatts of solar power on the ground last year and is in the process of installing 1,600 megawatts of additional renewable energy — solar, wind, geothermal and other renewables — by 2021.

Florida Power and Light has more than 335 megawatts of solar generation. It has announced plans for another 600 megawatts to be installed within the next year with an additional 1,500 megawatts by 2023.

In the Carolinas, Duke Energy Carolinas and Duke Energy Progress reported more than 1,400 megawatts of solar generation last year and should exceed 4,500 megawatts by the end of this year. Recent legislation in North Carolina will enable the combined Duke entities to achieve more than 6,000 megawatts of solar energy by 2022.

Nationwide, the U.S. Energy Information Agency said in the first six months of 2017 solar power generation grew by 45.1 percent, hydropower increased by 16.1 percent, wind expanded by 15.6 percent and geothermal was up by 3.2 percent compared with the first half of the previous year.

TVA should increase the size limit for solar systems & significantly increase the 10MW cap. Larger system sizes provide greater benefit to small businesses interested in clean energy solutions.

Thank you

Wayne Ammons Group, LLC
601-613-7039

www.distributivesolar.com

Choctaw County School District

P.O. Box 398
Ackerman, Mississippi 39735
Phone (662) 285-4022
Fax (662) 285-4049
www.choctaw.k12.ms.us

Stewart G. Beard. Jr.
Superintendent of Education

March 27, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, my name is Glen Beard. I am the Superintendent of Education for the Choctaw County schools. The Choctaw County School District has a vision that is very clear. We prepare every student for a positive and productive future. The mission of the Choctaw County School District is to prepare our students to exit each grade level meeting or exceeding requirements to be prepared for college or a career or to be a positive productive member of society.

Research indicates that family assets positively impact academic achievement in grade schools, as well as college attendance and completion. Assets improve outcomes for children in several ways. By helping families weather temporary economic hardships such as a job loss or high medical bills, savings another liquid assets reduce parental stress and may improve parenting. Assets also give parents the financial means to invest in their children's education. Helping families accumulate assets can increase their long-term financial stability, improve economic mobility and bolster children's chances of success regardless of race or ethnicity. (Source: The Annie E. Casey Foundation.)

Students that come from an economically successful household are more likely to be focused, be engaged, be rested, and be prepared to learn and grow from an educational experience. This will lead to better opportunities and likely a more successful future. We hope that as you plan for your next IRP, you take into consideration things such as economic household data before and after the Red Hills plant and coal mine, student scores, graduation rates, success with the Mississippi Board of Education, etc. For example the Choctaw County School District has been able to keep lower student to teacher ratios throughout its schools. The district has also been able to add programs in the Career and Technology fields that have greatly benefited our students. The programs are Culinary Arts and Sports Medicine. Both programs have seen a number of students take advantage of the opportunity to enter these fields. Neither of these would have been possible without the financial advantages that we have been able to have due to the power plant. In addition to these programs the district has been put in a position that very few school district in our state have where we can take on significate and much needed building projects without being a burden to the tax payers of the county.

The Choctaw County School District has education goals that will continue to improve instructional delivery in the years to come and to become a top five ranking District in the State of Mississippi in all areas. We also have an organizational goal that believes that quality instruction begins with well-trained, fairly compensated faculty and support staff. Choctaw County schools will continue to invest in its human capital through study of plans and actions that lead to improve teaching and learning. We believe that by having the economic advantage of having a very fair tax base that provides the necessary funding from the state to our local schools is absolutely critical in hiring the best teachers, but also to make sure the students have the resources we need for them to have a quality education. Speaking from experience, since the Red Hills power plant and Red Hills mine have begun operations in Choctaw County, the tax base has risen, the funding levels to the state have risen, and as such, the Choctaw County schools are in a much better economic position, as are all of the thousands of students that have been taught, graduated, and went on to successful lives that once begin in the Choctaw County School District.

As you continue on your IRP, we would like you to consider any negative impact on our communities and school district that it would have if you decide to run less coal, or run Red Hills power plant or coal mine less. We are not in the position of picking winners and losers in the marketplace, but we would be very concerned if our tax base or our business climate was rerouted so that the burden would fall on the residential areas, or even worse, eroded completely so that we would lose our tax base to educate our students. We believe it would be a terrible environmental and socioeconomic injustice if you take away any of our existing benefits, or threaten our funding sources directly or indirectly with a negative impact to our state and students therein.

Should you want to hear about how energy usage will change in the next 20 years in the Tennessee Valley Region, it is important to remember that the most recent history is the best indicator of the future itself. Take a look back on the benefits to both TVA and the State of Mississippi since the Red Hills coal mine and power plant have been developed, and then review all the ancillary businesses, population increases and student body numbers. We hope that you will consider this going forward. Thank you for your consideration.

Sincerely,

Glen Beard
Superintendent of Education
Choctaw County

The ENTERPRISE
Choctaw | Webster

P.O. Box 327
Eupora, MS 39744
769.610-1795

theEnterpriseMS
theEnterpriseMS

March 26, 2018

Ashley Pilakowski
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

The Enterprise of Mississippi serves as the economic development organization representing Choctaw County, Mississippi home to the Red Hills Mine operated by North American Coal. Red Hills Mine is the largest manufacturing/production facility in our region.

The Red Hills Mine and adjoining power plant provide residents with the highest paying jobs in our region. Red Hills Mine has provided a safe and dependable workplace for over 20 years. The jobs created at Red Hills Mine has allowed the most talented and trained professionals to remain in our community. The commitment Red Hills has made to their employees is evident in their one percent turnover. Red Hills Mine is continually providing training and advancement opportunities for employees.

The impact of Red Hills Mine does not stop at their employees. The mine and power plant generated a historic increase to the local tax base upon their conception. The increase in the operating budget for Choctaw County has allowed the county to invest in a state of the art medical facility and provide funding at the highest level per pupil in our area to students in the county school district. Red Hills Mine purposefully chooses to buy local and source as many materials and parts as possible. This has led to the success and growth of multiple small businesses in the region. Whenever there is a need or cause in the community the Red Hills Mine is the first to the table to with volunteers and financial support. There has not been another organization in our community who has made more of an impact economically or socially than Red Hills Mine through their direct and indirect contributions.

This region of north Mississippi has always been known for an abundance of natural resources. Rather by timber or agriculture or natural spring water residents and generations before supported their selves off these natural resources. The community supports the production of lignite coal for power production. Red Hills Mine is reclaiming the mined land and returning it with a higher value for the next generation of residents to continue to live and thrive. The community recognizes the importance of being good stewards of the environment and supports Red Hills Mine in their efforts to continue mining for decades to come and restoring our land through reclamation.

The | ENTERPRISE
Choctaw | Webster

P.O. Box 327
Eupora, MS 39744
769.610-1795

theEnterpriseMS
theEnterpriseMS

Without Red Hills Mine and the power plant, I would not be able to do my job. The Enterprise of Mississippi has been able to use the success story of a major corporation, North American Coal, making an investment in a rural area to attract the attention of other industrial companies. In the past three years, there has been three new industrial tenants creating over 100 jobs in The Enterprise region. Red Hills Mine has provided a road to success for other companies to follow. Their commitment to this county and region has been transformative and will continue to be as long as they are in operation and increasing production.

In a rural region like ours, every job retained and created has a significant impact. Each family who can live and work in our community allows us to have continued growth. Choctaw County has benefitted from some of the lowest unemployment numbers in the state and highest workforce participation numbers in the past year. Red Hills Mine has created an environment and culture in the community for each person to work hard daily to provide power to the Tennessee Valley at an affordable and reliable rate.

I hope you will consider and study the economic and socio-economic benefits of utilizing the Red Hills generation power facility and the Red Hills Mine at their full capacity. It is important to look at the impacts which have been made directly and indirectly in our community from the operation of these facilities. Choctaw and surrounding counties are a better place today than they were 20 years ago. The Red Hills Mine has given the local communities a needed boost and improvement in the quality of life they are able to afford to residents. I ask for your continued support in helping to grow and sustain our communities by allowing us to increase power generation from Red Hills for the Valley.

Sincerely,

Lara Bowman

Lara Bowman
Executive Director

From: Brice, Logan K
To: Integrated Resource Plan
Cc: Rothfeder, Robin
Subject: TVA: TPSM
Date: Monday, March 5, 2018 9:39:15 AM

TVA External Message. Please use caution when opening.
Agency: Tennessee Valley Authority (TVA)
Topic: Environmental Impact Statements; Availability, ect.:

I am a student at the University of Wisconsin-Stevens Point (UWSP) that will be graduating in May 2019 with a degree in natural resources planning with an emphasis in sustainable energy. Through my studies I have explored the NEPA process as well as environmental and energy related policy across various scales. Stemming from this base information, I have formulated reports that conceptualize the renewable energy potential of an area which addresses the environmental, social equity, and economic elements present. I was then able to create realistic models within the limitations of that location in a presentable format.

The energy dispatch range of TVA remains rich in coal. These resources are dwindling rapidly as energy demand across the nation continues to climb coupled with a history of heavy use. Increases in the cost to burn coal will result from this reduction in supply and/or from attempts to excavate previously unfeasible stocks. The Target Power Supply Mix (TPSM) developed by TVA estimates closing coal fired plants during its next 20 year plan. To support this lack of energy production a new generation source will need to be established.

Currently, the cheapest source available is onshore wind technologies followed by combined-cycle natural gas combustion. Wind averages around $45/MW, while combined-cycle combustion remains at about $60/MW compared to $108/MW for coal and $148 for nuclear fission represented as levelized costs in 2017. The TPSM is projecting expansion of nuclear fission generation capacity while the cost and waste produced remains unstable. Renewable energy technologies' costs are decreasing as research and development progress as well as from the expansion in supply as a response to intensifying demand. Kentucky and Alabama both have moderate potential wind capacity (140-155 GW) with Tennessee and Mississippi similarly close behind (110-120 GW). By investing into these sustainable sources of energy we start to establish true energy security and independence from foreign fuels. Localizing the grid allows for less energy loss in transmission and faster recovery after adverse natural events. The future has many uncertainties especially now with global climate destabilizing at a rate never before experience on earth. We must decentralize our energy infrastructure to strengthen our resilience and adaptability as we move towards the unknown conditions of what is to come.

Thank you for taking the time and effort to read and consider these statements.

peace,

Logan Brice
Natural Resources Planning Major
Sustainable Energy
Peace Studies Minors
Society of Ethnobiology President
Yoga and Meditation Club Vice President
Giving Gardens/HPPP Intern

Dr. Nola Bryant
7700 McGee-Thompson Rd
Ackerman MS 39735

Greetings,

My name is Nola Bryant, a resident of Ackerman, MS, Choctaw County. I am an administrator of the public school system. My husband is a pastor. I am representing the citizens and members of the National Association for Advancement of Colored People (NAACP) of Choctaw County. The membership is represented of approximately 70, located in the Choctaw County Branch, affiliated with over 3,500 statewide.

The reason for my communication is to lend support for the Red Hills Mine/Plant of Choctaw County to remain open. The Red Hills Mine/Plant is vital to the economy and personal use of the greater community and employees and their families employed by the industry.

The NAACP seeks to assist families in need of jobs, school assistance, food, shelter, and unfair advantages in various areas. Statically speaking, the cost of energy would increase tremendously.

The Red Hills Mine/Power Plant has reduced the cost of electricity provided to Choctaw County and surrounding communities by providing a competitive cost rates. The poverty of families is central mainly by the employment of the industry. Instead of depending on a once a month food stamp allotment, they are able to purchase food, clothing, and keep lights on in their homes.

Prior to the mine and power plant, the Choctaw County community was dying for the lack of employment. Parents had to make the decision whether to pay bills or buy food. Sometimes children in the home that attended public school were only receiving meals at school. Children often went to bed hungry at night. Since the Red Hills Mine/Plant came to Choctaw County, improvement in life and resources, health care, food availability, clothing, and home utilities has been secured.

In conclusion, we the NAACP community, of Choctaw County, are asking for the following:

-Red Hills Mine/Plant and Mine remain open

-Sustainability of family way of life

-Continue support of school resources

-Remain as vital employment entity for our town

Thus, I thank you for receiving these comments. I look forward to hearing from you on behalf of our organization and the families of Choctaw County. You may reach me at any time via 662-803-7790 or through Levon Murphy.

Thank you,

Dr. Nola Bryant

NAACP Community Action Chair Person

From: Madison Coburn
To: Integrated Resource Plan
Cc: John Brunini
Subject: 2019 IRP EIS Public Comments
Date: Monday, April 09, 2018 4:55:48 PM
Attachments: TVA IRP Letter -Choctaw County Board of Supervisors_41464441_1.pdf
TVA IRP Letter -Central Electric Power Association_41464478_1 (2).pdf

TVA External Message. Please use caution when opening.

To whom it concerns:

Attached to this email, please find letters submitted by the Choctaw County Board of Supervisors and Central Electric Power Association for consideration in TVA's Integrated Resource Plan Environmental Impact Statement process.

Best personal regards,

Madison Coburn

Madison E. Coburn
Butler Snow LLP

D: (601) 985-4490 | F: (601) 985-4500
1020 Highland Colony Parkway, Suite 1400, Ridgeland, MS 39157
P.O. Box 6010, Ridgeland, MS 39158-6010
Madison.Coburn@butlersnow.com | vCard | Bio

Twitter | LinkedIn | Facebook | YouTube

CENTRAL ELECTRIC POWER ASSOCIATION

CENTRAL ELECTRIC POWER ASSOCIATION

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1-866-846-5671 Toll-free

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Rankin District
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Sandhill, MS 39161
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1-866-900-1201 Toll-free

www.centralepa.com

"A public utility owned and operated by the member-consumers served in seven Central Mississippi counties"

April 6, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski,

Central Electric Power Association has been providing affordable, reliable electricity to our members in Attala, Leake, Neshoba, Scott, Newton, Rankin, and Kemper County for 81 years. The board of directors at Central Electric continues the history of supporting the people and communities we serve, keeping safety first, and keeping the rates as low as possible to our members.

TVA has supplied our Association with dependable and economical power since December 19th of 1939.

As Mississippi's only coal generation facility, the Red Hills Mine and Power Plant provides some of the cleanest burning coal available. The environmental efforts of their land remediation process are to be commended, with much of the land returned being more useful than prior to being mined. The plan has also provided an economic boost to the communities in Central Mississippi by providing well-paying jobs to hundreds of people in the surrounding area.

Central Electric Power Association recognizes and supports TVA's role of purchasing and dispatching the lowest cost generation of power to all ratepayers across the Valley.

As TVA prepares their latest Integrated Resource Plan, the board of directors at Central Electric Power Association ask that you strongly consider the Red Hills generation facility as a vital part of generation located within the Valley.

Sincerely,

Joe Sanders
Board President

Pettey Leach
Board Vice President

Danny Thornton
Board Secretary

Philip Crosby
Director

Mike Brooks
Director

Earl Browning
Director

Hanna Watson
Director

Max Loper
Director

Don Howington
Director

David Boyd
Director

Name: Don Childress

Comments: TVA operates numerous coal-fired power plants and will likely continue to do so for the foreseeable future. Fly Ash produced as a by-product of burning coal is a critically important resource for the ready mix concrete industry, as well as related concrete production industries. As recent events in Tennessee and elsewhere have demonstrated the fly ash produced by the production of electricity through the burning of coal places significant liability on the operators of such power plants, and can become a significant financial liability to the operators and by extension to the rate-payers who use this electricity. The historical methods of landfilling coal combustion byproducts have proven to create significant and ongoing environmental concerns for both the power plants and surrounding communities.

TVA should move quickly to embrace existing technology that allows landfilled (either dry or wet) fly ash to be beneficiated and sold to industry. While not all landfilled fly ash can be beneficiated and sold as a commercial product, a significant portion of such landfilled fly ash can be recovered and sold to industry. This permanently reduces the need to landfill and manage fly ash while improving the quality of the construction in which such fly ash is utilized. In addition, some beneficiation process can be used to treat both landfilled fly ash as well as the fly ash resulting from current electricity production. In these cases, the cost of landfilling fly ash is avoided on the front end and revenue can be realized to offset any additional cost related to the specific beneficiation process.

The concrete industry is currently facing persistent and recurring shortages of commercial grade fly ash even in areas such as Tennessee where much of our electricity is produced from burning coal. This is due primarily to the variability in the fly ash that results from current operational practices utilities employ as they produce electricity. This type of variability can be addressed by various beneficiation processes that are already commercially available in the marketplace.

A key factor here is that commercial grade fly ash has a definitive market-value and a well-established market demand throughout the Southeast. The ongoing need for such fly ash is real and well recognized within the concrete industry where fly ash has become a critical component in the production of everyday commercial concrete as well as high-performance concrete for tall buildings, bridges and other structures that utilize concrete. TVA should recognize and embrace their responsibility to better manage fly ash produced at it's power plants by making this product available to industry as a first priority rather than using landfilling as the first option.

Landfilled fly ash represents an ongoing liability for utilities that is quite likely to grow over time and one that will never completely disappear. Employing technology to beneficiate fly ash and make it available to industry represents a permanent and responsible solution that creates an additional revenue stream for the utility and eliminates the creation of a lingering and potentially immense liability from landfilling fly ash.

TVA's future Integrated Resource Plan should recognize and immediately begin to implement the existing technology described above. This clearly meets the objectives outlined in the request for comments on the 2019 IRP as shown below:

The 2019 IRP will consider many views of the future to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Valley over the next 20 years. As part of the IRP decision-making process, and in alignment with the National Environmental Policy Act (NEPA), TVA will analyze potential environmental implications associated with an updated IRP by issuing an environmental impact statement (EIS).

Implementing a long-term strategy to beneficiate currently produced fly ash and to recover (where feasible) landfilled fly ash meets every criteria listed above:

1. Beneficiated fly ash is commercially viable product with a demand that extends at least 20 years into the future and can help reduce the cost of electricity produced by TVA.

2. Diverting fly ash to beneficial industrial use that safely incorporates the fly ash into the

product (like concrete) is a far preferable method for TVA to demonstrate environmental stewardship.

3. A steady, consistent source of fly will allow concrete producers to provide higher-quality, lower cost concrete for construction that will aid in economic development for the communities served by TVA.

close window

From: Keith Clevenger
To: Integrated Resource Plan
Subject: Comments on IRP concerning Red Hill Mines
Date: Friday, April 13, 2018 8:21:38 AM
Attachments: DOC041218-04122018120542.pdf

TVA External Message. Please use caution when opening.

Dear Ms. Pilakowski,

I have attached a letter regarding the role of Mississippi Lignite (Red Hills Mine) in your upcoming IRP. Your thoughtful consideration is greatly appreciated. Sincerely,

Keith Clevenger
Parts Manager
TEC Tuscaloosa
205-520-6453

-----Original Message-----
From: Tuscaloosa Toshiba [mailto:B2Toshiba@TEC1943.com]
Sent: Thursday, April 12, 2018 12:06 PM
To: Keith Clevenger <kclevenger@TEC1943.com>
Subject: Send data from MFP11935635 04/12/2018 12:05

Scanned from MFP11935635
Date:04/12/2018 12:05
Pages:1
Resolution:200x200 DPI

Dear Ms. Pilakowski:

My name is Keith Clevenger and I am the Parts Manager for Tractor and Equipment Company in Tuscaloosa Alabama. With twenty-three (23) branches and approximately 500 employees, we have been serving our customers' construction, quarry, and mining needs in the southeast for over 75 years. For over fourteen (14) years, Red Hill Coal Mine in Ackerman, Mississippi has been a valued client.

We have an interest in promoting the general welfare of the citizens of the Tennessee Valley Authority (TVA) service territory. We believe TVA should consider the benefits that the Red Hills Coal Mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resource options which, in turn, benefit the citizens of Mississippi and the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills Power Plant and Red Hills Coal Mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills Power Plant and Red Hills Coal Mine at maximum capacity, you will help fulfill this mission, and as a side benefit, *TVA will obtain baseload support and resiliency for the electrical grid.*

We urge TVA to consider the potential positive impact that the Red Hills Power Plant and Red Hills Coal Mine have in the communities where their employees live. We hope you can source as much opportunities from this region as a maximum utilization means more socio-economic and economic benefit to many businesses, citizens and organizations. These facilities offer you an environmentally conscious, reliable, low-risk diverse fuel source and can be counted on as a backbone to a successful power grid; we hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills Power Plant and Coal Mine. It is with great consideration and understanding that you will do right by all interested parties. Thank you for your consideration and receiving these comments.

Respectfully yours,

Keith Clevenger

Keith Clevenger

Name: John Cockerham

Comments: It is essential that we shift to renewable fuels, continuing our progress away from fossil fuels, especially coal, to mitigate already unstoppable, dangerous shifts in climate patterns. This is backed by incontrovertible scientific investigate. The future of the human race rests on the decisions you make now. Are you intelligent enough to do this or will you be part of the reason uncountable numbers of humans, animals, and plants will die in the future?

close window

4 COUNTY ELECTRIC POWER ASSOCIATION

5265 South Frontage Road – P.O. Box 351 – Columbus, MS 39703 – (662) 327-8900

March 22, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

4-County Electric Power Association has been providing affordable, reliable electricity to our owner/members for almost 80 years as a distributor of Tennessee Valley Authority power. The goal of our original Board of Directors and members was to provide power to the underserved rural population of the area and in doing so, create a better and more viable future. Some eight decades later 4-County's mission of improving the lives of all those we touch continues our history of supporting the people and communities we serve. As a partner of TVA for that same period, we have worked with you to create opportunities for our members, Mississippi and the Valley. One of those opportunities came to fruition in 1999 when the Red Hills mine began producing lignite to power the Red Hills generation facility. Now, more than 20 years after the project first began, we all continue to reap the benefits.

As you prepare your newest Integrated Resource Plan, we ask that you consider a more robust role for the Red Hills generation facility. We believe that dispatching the facility would benefit TVA, 4-County Electric Power Association, and our stakeholders and end users in a variety of ways that all fall under TVA's primary considerations of Energy, Economic Development and Environment.

First, both the Red Hills mine and the power plant have played a significant role in improving the standard of living in Choctaw County and surrounding areas. The facilities have created hundreds of well-paying jobs. They have also contributed millions of dollars in funding for schools, local organizations and more through taxes and charitable support. This is especially important in our area. Every county in our service territory has a poverty level of 20% or better, and several stand at more than 30%. As you can see, keeping the mine and the power plant viable and productive has a huge local impact.

As you are well aware, stability in forecasting and dispatching is probably the most important aspect of fleet and resource planning. We feel that the Red Hills generation will help provide this for TVA. As we understand it, the long term pricing contract you have with the plant allows for consistency and transparency in the cost of dispatch since price volatility is taken out of the equation. With little or no load growth projected in the Valley, this stability becomes even more important in terms of being able to keep power affordable for our members, many who already struggle to make ends meet.

Ms. Ashley Pilakowski
March 22, 2018
Page Two

Finally, we understand the need to provide clean, environmentally friendly sources of power. We are home to some 6.5 MW of solar generation and we helped bring Mississippi's first landfill methane gas generation online, which now provides another MW of clean power. We also understand that to have the reliability—not to mention the affordability—we all require, that a fleet that uses a broad spectrum of fuel is needed. The Red Hills mine provides some of the cleanest burning coal available. We would also like to commend the mine on their land remediation efforts. Not only do they return the land in an almost pristine state, it will actually be more useful when returned than it was prior to mining. The mine also has a very beneficial partnership with Mississippi State University. The school works closely with the mine on many facets of remediation and that work is being recognized nationally for its effectiveness in meeting or exceeding environmental benchmarks.

The Red Hills Mine and Power Plant has already been a much needed boost to the local community. But 4-County feels that the Red Hills Mine and Power Plant can play an even bigger role moving forward. By increasing the level at which the plant contributes to generation in the Valley, we all can capitalize on the increased capacity, the cleaner generation and the community support the Red Hills Mine and Power Plant provide. These things may be invisible to most of our members, but what is not invisible is the real effects the RHM/PP provides. By adding competitively priced power that is generated locally, not only can we continue to keep energy rates low and increase reliability, but we can also continue to provide opportunities to recruit more business and industry and in doing so, be even better at our mission of improving the lives of all we touch.

As you put your plan in place, the Board of Directors of 4-County Electric Power Association asks that you consider making the Red Hills plant part of your base load generation or at the very least, to dispatch the plant at higher levels than it is currently being used.

Thank you.

Sincerely,

Marty Crowder, President
4-County Electric Power Association Board of Directors

From: Perrin de Jong
To: Integrated Resource Plan
Cc: Peter Galvin; Howard Crystal; Jean Su; Greer Ryan; Noah Greenwald; Tierra Curry; Amy Atwood

Subject: TVA 2019 IRP Scoping Comments by Center for Biological Diversity
Date: Monday, April 16, 2018 11:15:55 PM
Attachments: TVA 2019 IRP scoping comments 4.16.18.pdf
404 SE aquatic specs petition.pdf

TVA External Message. Please use caution when opening.

Dear Ms. Pilakowski,

Attached, please find the scoping comments of the Center for Biological Diversity for the 2019 Integrated Resource Plan. Also added as an attachment is our petition to list 404 Southeastern aquatic species under the ESA, which provides reams of supporting documentation regarding the points made in the letter about the impacts of TVA's energy systems on specific imperiled species.

Perrin de Jong
North Carolina Staff Attorney
Center for Biological Diversity
Asheville, North Carolina Office
(828)252-4646
www.biologicaldiversity.org

April 16, 2018

via email to at IRP@tva.gov
Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Re: Scoping Comments on the Tennessee Valley Authority's 2019 Integrated Resource Plan

Dear Ms. Pilakowski:

I write on behalf of the Center for the Biological Diversity (the Center) to comment on the Tennessee Valley Authority's (TVA) 2019 Integrated Resource Plan (IRP). The Center is a national non-profit organization with over 1.5 million members and online supporters, including thousands in TVA's service area, dedicated to the preservation, protection and restoration of biodiversity, native species, ecosystems, public lands and waters, and public health. Among the Center's missions are to reduce U.S. greenhouse gas (GHG) emissions and other air pollution from coal and other dirty energy sources, and to engage in projects that support the expeditious and urgent transition to a 100 percent clean and just energy system that optimizes wildlife-friendly energy sources such as distributed solar. Another of the Center's primary missions is to prevent the extinction and extirpation of native wildlife, and to protect their habitat.

As discussed below, the Center has serious concerns with the TVA's 2019 Integrated Resource Plan, for which TVA has proposed to prepare a Programmatic

Environmental Impact Statement (EIS), as mandated by the National Environmental Policy Act (NEPA), 42 U.S.C. § 4321, *et seq.* Because of TVA's enormous environmental footprint in this age of climate change and mass extinction, the Center is acutely concerned with pushing TVA away from dirty energy sources and towards energy efficiency and energy sources with minimal environmental impacts. In conjunction with our discussion of the IRP, we must also examine the parallel proposal TVA has put forward to change its customer rates via its March 2018 Proposed Wholesale Rate Change and the associated Environmental Assessment (EA). As we will discuss, TVA's rate change initiative, in conjunction with the IRP, would inevitably insure additional energy generation from traditional fossil fuel sources, which serves to lock in fossil fuel power plants for decades, and pollute the environment, exacerbating climate change and extinction.

Furthermore, TVA's effort to segment the analysis of the impacts of these two interlocking proposals appears to be a strained and unlawful shell game. The March 2018 Proposed Wholesale Rate Change EA purports to tier its analysis of the environmental impacts of discouraging distributed energy resources (DER) to the impacts analysis in the prior, 2015 IRP. TVA may not rely on the 2015 IRP's impacts analysis to stand in the place of the rate change EA's impacts analysis, since the 2015 IRP EIS excluded DER from analysis. Also, TVA may not rely on the 2019 IRP's impacts analysis to stand in the place of the rate change EA's impacts analysis, unless the 2019 IRP EIS fully analyzes the impacts of stifling investment in DER, and is completed before analysis and a decision are undertaken by TVA regarding the 2018 rate change proposal.

Finally, the Center is gravely concerned about TVA's choice of energy sources because, as discussed in detail below, the current mix of energy sources in use by TVA is pushing countless species to the brink of extinction while destroying and degrading their habitat. For this reason, TVA must carefully analyze the impacts of its energy systems – as well as its paltry focus on energy efficiency – on all affected species before making a final decision regarding its 2019 IRP.

BACKGROUND

A. Statutory and Regulatory Framework

1. The TVA Act

The TVA Act requires that TVA craft its IRP by taking into consideration, *inter alia*, "the economic, environmental, social, or physical well-being of the people of the service area." 16 U.S.C. § 831a(g)(1)(K)(ii). The Act directs TVA to engage in a "planning and selection process for new energy resources which evaluates the full range of existing and incremental resources (including new power supplies, energy conservation and efficiency, and renewable energy resources) in order to provide adequate and reliable service to electric customers of the Tennessee Valley Authority at the lowest system cost." 16 U.S.C. § 831m-1(b)(1). The statute further mandates that this planning process: (a) "take into account necessary features for system operation, including diversity, reliability, dispatchability, and other factors of risk"; (b) "take into account the ability to verify energy savings achieved through energy conservation and efficiency and the projected durability of such savings measured over time"; and (c) "treat demand and supply resources on a consistent and integrated basis." *Id.* § (b)(2). It also defines "system cost" to mean:

> all direct and quantifiable net costs for an energy resource over its available life, including the cost of production, transportation, utilization, waste management, environmental compliance, and, in the case of imported energy resources, maintaining access to foreign sources of supply.

Id. § (b)(3).

Congress also specifically required that TVA would contemplate and promote energy efficiency and renewable energy, including distributed solar development, as a part of its utility planning process. As a part of the agency's mandated "least cost planning program," the TVA Act calls on the agency to entertain energy efficiency and renewable energy proposals; to help distributors develop energy efficiency initiatives; and to work with its distributors to educate consumers about, *inter alia*, "renewable energy options and programs." *Id.* § 831m-1(c).

2. The National Environmental Policy Act

As the nation's "basic national charter for protection of the environment," 40 C.F.R. § 1500.1(a), the National Environmental Policy Act's (NEPA) purpose is to "help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment." *Id.* § 1500.1(c). NEPA's "twin aims" are to (a) "'place[ ] upon an agency the obligation to consider *every* significant aspect of the environmental impact of a proposed action,'" and (b) to "inform the public that [the agency] has indeed considered environmental concerns in its decision making process." *Baltimore Gas & Elec. Co. v. Natural Res. Def. Council*, 462 U.S. 87, 97 (1983) (quoting *Vt. Yankee Nuclear Power Corp. v. Natural Res. Def. Council*, 435 U.S. 519, 553 (1978)) (emphasis added).

To achieve those aims, NEPA requires that before undertaking any "major Federal actions significantly affecting the quality of the human environment," an agency must prepare an EIS that addresses (1) the "environmental impact of the proposed action," (2) any "adverse environmental effects which cannot be avoided . . .;" (3) reasonable alternatives to the proposed action, and (4) the "irreversible or irretrievable commitment of resources" involved in implementing the proposal. 42 U.S.C. § 4332.

The CEQ – an agency within the Executive Office of the President – has promulgated NEPA implementing regulations that are "binding on all Federal agencies." 40 C.F.R. § 1500.3. These regulations set forth a series of factors that govern whether a project may have "significant" impacts, therefore requiring an EIS. *Id.* § 1508.27. The regulations provide that an action is more likely to have a "significant" impact, and therefore require an EIS, depending on: (a) "[w]hether the action is related to other actions with . . . cumulatively significant impacts"; (b) whether the proposed impacts are either "highly controversial" or "highly uncertain"; (c) "[w]hether the action threatens a violation of Federal . . . law or requirements imposed for the protection of the environment"; and (d) "[t]he degree to which the action may establish a precedent for future actions with significant effects." 40 C.F.R. § 1508.27(b). The presence of any one of these factors triggers the requirement for an EIS. *E.g. The Fund for Animals v. Norton*, 281 F. Supp. 2d 209, 218 (D.D.C. 2003).

Although the CEQ regulations also provide that an agency may prepare an EA to determine whether an EIS is necessary, 40 C.F.R. § 1501.4, an EA must consider reasonable alternatives in the same manner as an EIS, *id.* § 1508.9(b), and must "provide sufficient evidence and analysis for determining whether" to prepare an EIS. *Id.* §

1508.9(a)(1). If the agency concludes after completing an EA that an EIS is not required, it must sufficiently explain the basis for that determination. *Id.* §§ 1501.4(e); 1508.13. TVA's regulations impose similar requirements.[1]

Regardless of whether an EIS or an EA is prepared, the CEQ regulations make it absolutely clear that agencies must complete the NEPA process "*before* decisions are made and before actions are taken." 40 C.F.R. § 1500.1(b) (emphasis added); *see also id.* § 1500.5(f) (requiring NEPA review "early in the process"). In particular, the NEPA process must be completed "early enough so that it can serve practically as an important contribution to the decision-making process and will not be used to rationalize or justify decisions already made." *Id.* § 1502.5. As the Supreme Court has noted, "NEPA ensures that important effects will not be . . . discovered [only] after the die [is] otherwise cast." *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332 349 (1989).

In appropriate circumstances, NEPA permits an agency to prepare a broad NEPA document and then "tier" from that document in a subsequent NEPA process over a more site-specific decision. 40 C.F.R. § 1502.20. However, it is well-established that tiering is only permissible for an issue that was actually *considered* in a prior NEPA review. *E.g.*, *Kern v. BLM,* 284 F.3d 1062, 1076 (9th Cir. 2002).

3. The Endangered Species Act

The ESA requires federal agencies such as TVA to "insure that any action authorized, funded, or carried out by such agency (hereinafter ... referred to as an 'agency action') is not likely to jeopardize the continued existence of any endangered species or

[1] *See* TVA NEPA Procedures, *available at* https://www.tva.gov/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/Environmental%20Reviews/tvanepa_procedures.pdf.

threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary ... to be critical." 16 U.S.C. § 1536(a)(2). Section 7(a)(2) of ESA requires agencies to consult with either the United States Fish and Wildlife Service or the National Marine Fisheries Service (hereafter "Services" or "Service") whenever an agency takes action that "may affect" listed species or their habitats. 16 U.S.C. § 1536(a)(2); see also 50 C.F.R. § 402.14(a).

The regulations promulgated under the ESA define "agency action" as:

> Action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. Examples include, but are not limited to: (a) actions intended to conserve listed species or their habitat; (b) the promulgation of regulations; (c) the granting of licenses, contracts, leases, easements, rights-of-way, permits, or grants-in-aid; or (d) actions directly or indirectly causing modifications to the land, water, or air.

50 C.F.R. § 402.02.

If the agency determines that its action "may affect" endangered or threatened species or critical habitat, the agency must pursue either informal or formal consultation with one of the Services. *See* 50 C.F.R. §§ 402.13-402.14. Formal consultation is required unless the agency determines, as a result of informal consultation with the Service, "that the proposed action is not likely to adversely affect any listed species or critical habitat." *Id.* § 402.13(a). If the agency action "may affect listed species or critical habitat," formal consultation is required. *Id.* § 402.14(a). If formal consultation is required, the Service prepares a Biological Opinion stating whether the proposed action is likely to "jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat." *Id.* § 402.14(g). Thereafter, the agency must determine how to proceed with its action in light of the Service's Biological Opinion.

Id. § 402.15.

An agency is required to reinitiate formal consultation if the agency retains discretionary involvement or control over the action and one of the following four triggers occurs:

> (a) If the amount or extent of taking specified in the incidental take statement is exceeded;
>
> (b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
>
> (c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or
>
> (d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Id. § 402.16.

B. TVA's Operations and NEPA Compliance

1. TVA Serves Its Customers Almost Entirely Through Dirty Energy Sources, Threatening Humans and Wildlife

TVA operates the largest public power system in the nation, providing electricity to about 9 million people in an 80,000-square mile area comprised of most of Tennessee and parts of Virginia, North Carolina, Georgia, Alabama, Mississippi, and Kentucky. It provides wholesale electricity to 154 independent power distributors and 56 directly served large industrial and federal customers. 83 Fed. Reg. 6,668 (Feb. 14, 2018).

TVA generates most of the power it distributes with 3 nuclear plants, 7 coal-fired plants, 9 simple-cycle combustion turbine plants, 7 combined-cycle combustion turbine plants, 29 hydroelectric dams, a pumped-storage facility, a methane-gas cofiring facility, a diesel-fired facility, and 16 small solar photovoltaic facilities. *Id.* TVA's facilities generated 142.2 billion kilowatt-hours in fiscal year 2014. 80 Fed. Reg. 65,282 (Oct. 26, 2015). The major sources for TVA's power are coal (25%), nuclear (38%), natural gas (16%), non-renewable power purchases (9%), hydroelectric (7%), and renewable energy power purchase agreements (5%). *Id.* As discussed in detail below, at this scale, TVA's chosen energy systems generate tremendous GHG and climate impacts, destabilizing the environment on which we all rely for survival and comfort. The operation of TVA's chosen energy sources also threatens countless species with extinction, as discussed in detail below.

2. The 2015 IRP and Associated EIS

In 2015, TVA completed an Integration Resource Plan (IRP) and accompanying Environmental Impact Statement (EIS). The EIS considered several alternatives, including one called "Maximize Renewables," but *none* of the alternatives, including this one, addressed or analyzed expanding distributed solar resources.

Rather, the discussion of expanding solar generation was limited to *utility-scale solar projects*. *See, e.g.,* 2015 EIS at S-16. Indeed, the IRP expressly removed from analysis any consideration of "purchases of power from residential solar installations" on the grounds that this "is a resource acquisition issue *outside the scope of the IRP*." 2015 EIS at 136 (emphasis added). As TVA elsewhere explained, "IRP strategies primarily focus on central station or utility-scale resource planning options" and thus do not expressly address distributed generation growth. *See* IRP App. C at 1; IRP Response to Comments at 15 ("the analysis around deploying distributed resource is an undertaking *outside the IRP study process*") (emphasis added). In sum, the IRP's NEPA analysis failed to analyze distributed solar generation at all.

3. The 2018 Rate Plan EA

In March, 2018, TVA issued its March 2018 Proposed Wholesale Rate Change EA. The proposed action under review in the EA is TVA's changes to the electricity price structure it charges for wholesale power – a price structure TVA fully expects power companies to pass along to consumers. EA at 13 (explaining that TVA's analysis "assumes that LPCs would adopt the default rate" approach).

i. Imposition of a Mandatory Fee Regardless Of Energy Use

Of preeminent concern to us is TVA's proposed changes to its Standard Service prices for residential and small commercial and industrial (C&I) customers, in which TVA plans to reduce standard service charges by $1.2 billion/ year and recover the same amount through an unprecedented "fixed cost recovery charge." EA at 48 (March 2018 Proposed Wholesale Rate Change).

According to the EA, TVA is facing "competitive and technological changes" that threaten its "business model" because "distributed generation, energy efficiency, technological advances, [and] shifts in customer behavior" are reducing the amount of electricity customers want to receive from TVA, and thus its ability to generate income. 2018 Rate Change EA, at 1. Rather than *embrace* these opportunities to reduce reliance on dirty fuel sources that pollute the air and exacerbate climate change, which would be consistent with TVA's statutory mission, the EA reveals that TVA is focused on making sure that these developments, in fact, do not reduce TVA's stranglehold on energy production. Thus, under the guise of protecting consumers from "cost-shifting," TVA has designed rate changes *that encourage consumers to use more energy, while* *discouraging them from producing their own energy through distributed energy generation.*

ii. ***Discussion of environmental impacts and relation to Integrated Resource Planning***

In terms of addressing environmental impacts, the EA claims it is "tiered" from TVA's 2015 IRP, EA at 20, even though, as noted, that IRP did not consider distributed solar resources. TVA can not rest their analysis on a tiered document that does not analyze relevant factors. *E.g.*, *Kern v. BLM,* 284 F.3d 1062, 1076 (9th Cir. 2002). Thusly, TVA must wait to make a decision on its rate change initiative until its 2019 IRP EIS, with a full examination of the DER impacts of its rate change proposal, is completed.

With respect to the no action alternative, TVA claims that doing nothing would have a negative effect on customers because both residential and commercial customers would continue to have "increased incentives to pursue uneconomic DER." EA at 24. Nonetheless, TVA projects that only 2 percent of households in its service territory will install DER by 2030. *Id.* at 25.

As for environmental consequences, although TVA acknowledges that, under the no action alternative, TVA's need for central station generation may change as more customers conserve and rely on DER, the agency claims those impacts are too "speculative" to analyze. EA at 32. Similarly, although the entire purpose of the rate change is to dis-incentivize the growth of DER, TVA counter-intuitively concludes that its proposed rate changes are "unlikely to influence the rate of investment in DER among TVA consumers" and thus will not result in "any direct, indirect, or cumulative impacts." EA at 34. Indeed, the EA claims that even a 2.5 cents per kilowatt hour charge would have no influence on DER investment, and thus no impacts on the environment. *Id.* at 36. This arbitrary and capricious reasoning seeks to have it both ways, acknowledging that the purpose of the proposed action is to dis-incentivize investment in DER, and then claiming the proposed action would have no influence on investment in DER as a means to escape review of the environmental impacts of its proposed action. The 2019 IRP EIS should exclude any such specious reasoning.

In the EA, TVA recognizes that its dirty power generation produces air pollution and GHG emissions. EA at 38-39. However, relying on its premise that these rate changes will not change customer behavior, the EA claims that there will be no measurable change in these emissions. *Id.* TVA should avoid repeating such unsupported and fallacious reasoning in its 2019 IRP EIS.

4. The 2019 IRP

On February 14, 2018, TVA announced its Notice of Intent (NOI) and the scoping process for the 2019 IRP. 83 Fed. Reg. 6,668 (Feb. 14, 2018). TVA explained the IRP is being updated "in response to major changes in the electrical utility industry," particularly "advances in the development of distributed energy resources." *Id.*

According to the NOI, the 2019 IRP will address the impacts of "alternative portfolios of energy resource options," including DER, taking into account the fact that "consumer demand for renewable and distributed energy resources . . . is growing." *Id.* Thus, the new IRP will address, *inter alia*, "the availability and use of" DER; the "effects of power production on the environment, including climate change," emissions of greenhouse gases, air quality, water quality, ecological issues, energy efficiency, and "how [DER should] be considered in TVA planning." *Id.* at 6,668-69. The NOI states a draft IRP is expected later this year, and a final new IRP next year. *Id.*

DISCUSSION

I. ENERGY SOURCES, ENERGY EFFICIENCY AND CLIMATE CHANGE

As discussed in detail below, TVA's operations have enormous impacts on the environment, and on a very long list of imperiled species. Most significantly, TVA's power choices are fueling the acceleration of climate change, the greatest existential threat to *homo sapiens*, and indeed to all species on Earth.[2]

A. RANGE OF ENERGY SOURCE ALTERNATIVES

The Center urges TVA to take full advantage of the 2019 IRP EIS to examine a reasonable range of alternatives, each of which would enable it to: a) move away from the use of fossil fuels as quickly as possible; and b) to instead meet consumer demand through a combination of aggressive energy efficiency initiatives, as well as deployment of – and encouragement of – both centralized and distributed renewable energy resources.

Within this range of alternatives, TVA should evaluate two individual alternatives that explore options to: a) maximize DER as a component of TVA's overall mix of power sources; and b) chart a course to attaining a 100% renewable energy mix for TVA by 2050. This second alternative would achieve its goal via a voluntary, in-house, TVA-specific "renewable portfolio standard," which would gradually increase over the passage of time until 100% renewable power generation is attained.

B. SCOPE OF NEPA IMPACTS ANALYSIS

As discussed, *supra,* NEPA requires that TVA "consider *every* significant aspect of the environmental impact of a proposed action." *Baltimore Gas & Elec. Co.*, 462 U.S.

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[2] *See* ADDENDUM, *infra.*

at 97. The 2019 IRP EIS must address all of the effects of the totality of TVA's operations which would result from the implementation of the proposed IRP. This totality of operational effects includes the present day, ongoing operational effects that would continue under the proposed IRP, and therefore TVA may not artificially limit its NEPA review to the changes TVA plans to make to its energy mix relative to the status quo. This is because, as the agency's March 2018 rate change proposal shows, TVA has conveyed an intent to continue relying on dirty and destructive energy sources for the foreseeable future. Under these circumstances, the implementation of the 2019 IRP will result in continuing GHG, air pollution, water pollution, adverse habitat modification, extirpation and extinction impacts, as discussed in detail, *infra*. As to the extinction consequences flowing from TVA's prospective energy source choices, these impacts bring into sharp relief the rationale behind NEPA's command to address in the 2019 IRP EIS every "irreversible or irretrievable commitment of resources" resulting from the implementation of the IRP.

The character of TVA's energy source impacts must be examined to fully appreciate why simply analyzing impacts of changes to TVA's current energy source mix is insufficient to satisfy the commands of NEPA. The coal industry, coal plants, nuclear power plants and dams can inflict chronic, cumulative and synergistic harms on a species weaken the species as a whole, but do not drive it extinct in one, five, or even ten years. However, under this barrage of stressors, a species could succumb to extirpation from a watershed or even extinction in year 35. If TVA were to write its IRP in year 34 of this time period, and dismiss all ongoing impacts from continuing activities by the agency, only to have our hypothetical species go extinct the following year as a result of all of the cumulative stressors that TVA generated and chose to ignore, this would constitute an inexcusable subversion of NEPA's command to "consider *every* significant aspect of the environmental impact of a proposed action." *Baltimore Gas & Elec. Co.*, 462 U.S. at 97.

C. THE 2019 IRP's EIS MUST CLOSELY EXAMINE EFFICIENCY MEASURES

The Center urges TVA to devote significant resources to examining efficiency measures in its EIS. A transition to greater reliance on DER and centralized renewable energy sources necessitates a concurrent transition to an aggressive energy efficiency regime, As discussed further below, glaring inefficiencies exist all along TVA's energy chain. From inefficiencies in TVA's energy production systems, to glaring inefficiencies in TVA's sprawling energy transmission infrastructure, as well as dramatic end-use inefficiencies that all add up to staggering losses of potential power that go unused. TVA must examine a reasonable range of alternatives in pursuit of aggressive efficiency gains, both to enable a more rapid transition to renewable energy sources, and to reduce energy consumption as a means to protect the environment from the land, air, water, and climate pollution generated by TVA's energy operations. TVA should focus significant resources on tackling inefficiencies in its own power systems, but TVA should also invest significant amounts of money and man-hours in helping customers to boost end-use energy efficiencies in their homes.

D. THE 2019 IRP's EIS MUST MEANINGFULLY CONSIDER THE ENVIRONMENTAL IMPACTS OF TVA'S 2018 RATE PROPOSALS DUE TO SUPPRESSION OF DER.

Generally DER is important to the Center's mission because of the significance of DER as one part of a comprehensive solution to address the climate crisis. The treatment of DER in the 2019 IRP EIS is a key priority for the Center because TVA recently put forward the March 2018 Proposed Wholesale Rate Change in order to stifle the growth of DER. TVA has tiered its analysis of the DER-stifling impacts of its rate change proposal to the 2019 IRP's EIS, and so we must necessarily discuss the 2018 rate change EA and analysis of DER impacts in detail here. The criticisms provided here regarding the 2018 rate change EA are provided as examples of mistakes to be avoided in the preparation of the 2019 IRP EIS.

1. The Rate Proposal Will Have Concrete Adverse Environmental Impacts.

TVA's March 2018 Proposed Wholesale Rate Change will take $1.2 billion dollars per year currently paid by customers based on the amount of electricity they use, and shift that amount to a mandatory fee paid by residential customers *regardless* of their energy usage. According to TVA's own analysis, this will result in DER customers paying *more* for their electricity than they do currently, along with others whose reliance on TVA for their electricity is on the lower end of the spectrum (due to energy efficiency or other conservation measures). In other words, customers purposefully buying less energy from TVA will be monetarily penalized for their usage and overall conservation efforts—a perverse result given TVA's statutory mandates as well as the current environment of runaway climate change and air pollution.

The "primary objective" of the March 2018 Proposed Wholesale Rate Change is to increase the charges paid by DER customers in TVA's service territory, which TVA calls "uneconomic." Indeed, with approximately 4 million households served by TVA,[3] TVA's proposal will add mandatory fees of $300 on average per year to each household, regardless of their energy usage. For those considering investing in distributed energy

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[3] S*ee* https://www.tva.gov/About-TVA.

systems, this lost savings will inevitably turn them away from such an approach, given that these added costs will add *years* to the time necessary for them to recoup that investment. For example, if a homeowner currently sought to invest in a solar system for a net cost of $10,000 after the Investment Tax Credit (ITC) and anticipate recovering that investment over a 10 year period, the imposition of TVA's mandatory fees of $300 per year will elongate the payback period to *more than 14 years*.[4]

Indeed, a study by LBNL found that adoption of DER is "highly sensitive" to retail rate structures and that "rate structures with higher monthly fixed customer charges or PV compensation at levels lower than the full retail rate can dramatically erode aggregate customer adoption of PV (from -14% to -61%, depending on the design)."[5] These commonsense economic principles of how price influences demand illustrate the detrimental impacts of TVA's proposed rates on DER demand: even with federal tax and other incentives, TVA's mandatory fees threaten to dramatically decrease DER investment in the region, with concrete environmental impacts that must be analyzed.

Moreover, particularly given that one of TVA's "Guiding Principles" is the recognition that consumers make rational decisions in response to the price signals

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[4] If the homeowner recovers $1,000/year in electricity savings, the $10,000 would be recovered by year 10. Reducing that savings by $300/year, to only $700/year, extends the time necessary to recoup the investment to past year 14. This four year difference in payback period will concretely influence consumer decision to buy panels; a study by DOE's National Renewable Energy Laboratory found that a payback period difference of one to three years can influence the likelihood of non-PV households to adopt PV. *See* Diffusion into New Markets: Economic Returns Required by Households to Adopt Rooftop Photovoltaics (NREL Report) at 1, *available at* https://www.aaai.org/ocs/index.php/FSS/FSS14/paper/viewFile/9222/9123.

[5] *See* Lawrence Berkeley National Laboratory report, "Net metering and market feedback loops: Exploring the impact of retail rate design on distributed PV deployment" (LBNL Report) at 1, *available at* http://emp.lbl.gov/sites/all/files/lbnl-183185_0.pdf.

established through TVA's rate-setting process, *see* EA, Appendix C at 3, it could not be more clear that both the *intended* and *actual* result of the March 2018 Proposed Wholesale Rate Change will be *to increase residential customer reliance on TVA's power generation, almost 50 % of which still comes from coal and natural gas*.

As a result, TVA must evaluate the environmental impacts associated with increased reliance on coal and natural gas likely to result from this action. This includes not only the increased amount of and exposure to air pollutants, but also the increased release of GHGs and associated impacts on climate change. In addition, any meaningful analysis of the environmental impacts must also include the construction and maintenance of existing and new fossil fuel power plants and the "lock in" effect of such capital-intensive projects that have multi-decade lifespans and inherently commit energy portfolios to dirty energy sources in the long-term.

Indeed, the connection between TVA's 2018 rate changes and the inevitable increases in fossil fuel facilities and production by TVA – as a result of (a) reduced development of DER; (b) reduced incentives to implement energy efficiency or other conservation measures; and (c) new incentives to use *more* electricity supplied by TVA – is considerably closer than in other cases, where reviewing courts have consistently required agencies to consider the indirect effects of their decisions on climate change and air pollution.[6]

[6] TVA may not ignore relevant impacts on the grounds that it is simply passing along new rates to power companies, whose decisions whether to impose them on customers is not in TVA's control. To the contrary, TVA knows and anticipates that its power companies will pass along these new rates, and its analysis expressly proceeds on that assumption. See EA at 13 (discussing TVA's review process for power company rate change, which TVA assumes will follow TVA's new structure).

For example, in recent years courts have consistently required federal agencies to consider these issues in connection with the mere *sale* of fossil fuels, rejecting agency arguments that the connection between the agency decision at issue and the subsequent emissions is too uncertain and attenuated to require NEPA consideration. *See, e.g., WildEarth Guardians v. BLM,* 870 F. 3d 1222, 1236 (10th Cir. 2017) (requiring consideration of ultimate emissions resulting indirectly from sale of coal).[7] Here, of course, the connection is much closer, since it is evident that TVA *itself* will burn additional fossil fuels to satisfy the substantial additional electricity demand that its March 2018 Proposed Wholesale Rate Change is designed to, and will inevitably, generate. *See also Sierra Club v. FERC*, 867 F.3d 1357, 1375 (D.C. Cir. 2017) (requiring consideration of emissions associated with a gas pipeline, explaining that the agency must analyze "whether total emissions, on net, will be reduced or increased by this project, [and] what the degree of reduction or increase will be"). Moreover, TVA's organic statute *itself* requires that in any evaluation of energy costs, the agency must take into account "all direct and quantifiable net costs for an energy resource over its available life, including the cost of production, transportation, utilization, waste management, [and] environmental compliance . . . ." 16 U.S.C. § 831m-1(b)(3).

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[7] *See also Dine Citizens Against Ruining Our Env't v. Office of Surface Mining Reclamation & Enf't*, 82 F. Supp. 3d 1201 (D. Colo.2015) (same); *WildEarth Guardians v. Office of Surface Mining, Reclamation & Enf't*, 104 F. Supp. 3d 1208, 1230 (D. Colo. 2015) (same); *Conservation Advocates v. U.S. Forest Serv.*, 52 F. Supp. 3d 1174 (D. Colo. 2014)(same); accord *Mid States Coal. for Progress v. Surface Transp. Bd.*, 345 F.3d 520, 549 (8th Cir. 2003) (requiring consideration of air quality and greenhouse gas emissions associated with coal transportation); *N. Plains Res. Council, Inc. v. Surface Transp. Bd.*, 668 F.3d 1067, 1082 (9th Cir. 2011) (same).

As a starting point, therefore, TVA must systematically and meaningfully analyze how *much more* fossil fuels likely will be burned as a result of the March 2018 Proposed Wholesale Rate Change. It must then calculate the costs associated with this result, according to well established metrics regarding the social cost of carbon and methane. *See, e.g., Montana Environmental Information Center v. U.S. Office of Surface Mining*, 2017 U.S. Dist. LEXIS 129018 (D. Montana, Aug. 14, 2017); *High Country Conservation Advocates*, 52 F. Supp. 3d at 1191 (finding it was "arbitrary and capricious to quantify the benefits of the [proposed] lease modifications and then explain that a similar analysis of the costs [due to greenhouse gas emissions] was impossible"). The fact that TVA's power generation mix as evaluated in the 2015 IRP is already anticipated to result in declining GHG emissions, *see* EA at 38, is entirely irrelevant to this necessary analysis. To satisfy NEPA, TVA must evaluate the additional emissions associated with the 2018 rate change as compared to the baseline no action alternative, regardless of the direction of GHG emissions under that alternative. *See Ctr. for Biological Diversity v. United States DOI*, 623 F.3d 633, 642 (9th Cir. 2010) (explaining that an agency's NEPA analysis must compare the impacts of a proposed action against "a baseline" under which the proposed action is not taken, but where other factors remain the same). Put another way, if TVA GHG emissions without this rate change would decline 2%, but with this change they will only decline 1%, TVA must fully evaluate this 1% *increase* in GHG emissions.

Moreover, given the impacts of increased greenhouse gas emissions and climate-change-driven superstorms, TVA must also consider the risks these increased emissions pose to TVA's service territory, which is no stranger to such storms. Just the opposite:

Hurricane Katrina resulted in extensive damage in Alabama and Mississippi, where TVA collectively serves more than 800,000 homes, and future superstorms in the area are inevitable. Given the urgent need to reduce GHG emissions in order to fulfill U.S. GHG-reduction commitments in the Paris Agreement[8] – adopted at the 2015 United Nations Framework Convention on Climate Change Conference of the Parties – science shows that the U.S. must transition from a fossil-fuel based economy to a clean energy economy as fast as possible. The wide deployment of solar energy is key to unlocking this country's just transition to clean, renewable energy to avoid the worst impacts of climate change.

Given how close we are to the tipping point where we can no longer forestall the worst impacts of climate change, it is vital that we undertake this renewable energy deployment as rapidly as possible. Yet, TVA's 2018 rate change is expressly designed to delay and obstruct this transition. Consequently, TVA must also evaluate the risks the 2018 rate change poses to the clean energy transition, and resulting risks it poses to exacerbating the direct and indirect impacts associated with climate change.[9] As a corollary, TVA must also analyze the impact of increased demand for fossil fuel energy on the construction of new fossil fuel plants to supply such demand, factoring in the environmental effects of such additional power plants that lock in TVA's commitment to

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8 *See* United Nations Framework Convention on Climate Change, Conference of the Parties, Nov. 30-Dec. 11, 2015, Adoption of the Paris Agreement Art. 2, U.N. Doc. FCCC/CP/2015/L.9, (Dec. 12, 2015), http://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf ("Paris Agreement").

9 Further details concerning the need for a rapid transition to clean energy in order to avoid the worse effects of climate change are contained in an Addendum appended at the end of these comments.

fossil fuel infrastructure for multiple decades—and the avoided benefits of transitioning away from fossil fuel plants.

For the same reasons, TVA must analyze the impacts of the increased fossil fuel emissions that will be engendered by the 2018 rate change on other environmental resources, such as water quality. For example, the EA recognizes that these emissions generate "air pollutants such as mercury" which is "spread through rainfall and deposition." EA at 40. In addition, particularly at TVA's many coal-fired power plants, emissions of numerous other pollutants into waterbodies are common, including selenium, arsenic, nickel, thallium, and zinc. *See, e.g.,* 78 Fed. Reg. 34,432 (2013). Indeed, as the federal Environmental Protection Agency (EPA) has explained, coal plants "contribute 50-60 percent of all toxic pollutant discharged into surface waters by all industrial categories," levels that will only further increase "as pollutants are increasingly captured by air pollution controls and transferred to wastewater discharges." *Id.*; *see also* 80 Fed. Reg. 67,838 (Nov. 3, 2015) (EPA Final Rule concerning coal plant discharges).

Similarly, given the myriad other risks posed by coal plants – such as coal ash ponds, which have had devastating environmental impacts – TVA must take these risks into account as well.[10] In sum, since the 2018 rate change will inevitably lead to further fossil fuel production, these and other related impacts must also be analyzed.[11]

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10 *See, e.g.* Kingston Fossil Plant Ash Slide Interim Report (concerning the Ash spill at TVA's Kingston Fossil Plant), *available at* https://oig.tva.gov/reports/09rpts/2008-1228301.pdf; *TVA fined $11.5 million in sludge spill*, CNN, June 14, 2010, *available at* http://www.cnn.com/2010/US/06/14/tennessee.sludge.spill/index.html.

11 At one point, the EA asserts, without any support, that "any additional generation needs" stemming from the 2018 Rate Change "would be met by natural gas generation due to its low cost." EA at 39. However, since TVA continues to rely heavily on coal

Finally, on the socio-economic front, TVA must consider the adverse impacts of the overall rise in electricity costs it is proposing for those on the lower end of the spectrum of residential electricity usage, which includes communities seeking to use less energy either for energy conservation goals or economic savings and will include lower income families. *See* EA at 28. Thus, particularly given TVA's stated concern with "lower income households heating their homes to less than comfortable temperatures" in order to afford their utility bills, EA at 25, TVA must consider the inevitable adverse impacts of raising electricity prices for those who can least afford these increased costs. The EA is void of this basic analysis on its most economically vulnerable consumers.

i. TVA Cannot Avoid Considering The GHG and Climate Impacts of The 2019 IRP On The Grounds That They Are Unquantifiable.

First, as discussed in cases requiring agencies to consider GHG emissions that are an indirect effect of agency decisions, TVA may not dismiss these impacts as simply too speculative or unquantifiable.[12] Even if TVA cannot entirely "accurately" calculate the

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generation *despite* the low cost of gas, there is simply no basis for TVA's assumption that it will only rely on gas to supply the additional central generation electricity the 2018 Rate Change is designed to generate. This assumption is further undermined by the ongoing efforts being made at the federal level to subsidize coal production. *See* Bloomberg Politics "Trump Says He's Looking at Emergency Aid for Battered Power Plants," *available at* https://www.bloomberg.com/news/articles/2018-04-05/trump-says-emergency-aid-sought-by-firstenergy-to-be-examined .

[12] As an example of how greenhouse gas emissions have been successfully quantified, Maine's PUC took avoided emissions costs into account in its 2015 valuation study by applying values for "Net Social Cost of Carbon" (2.1 cents per kWh), "Net Social Cost of SO_2'' (6.2 cents per kWh), and "Net Social Cost of NO_x" (1.3 cents per kWh) for a total of 9.6 cents per kWh. *See "*Maine Distributed Solar Valuation Study" at 6 *available at* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-ExecutiveSummary.pdf.

total emissions expected from the 2018 rate change, it must make appropriate estimates, for some "speculation is . . . implicit in NEPA," and agencies may not "shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as crystal ball inquiry." *N. Plains Res. Council, Inc. v. Surface Transp. Bd.*, 668 F.3d 1067, 1079 (9th Cir. 2011) (citation omitted); *High Country Conservation Advocates*, 52 F. Supp. 3d at 1196.

ii. TVA Also Cannot Proceed With Its Rate Change At This Time and Ignore These Environmental Impacts, On The Grounds That Such Analysis Will Be Covered By An IRP.

Second, TVA may not avoid these NEPA duties by claiming that the missing impacts analysis is more suitably handled in the context of the IRP process. *See* EA at 39 (claiming any environmental impacts to air pollution or greenhouse gas emissions from the 2018 rate change was addressed in the 2015 IRP). As numerous precedents have established, while an agency may rely on the "tiering" process to avoid addressing issues twice – by, for example, fully addressing broad issues in a programmatic document and then incorporating that analysis by reference into a site-specific document – tiering is only permissible where the issue was actually *addressed* in the document to which the agency seeks to tier. *See, e.g., Kern v. BLM,* 284 F.3d 1062, 1076 (9th Cir. 2002).

TVA last prepared an IRP in 2015. While that plan addressed TVA's power generation and alternatives generally, as noted, the 2015 IRP and associated EIS *expressly did not address issues related to DER*. Rather, as noted, the 2015 IRP expressly excluded DER as a "resource acquisition issue *outside the scope of the IRP*." 2015 EIS at 136 (emphasis added); IRC Response to Comments at 15 ("the analysis around deploying distributed resource is an undertaking *outside the IRP study process*")(emphasis added). Accordingly, there is absolutely no basis on which TVA could "tier" to the 2015 IRP in addressing environmental impacts associated with rate changes that will impact the development of DER in TVA's service territory. Rather, those impacts must be addressed in the NEPA analysis over the 2018 rate change itself.[13]

Alternatively – and even more appropriately – TVA may address these environmental impact issues in its 2019 IRP and associated EIS, the process for which has just recently begun. Indeed, as noted, the new IRP is slated to address many of the environmental issues discussed above, including, *inter alia*, "the availability and use of" DER; the "effects of power production on the environment, including climate change," "emissions of greenhouse gases," and "air quality," and "how [DER should] be considered in TVA planning." 83 Fed. Reg. 6,668-69 (Feb. 14, 2018). Accordingly, it would be entirely appropriate for TVA to consider these environmental impacts associated with the agency's unprecedented shift to mandatory fees in the NEPA process that will be undertaken in connection with the 2019 IRP.

However, should TVA proceed in this manner and undertake this environmental analysis in the 2019 IRP, *it may not impose the proposed $1.2 billion in mandatory fees until the 2019 IRP process is complete*. As noted, the fundamental purpose of a NEPA process is to inform agency decision-making prior to the final decision--and not to ratify a decision already made. *See, e.g., Sierra Club v. Peterson*, 717 F.2d 1409, 1415 (D.C. Cir. 1983) (NEPA "requires federal agencies to evaluate the environmental consequences

[13] This includes cumulative impact issues, which the EA also indicates were somehow addressed in the 2015 IRP. EA at 46. (claiming TVA relies on the IRP process to consider the cumulative impacts of pricing and other policies that impact consumer behavior).

of their actions *prior* to the commitment to any actions"); *Metcalf v. Daley*, 214 F.3d 1135, 1143 (9th Cir. 2000); *Cal. ex rel. Lockyer v. United States Dept. of Agric.*, 459 F. Supp. 2d 874, 905 (N.D. Cal. 2006). (explaining that reasonable alternatives must be considered "before the environmental die is cast"). Thus, since it seems clear that TVA already intends to consider these vital issues in the 2019 IRP, it must shelve these proposed rate change until that process is complete. *See Black Warrior Riverkeeper v. Ala. DOT*, No. 11-CV-267-WKW, 2016 U.S. Dist. LEXIS 5839, *8 (M.D. Ala. Jan. 19, 2016) ("NEPA requires federal agencies to prepare an EIS *before* undertaking major federal action that will significantly affect the quality of the human environment.") (emphasis added).

There is no reason that this approach should cause any hardship to TVA. The process for the 2019 IRP has already begun, and will be completed next year. Since, as we will discuss, TVA cannot separately go ahead with its 2018 rate change proposal without at least preparing a separate EIS, it will likely take a comparable amount of time for the agency to simply wait until after the 2019 IRP to re-consider the current proposal. At that time, assuming the 2019 IRP has fully and fairly considered the environmental impacts of, and reasonable alternatives to, mandatory fees that will diminish adoption of DER and otherwise encourage additional reliance on TVA central energy production, TVA could tier to *that* NEPA review in its site-specific analysis for imposing mandatory fees on residential customers.

Overall, the one step TVA may *not* take, however, is to proceed on its current course, refusing to address the environmental impacts of its 2018 Rate Change on the grounds that those issues are better addressed in the EIS conducted in the IRP planning process. Since these matters were not addressed in the 2015 IRP, TVA must either address them in its 2018 rate change proposal's NEPA analysis, or wait until they are addressed in the 2019 IRP before proceeding.

D. ANY NEPA ANALYSIS OF THE MARCH 2018 PROPOSED WHOLESALE RATE CHANGE MUST CONSIDER A REASONABLE RANGE OF ALTERNATIVES FOR DISTRIBUTED ENERGY RESOURCES.

If TVA chooses to remain on its current course and analyze rate change impacts in the 2019 IRP EIS, then a reasonable range of alternatives must be included for DER in its analysis. Since the stated purpose of the 2018 rate change is to impact the adoption of DER (by addressing purported "over-incentives"), TVA must consider a reasonable range of alternatives regarding the rates of DER adoption in TVA service territory. For example, rather than only considering alternatives that will stifle DER development, TVA must consider alternatives that will *expand* that development so that it is more commensurate with the development of DER in other areas of the country. Indeed, given how far behind the states served by TVA are in DER development, TVA plainly must consider alternatives that will encourage further adoption of DER. [14] It must then address the comparative environmental benefits of this approach as compared to TVA's

[14] Alabama's and Tennessee's small-scale PV capacity of 4.7 and 53.1 MW made up *0.02* and *0.25* percent, respectively, of their net capacity from all utility sources for December 2016 (the most recent year available for both, as December 2017 data was not statistically meaningful for Alabama). Maine, Pennsylvania, Arizona, and New Jersey's respective small-scale PV capacity of 23.4, 213.7, 871.8, and 1058.3 MW made up *0.48, 3.06, 5.60, and 8.65* percent, respectively, of their net capacity from all utility sources for December 2016. *See* EIA's Electric Power Monthly: February 2018, Tables 6.2.A and 6.2.B, available at https://www.eia.gov/electricity/monthly/archive/february2018.pdf.

continued reliance on fossil fuels for the electricity generation that could be provided through DER.

TVA must also consider alternative means to address the needs of low-income consumers that take into account the adverse impacts of the proposed mandatory fees on such communities. TVA's principal rationale for the 2018 Rate Change is a purported concern that DER is having adverse impacts on lower income consumers who have not installed DER (and who TVA claims are being forced to subsidize DER development). *See* EA at 25 ("TVA's desire to avoid shifting costs to customers without DER, and particularly to avoid shifting costs onto low-income households, is one of the reasons why TVA has proposed a rate change"); *see also id.* (claiming "current policies would result in lower income households paying increasing shares of the cost of residential electricity over time [which] could potentially impose meaningful financial costs on the lowest income residential customers"). However, if TVA wants to show concern for low-income populations as the EA purports, the agency should consider alternatives that incorporate guidelines developed by groups such as NAACP and GRID Alternatives, which outline policies that help increase access to distributed solar for low- and middle-income communities.[15] Both groups recommend full retail-rate net metering and virtual net metering *without* excess or fixed fees, and community solar as options to increase distributed solar access to low- and middle-income communities.[16]

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15 *See* NAACP Model Energy Policies, *available at* http://www.naacp.org/wp-content/uploads/2014/03/Just-Energy-Policies_Model-Energy-Policies-Guide_NAACP.pdf; *See also* Low-Income Solar Policy Guide, *available at* http://www.lowincomesolar.org/wp-content/uploads/2017/03/Policy-Guide_3.7.17.pdf.

16 *See* NAACP Model Energy Policies at 25-29, *available at* http://www.naacp.org/wp-content/uploads/2014/03/Just-Energy-Policies_Model-Energy-

In any event, TVA's arguments—that distributed generation at TVA's current levels threaten low-income communities via cost-shifting, as discussed above, and that there would be "more stability" with less distributed solar, implying that only high-income customers can afford solar--are not supported by the facts.

First, TVA's arguments regarding DER's negative impacts on electricity stability are patently false and unsupported by evidence. Distributed solar serves to increase grid resiliency benefits as well as adds value as a solution to hedge against long-term volatile fossil fuel prices.[17] The argument for preventing distributed solar expansion in order to improve stability for low-income customers is in any event a farce; TVA asserts that the proposed rate changes would benefit low-income communities by lessening seasonal bill fluctuations, but without evidence to back this claim. TVA also acknowledges that these alternatives all have the potential to increase monthly bills for the majority of customers, but fails to explain what this increase would be or how it will impact electricity bills for low-income customers. EA at 15.

Policies-Guide_NAACP.pdf; *see also* Low-Income Solar Policy Guide at 13 and 15, *available at* http://www.lowincomesolar.org/wp-content/uploads/2017/03/Policy-Guide_3.7.17.pdf

[17] *See* National Renewable Energy Laboratory report "The Use of Solar and Wind as a Physical Hedge against Price Variability within a Generation Portfolio at vii, *available at* https://www.nrel.gov/docs/fy13osti/59065.pdf. *See also* Lawrence Berkeley National Laboratory report "Quantifying the Value that Energy Efficiency and Renewable Energy Provide As a Hedge Against Volatile Natural Gas Prices" at 5.24, *available at* https://pub-jschol-prd.escholarship.org/uc/item/0t4653n0. As an example of how the hedge value of DER can be considered, Austin utility Austin Energy quantified this benefit by including a solar hedge value in its methodology for its Value of Solar tariff (VOST). *See* Designing Austin Energy's Solar Tariff Using a Distributed PV Value Calculator at 2, *available at* http://www.cleanpower.com/wp-content/uploads/090_DesigningAustinEnergysSolarTariff.pdf .

Second, although it is true that solar owners tend to have higher incomes than the national average, it is not true that the majority of solar owners are high-income or that low- and middle-income homes do not invest in solar. A report by GTM Research and PowerScout showed that in the four states that account for 65 percent of residential solar installations in the country, 70 percent of solar households are middle-income.[18] At bottom, increased levels of distributed solar generation would provide benefits to low-income communities and communities of color that are not considered in TVA's DG-IV[19] or EA reports. Distributed solar can also provide long-term financial benefits to families struggling with high and unpredictable energy costs and a source of clean energy sited in communities that have been disproportionately impacted by pollution and climate impacts from traditional power generation.[20]

Finally, the solar industry also offers employment opportunities that benefit low- and middle-income communities across the country; the national solar workforce increased by 168 percent from 2010 to 2017.[21] The solar workforce is also more racially

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[18] *See* How Wealthy Are Residential Solar Customers?: Household Income and Solar Adoption in the U.S. at 5 and 7, *available at* https://www.greentechmedia.com/research/report/how-wealthy-are-residential-solar-customers#gs.ay=GUEg.

[19] TVA's 2015 "Distributed Generation – Integrated Value" (DG-IV) report was meant to calculate the economic value that solar power provides to TVA's grid. *Available at* https://www.tva.gov/file_source/TVA/Site%20Content/Energy /Renewables/dgiv_document_october_2015-2.pdf .

[20] *See* Low-Income Solar Policy Guide at 4, *available at* http://www.lowincomesolar.org/ wp-content/uploads/2017/03/Policy-Guide_3.7.17.pdf.

[21] *See* National Solar Jobs Census 2017 at 4, *available at* https://www.thesolarfoundation.org/national/. In Tennessee alone, solar jobs increased by

and gender diverse than other energy sectors, including the coal and oil and gas industries.[22]

Accordingly, to the extent the purpose of TVA's action is to benefit low-income communities, it plainly must consider reasonable alternatives that would actually benefit these communities by increasing their access to DER and its associated benefits to these consumers.

1. Alternatives that address the public's interest in DER options to promote energy independence, grid resiliency, and economic and environmental interests.

TVA's analysis must also include reasonable alternatives that account for the public's strong interest in expanding DER development in TVA's service area. According to a state-wide poll conducted in October 2017, 81% of Tennessee voters – representative of all income levels – would prefer to see more solar in the state. Eighty-eight percent would want to see solar on their own home, and the same percentage of voters would prefer their electricity bill to be based on usage rather than a fixed fee.[23] The poll's results show that TVA's Rate Proposal is not supported or preferred by its customer base.

24.3 percent in 2017. *See* National Solar Jobs Census 2017: National Map: Tennessee, *available at* https://www.solarstates.org/#state/tennessee/counties/solar-jobs/2017.

[22] *See* Bureau of Labor Statistics 2017 at Table 18.Employed persons by detailed industry, sex, race, and Hispanic or Latino ethnicity, *available at* https://www.bls.gov/cps/cpsaat18.htm, as reported in the Solar Jobs Census 2017, *available at* https://www.thesolarfoundation.org/national/ .

[23] *See* Solar Power World news item "Poll finds 81% of Tennessee voters want more solar in the state", *available at* https://www.solarpowerworldonline.com /2017/12/tennessee-voters-support-solar/.

In sum, in addition to the unfounded claims over cost-shifting, stability, and demographics, TVA's claims to be concerned on behalf of their general customer base and low-income customers in particular are further discredited by the fact that the agency's proposal disregards what TVA's customer base would prefer. Accordingly, TVA must consider reasonable alternatives that are responsive to the public's strong interest in DER.

E. TVA'S FALSE ASSUMPTIONS ABOUT THE ROLE OF DISTRIBUTED GENERATION AND ITS IMPACT ON THE GRID AND OTHER CONSUMERS ARE ARBITRARY AND CAPRICIOUS AND VIOLATE NEPA.

NEPA requires that agencies make decisions based on "high quality" data, and thus forbids agencies from relying on unsupported speculations regarding the bases for, or impacts of, its actions. 40 C.F.R. § 1500.1(b) (requiring that in a NEPA process "[t]he information must be of high quality [with] "[a]ccurate scientific analysis"). Courts, therefore, have not hesitated to invalidate agency decisions that fail to rely on "high quality information and accurate scientific analysis." *Idaho Conservation League v. Bennett*, No. 04-447-MHW, 2005 U.S. Dist. LEXIS 35356, *34 (D. Id. Apr. 29, 2005). By basing its 2018 Rate Change on unsupportable assumptions about the relative cost of DER to the grid and purported "cross-subsidies," TVA is violating these mandates. The 2019 IRP's EIS must not repeat these mistakes.

1. TVA's claim that distributed solar shifts costs from solar to non-solar consumers is erroneous and unsupported.

In response to increased penetration of distributed solar in the energy markets, monopoly electric utilities like TVA and pro-fossil fuel special interest groups, including Edison Electric Institute, Americans for Prosperity, and Consumer Energy Alliance, have all raised concerns about the purported "cost shifting" that occurs from solar customers to non-solar customers.[24] The "cost-shift" argument is based in the premise that compensation paid to solar customers for excess generation unfairly transfers costs both to non-solar customers and electric utilities by reducing the number of grid customers who are contributing to grid maintenance.[25] Both utilities and fossil fuel interest groups raise this "cost- shift" argument as grounds to weaken or remove compensation mechanisms, like net metering, that compensate distributed solar customers for the excess energy generation they provide to the grid.[26]

TVA bases much of its 2018 Wholesale Rate Proposal on this "cost-shift" claim by stating that, "TVA's current energy prices over-incentivize consumer installation of DER, leading to uneconomic results for the people of the Valley as a whole . . . The imbalance created by uneconomic DER investment means that costs are shifted to consumers throughout the Valley who do not invest in DER" (See EA, ES at i).

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[24] *See* Edison Electric Institute "Solar Energy and Net Metering" at 3, *available at* http://www.eei.org/issuesandpolicy/generation/NetMetering/Documents/Straight%20Talk%20About%20Net%20Metering.pdf; *See also* Americans for Prosperity "Why the Sun Isn't Free – By Joel Aaron Foster," *available at* https://americansforprosperity.org/why-the-sun-isnt-free-by-joel-aaron-foster/; *See also* Consumer Energy Alliance "How does solar cost-shifting happen?," *available at* https://consumerenergyalliance.org/kentuckians-solar-fairness/solar-cost-shifting/.

[25] *See* National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory report "Utility Regulatory and Business Model Reforms for Addressing the Financial Impacts of Distributed Solar on Utilities" at xi, *available at* https://www.nrel.gov/docs/fy16osti/65670.pdf.

[26] *See* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/ ; *See also* Frontier Group and Environment America Research and Policy Center report "Shining Rewards" at 11, *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf.

However, TVA fails to explain what data it is using to come to the conclusion that TVA's current energy prices lead to cost-shifting.[27]

This "cost-shift" argument has been repeatedly discredited. Numerous studies have shown that the benefits of distributed solar *equal or exceed* costs to the utility and non-solar customers where distributed solar penetration levels remain relatively low.[28]

Specifically, DOE's Lawrence Berkeley National Laboratory (LBNL) has directly debunked the "cost-shift" argument upon which TVA relies. According to the LBNL report, for the "vast majority of states and utilities, the effects of distributed solar on retail electricity prices *will likely remain negligible for the foreseeable future.*"[29] Moreover, as more states move to Time-of-Use rates and other structures that more closely match customer charges with the true cost to the utility for delivering electricity, any concerns of cost-shifting with even relatively high levels of penetration would likely be alleviated as well.

TVA's cost-shift argument is further undermined by the fact that jurisdictions with far higher levels of DER penetration are not facing the kind of cost-shift TVA claims to be concerned about. Thus, as noted, Alabama and Tennessee (the two states that

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27 TVA's assumptions may be based on a reductive cost-benefit analysis the utility itself conducted in 2015. *See TVA DG-IV report at 6*. If so, this just further demonstrates the inadequacies in TVA's analysis, as we discuss below.

28 *See* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/; *See also* Frontier Group and Environment America Research and Policy Center report "Shining Rewards" at 11, *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf.

29 *See* Lawrence Berkeley National Laboratory report "Putting the Potential Rate Impacts of Distributed Solar into Context" at 29, *available at* https://emp.lbl.gov/sites/all/files/lbnl-1007060.pdf (emphasis added).

make up the majority of TVA's territory) are nowhere *near* a comparable level of distributed solar diffusion in numerous states where cost shifting is still not an issue.[30] TVA certainly cannot proceed here without explaining why mandatory fees are so vital at this nascent stage of DER development in TVA's service area,when they remain entirely unnecessary in other areas of the country where DER penetration is so much higher.

Indeed, TVA also does not have as strong of a compensation mechanism for solar customers as the above mentioned states. By its own forecasting, TVA only expects 2 % of households in the Tennessee Valley to have distributed solar installations by 2030. *See* EA at 25. By contrast, studies conducted in Maine, Pennsylvania, Arizona, and New Jersey – states with much higher levels of rooftop solar diffusion than the Tennessee Valley – all showed that the value of solar still exceeds the retail rate of electricity paid to solar customers for the excess generation provided to the grid.

Moreover, the notion that mandatory fees are necessary to address cross-subsidies among residential customers ignores the reality that the entire system is inevitably riddled with ways in which consumers of electricity are not charged the *exact* costs for the energy they consume. For example, it is common for utilities to rely on commercial and industrial customers to help subsidize the costs from residential customers – although, as noted, TVA appears to be doing just the opposite.

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[30] Alabama's and Tennessee's small-scale PV capacity of 4.7 and 53.1 MW made up *0.02* and *0.25* percent, respectively, of their net capacity from all utility sources for December 2016 (the most recent year available for both, as December 2017 data was not statistically meaningful for Alabama). Maine, Pennsylvania, Arizona, and New Jersey's respective small-scale PV capacity of 23.4, 213.7, 871.8, and 1058.3 MW made up *0.48, 3.06, 5.60, and 8.65* percent, respectively, of their net capacity from all utility sources for December 2016. *See* Tables 6.2.A and 6.2.B from EIA's Electric Power Monthly: February 2018, *available at* https://www.eia.gov/electricity/monthly/archive/february2018.pdf.

As another example, there is no dispute that even energy production itself has varying costs over the course of the day, since the late afternoon and evening hours of peak usage typically require utilities to rely on the most expensive peak generation sources with the highest marginal costs. While utilities have made some effort to address these variations through mechanisms such as Critical Peak Pricing and Time Of Use rates, the fact remains that consumers in all classes are often not paying prices that accurately reflect their costs in all respects. As commentators have noted, in light of these various factors utilities' reliance on "cross-subsidies" as a basis to dis-incentivize DER development is disingenuous, as it fails to reflect the fact that rate design is more art than science, and that such efforts are a futile exercise in pursuit of "false precision."[31]

Critically, many of these studies take into account social and environmental factors, including avoided greenhouse gas emissions, grid resiliency, and economic development and jobs creation. Similarly, here, TVA must take these and similar factors into account before deciding whether there is, in fact, a "cost-shift" that could warrant the more than $1 billion in mandatory fees TVA is proposing.[32] And, as we have explained,

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[31] *See, e.g.,* Air Peskoe, *Unjust, Unreasonable, and Unduly Discriminatory: Electric Utility Rates and the Campaign Against Rooftop Solar*, 11 Texas Jrl. Of Oil, Gas and Energy Law 101,118-28 (2016), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2735789 (last visited Sept. 14, 2016).

[32] For information on retail rate net metering cost-benefit analyses from Maine, Pennsylvania, Arizona and New Jersey, *See* Frontier Group and Environment America Research and Policy Center report "Shining Rewards", *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf; *See also* EIA's Electric Power Monthly December 2017, table 1.17.b for comparative small-scale PV capacity.

see supra at 9-10, it may not rely on guidance from NARUC to simply assert that these cost-shifts are a real threat to consumers in TVA's service area.

2. TVA's cost-shift argument also ignores the proven net benefits of distributed solar to all consumers.

The cost-shift argument also fails because TVA does not acknowledge the greater net benefit that distributed solar brings to all consumers, both solar and non-solar, especially when linked to compensation policies like net metering. While TVA does not allow net metering and instead offers a dual-metering program in which TVA buys all the power solar customers generate, extensive studies on compensation policies help affirm the net benefit of distributed solar to the grid overall. By way of background, net metering is a billing mechanism that has historically compensated owners of distributed generation systems such as rooftop PV solar at retail rates for the excess electricity they send to the grid.[33]

According to two meta-analyses of distributed solar cost-benefit studies, discussed below, the marginal value of solar connected via net metering programs can be calculated as exceeding the retail rate of electricity, and compensation policies like net metering therefore provide a net benefit to all customers. First a meta-analysis conducted by Frontier Group and Environment America Research and Policy Center on

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[33] Net metering policies are widespread in the United States; 38 states and the District of Columbia have mandatory net metering policies in place. *See* NC Clean Energy Technology Center DSIRE Net Metering map, *available at* http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2017/11/DSIRE_Net_Metering_November2017.pdf. Because net metering can significantly improve the financial performance of a rooftop PV system from the consumer's perspective, these policies have contributed to the rapid growth rates of distributed PV in the United States. *See* Lawrence Berkeley National Laboratory report "Net Metering and Market Feedback Loops: Exploring the Impact of Retail Rate Design on Distributed PV Deployment" at 2, *available at* https://emp.lbl.gov/sites/default/files/lbnl-183185.pdf.

cost-benefit studies across the country found that not only is solar energy worth more than the credits offered to solar customers through net metering, but that "studies that find lower values for solar energy often exclude consideration of key benefits that solar panel owners provide to the grid and society."[34] It also found that studies performed by utilities tend to value solar lower than those that are performed by non-utility analysts. *Id.* at 14.

Second, a second meta-analysis performed by the Brookings Institution found the benefits of distributed solar outweigh the costs, and net metering provides a "net benefit" to all ratepayers, not just solar customers.[35] In one example, the Public Utilities Commission of Maine found via a robust cost-benefit analysis that the true value of solar is close to $0.35 per kWh, but Maine's retail rate of electricity was about $0.15 per kWh. In Maine's case, the value of solar *was more than two times the regular retail rate for electricity, and solar customers were putting twice as much value into the grid as what they were being compensated.*[36] Once again, TVA may not base its analysis here on a purported "cost-shift" without explaining why such a shift is occurring in TVA's service territory but not in all these many other jurisdictions – otherwise, TVA's EIS analysis will be patently arbitrary and capricious.

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34 *See* Frontier Group and Environment America Research and Policy Center report "Shining Rewards" at 11, *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf.

35 *See* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/.

36 *See "*Maine Distributed Solar Valuation Study" at 6 *available at* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-ExecutiveSummary.pdf; *See also* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/.

To be sure, despite the widespread success of full retail rate compensation programs and findings of these meta-analyses, debates over how best to compensate solar customers have increased in recent years. In some states (for example, New York), these solar policy debates have been focused on designing rates and policies to ensure that state distributed solar markets can continue to grow while utilities are still able to profit and meet mandated renewable energy goals.[37]

However, in other states, these debates, fueled by the anti-solar interests referenced above, have threatened state-level markets and growth of distributed solar.[38] In an extreme example, NV Energy, one of Nevada's largest public utilities, relied on erroneous data and premises to advance the refuted "cost shift" argument and convince the Nevada Public Utilities Commission (PUC) to drastically cut the state's net metering program, causing the state's three largest providers of rooftop solar to temporarily leave the state entirely. This resulted in an immediate drop in PV solar installations; NV Energy issued permits for 33MW of solar in Q4 2015 but only 3MW in Q1 2016, demonstrating the potential real-world effects of removing compensation mechanisms for solar customers based on cost-shift claims.[39] Fortunately, the Nevada legislature recognized the

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37 *See* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/.

38 *See* Energy and Policy Institute "Attacks on Renewable Energy Policies in 2015" *available at* http://www.energyandpolicy.org/renewable-energy-state-policy-attacks-report-2015/.

39 *See* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/.

false data on which the PUC had relied, and took action to bring State policies back in line with the actual facts.[40]

If TVA were interested in accurately valuating distributed solar resources so as to have rates representative of actual costs, and to maximize benefits for all ratepayers from increased solar diffusion, the agency would follow the lead of many other rate-making bodies across the country and develop a rate proposal based on a thorough cost-benefit study that includes grid, social, and environmental factors, including but not limited to: avoided adverse impacts on habitat and wildlife, reduced line losses, grid resiliency, job creation, avoided air pollution and GHG emissions, avoided water use and pollution, and the social benefits of access to affordable, customer-owned energy in low-income communities.[41] As noted, in one of the most comprehensive studies to date, Maine's Public Utilities Commission included the "social cost" of emissions including carbon, sulfur dioxide, and nitrous oxides (NOx) in their cost-benefit analysis.[42]

We encourage TVA to embark on a similar process, and would welcome the opportunity to participate in such a process. However, again, the most important point is

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[40] *See* PV Magazine "Vivint Solar to join Tesla, Sunrun in returning to the Nevada solar market," *available at* https://pv-magazine-usa.com/2017/06/09/vivint-solar-to-jointesla-sunrun-in-returning-to-the-nevada-solar-market/.

[41] *See, e.g.,* Frontier Group and Environment America Research and Policy Center report "Shining Rewards" at 11, *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf; *See also* Brookings Institution report "Rooftop solar: Net metering is a net benefit," *available at* https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/.

[42] *See* "Maine Distributed Solar Valuation Study" at 4 *available at* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-ExecutiveSummary.pdf.

that TVA may not proceed with mandatory fees until it has engaged in this kind of meaningful analysis, which has a proven track record of feasibility and utility in these important rate-making decisions.

Indeed, TVA's current EA fails to take these factors into account altogether. Further, although TVA's 2015 "Distributed Generation – Integrated Value" (DG-IV) report does at least identify these factors,[43] it entirely excludes these factors as part of the value of solar calculation--despite the fact that stakeholders brought to TVA's attention that these benefits would add approximately 6 cents per kilowatt hour to the calculation.[44]

TVA's DG-IV report is not unlike other reports conducted by utilities across the country by looking at so few factors. As the above mentioned meta-analysis found, cost-

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43 Specifically, TVA's claim that current energy prices "over-incentivize" consumer installation of DER seems to be based on TVA's 2015 "Distributed Generation – Integrated Value" (DG-IV) report (although that remains unclear as no data or reference is cited to back this claim in the rate proposal). Assuming this claim is based in the DG-IV report, which was meant to calculate the economic value that solar power provides to TVA's grid, it is clear that report is based on an inappropriate reductive analysis. The DG-IV report found that distributed solar avoids costs from burning coal or natural gas for electricity, but that the price TVA pays to solar owners for their excess generation exceeds the value of solar. Further, while the report purported to take into account benefits from deferring the need to build and maintain new power plants, avoided fuel costs, environmental compliance costs, and changes in transmission and distribution (T&D), it did not take into account other critical environmental and social factors that must be addressed, as discussed above. *See* DG-IV at 12-14, *available at* https://www.tva.gov/Energy/Valley-Renewable-Energy/Distributed-Generation%E2%80%93Integrated-Value-Report.

44 *See* Southern Alliance for Clean Energy's blog "TVA Undermines Distributed Solar and Disregards Its Own Stakeholder Process," *available at* http://blog.cleanenergy.org/2015/11/11/tva-undermines-distributed-solar-and-disregards-its-own-stakeholder-process.

benefit analyses performed by utilities are more likely to exclude environmental and social benefits, as well as indirect grid benefits, and focus only on costs and savings that affect the direct costs of operating the grid by utilities.[45] In short, failing to include a robust cost-benefit analysis of distributed solar in TVA's 2019 IRP EIS renders the agency's reliance on it arbitrary, capricious and contrary to the law under the APA.

F. THE OTHER TVA RATIONALES FOR THE RATE CHANGE PROPOSAL ARE INTERNALLY INCONSISTENT OR OTHERWISE UNREASONABLE.

TVA's 2018 rate change proposal EA's analysis of DER relies on internally inconsistent and/or unreasonable logic that should not be replicated in the 2019 IRP EIS. For example:

1. The EA claims that under the "no action" alternative, because more people will install DER, other customers will have price increases, which will result in "lower income households heating their homes to less than comfortable temperatures than they would have otherwise." EA at 25. TVA cannot make decisions based on such rank speculation. Indeed, even if there were price increases, it is just as likely that higher prices would lead homeowners to invest in insulation, DER or other measures that might reduce their reliance on TVA-supplied energy. Of course, these results do not satisfy TVA because it is plain that the agency's objective is to sell as much electricity as possible to feed their bottom line. But the agency cannot be permitted to justify its audacious effort to quash renewable energy by claiming that DER will cause kids in poor homes to be left in the cold.

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45 *See* Frontier Group and Environment America Research and Policy Center report "Shining Rewards" at 14, *available at* https://environmentamericacenter.org/sites/environment/files/reports/AME%20ShiningRewards%20Rpt%20Oct16%201.1.pdf.

2. Similarly, the EA asserts – again, with no substantiation – that additional DER investment will "reduce the future incentive for utility-scale investment in renewable energy generation." EA at 25. In particular, TVA claims that since additional DER reduces demand for additional central generation, this means less demand for utility-scale solar. *Id.* However, since it is just as likely that additional generation will come from other power sources – including coal and natural gas – this assumption is also baseless. It also ignores the benefits of DER over utility-scale solar, including avoided wildlife mortality and avoided land use and land cover change from both transmission and siting of utility-scale solar plants.[46] Again, TVA simply cannot justify the need to imposed mandatory fees on such illogical and unsupported premises.

3. The EA also claims that a benefit of this rate change will be to provide greater stability in bill amounts across seasons, and asserts that this benefits low-income households, "for which seasonal fluctuations can result in financial hardships." EA at 29. Again, absolutely no data is cited in support of this assertion, nor is there any discussion of other mechanisms available to address any such concern, such as bill averaging programs provided by many utilities. At base, claims of stabilizing monthly fees can be addressed with payment mechanisms which are already employed in other jurisdictions. For instance, PG&E has a "budget billing" program that averages customers' bills from the previous year to determine a monthly amount, and then will adjust every four months in case average usage changes, allowing customers to have more stable prices based on

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46 *See* Hernandez, RR, et al. 2015. Environmental Impacts of Utility-Scale Solar Energy, Renewable and Sustainable Energy Reviews. 29: 768, *available at* https://www.sciencedirect.com/science/article/pii/S1364032113005819.

their usage rather than a flat fee.[47] Using fee instability to justify stifling DER and imposing a fixed charge that negatively impacts solar customers constitutes a false solution to a separate problem that can be separately addressed.

4. The EA also makes unsupported assumptions about which types of customers may change their energy usage in response to the new rate structure, concluding that the rate change will not result in any meaningful consumption change. EA at 29. These assumptions are wrong and contradict TVA's purpose for changing rates. While TVA appears to base these assumptions on what it claims are "historical price response[s]," EA at 30, TVA entirely ignores the extent to which new and inexpensive technologies make it easier for customers to respond to higher prices with additional conservation measures. Several studies[48] and commonsense economic principles lead to the opposite conclusion: rate structures that reduce per kWh energy prices also reduce the incentive for conservation behavior and investments in efficiency,

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47 *See* PG&E Budget Billing website at https://www.pge.com/en_US/residential/save-energy-money/help-paying-your-bill/longer-term-assistance/budget-billing/budget-billing.page?WT.mc_id=Vanity_budgetbilling.

48 *See*, *e.g*., The Regulatory Assistance Project (discussing how fixed charges can decrease price per kWh and, in turn, reduce the economic incentive for energy conservation and investments in efficiency), available at: https://www.raponline.org/wp-content/uploads/2016/05/rap-lazar-electricutilityresidentialcustomerchargesminimumbills-2014-nov.pdf; *See also* Southern Environmental Law Center report "A Troubling Trend in Rate Design: Proposed Rate Design Alternatives to High Fixed Charges" at 1 (stating that "…high fixed charges are frequently perceived by customers as an effort to punish them for buying less of the utility's product."), available at https://www.southernenvironment.org/uploads/newsfeed/A_Troubling_Trend_in_Rate_Design.pdf

resulting in increased electricity usage (as TVA proposes to do here, see EA page 28), to the benefit of TVA's revenue. Therefore, TVA's assumptions that the proposed rate change will not influence or alter electricity consumption defy commonsense economic principles, studies, and the utility's own revenue generation intent. The 2019 IRP EIS should avoid this fallacy.

II. ANALYSIS OF IMPACTS TO WILDLIFE

A. LISTED SPECIES

Pursuant to Section 7 of the ESA, TVA is required to consult with the Services whenever TVA takes action that "may affect" any listed species or their habitats. 16 U.S.C. § 1536(a)(2); *see also* 50 C.F.R. § 402.14(a). As discussed in detail below, TVA's search for potentially affected species and habitats should be broad and all-encompassing. For example, TVA should examine the impacts of TVA's power plant water withdrawals on the Federally Endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Federally Endangered Shortnose sturgeon (*Acipenser brevirostrum*), and all other appropriate federally-listed species.

But the examination should not stop there; the EIS should examine the cradle-to-the-grave impacts of TVA's operations on listed species and their habitats, at every stage along the supply chain. To take the example of TVA's use of coal as a fuel, some examples of impacts to examine in determining whether TVA must consult on a listed species include: a) coal mining's degradation and outright obliteration of terrestrial and aquatic habitats in pursuit of coal sales to TVA; b) the resulting property damage to neighbors' real estate, structures, groundwater and wells; c) the resulting sedimentation and chemical pollution of aquatic habitats; d) air and water impacts due to the processing and transportation of TVA's coal; e) air and water impacts from the burning of coal in TVA's power plants; and f) land and water impacts resulting from land disposal of coal ash. TVA should perform a similarly thorough examination of the impacts of every other aspect of the IRP to determine whether Section 7 consultation with the Services is required.

B. OTHER SPECIES OF CONCERN

1. All affected species and habitats must have their impacts fully addressed in the EIS.

While Section 7 of the ESA requires TVA to consult on listed species and their habitats, NEPA requires TVA to examine the 2019 IRP's impacts on all species, whether listed or not. NEPA requires the EIS to address any "adverse environmental effects which cannot be avoided . . .;" (3) reasonable alternatives to the proposed action, and (4) the "irreversible or irretrievable commitment of resources" involved in implementing the proposal. 42 U.S.C. § 4332. Any species or habitat that might be harmed in any way must have its impacts fully addressed in the EIS.

2. Numerous Petitioned Species Awaiting a Listing Decision are Within TVA's sphere of influence.

The enormous environmental footprint of TVA's energy systems gives TVA an outsized role in determining the future condition of our world. Likewise, the choices that TVA makes for its energy future can mean the difference between survival and extinction for a surprisingly long list of species. Other than federally listed species, the Center is especially concerned here with aquatic species which have been petitioned for pursuant to the ESA for listing and/or critical habitat designation, but have languished for years past their listing deadlines without action by the Services, and which may be impacted by the suite of energy systems chosen by TVA. The following are TVA energy-related systems and activities that are pushing these species towards the brink of extinction. The impacts of each of these systems and activities must be fully addressed in the 2019 IRP's EIS.

i. Coal Mining and Coal Processing are Threatening Many Southeast Species with Extirpation or Extinction.

Of course, the GHG, air pollution, and climate impacts of TVA's decision to burn coal, fracked natural gas and other fossil fuels must be examined in the 2019 IRP EIS. However, the full life cycle of coal carries a heavy load of cradle-to-the-grave impacts that must also be analyzed.

Coal mining is widely recognized as the preeminent threat to the survival of a startling number of aquatic species. Coal mining is known for ruining aquatic habitat across entire watersheds. Coal mining is a major cause of sedimentation of aquatic habitats, and pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota. Coal surface mining also causes erosion, declining groundwater levels and general water quality degradation.

Mountaintop removal coal mining has pervasive and irreversible impacts to ecosystems and imperiled species. In mountaintop removal operations, over 1000 feet of mountain can be blown up and dumped into adjacent streams, which annihilates every visible life form unfortunate enough to be in the pathway of the debris flow. Mountaintop removal often fills in streams entirely and can cause significant downstream and groundwater pollution. Mountaintop removal operations are known to extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish. Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish.

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia. Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval *Desmognathus* salamanders in streams on the Cumberland Plateau (in Dodd 1997). Coal mining also imperils vulnerable aquatic species by degrading hydrologic flows that are vital to the survival and reproduction of freshwater mussel populations.

After coal is mined, it must be processed and transported to its end use destination. Coal processing inflicts well-documented water quality impacts on aquatic environments that must be addressed in the EIS. Coal transport by train inflicts well-known fugitive air emission impacts from particulate matter in the areas that the coal is transported through. As for coal trucks, impacts to imperiled aquatic species from coal and diesel spills resulting from coal truck wrecks on creekside roads are well-documented. Coal transport impacts must be addressed in the EIS.

After coal is combusted, the land-based disposal of coal ash residues via coal ash ponds inflicts toxic impacts on aquatic species. For example, there are fish consumption advisories in the Roanoke River Basin due to contamination from dioxin, selenium, and mercury from coal ash ponds.

In 2010, the Center petitioned for the listing of the following species as Threatened or Endangered pursuant to the ESA. 5 U.S.C. § 553(e). These species: a) are nearly 7 years overdue to receive an ESA listing decision from the Services, 16 U.S.C. § 1533(b)(3)(B); and b) have been threatened with harm in the Southeast United States – directly or indirectly – by coal mining, coal processing, and coal transportation operations that are executed in service of TVA's fuel supply, or by the type of coal operations that are executed in service of TVA's fuel supply. In light of TVA's ongoing obligation to re-initiate formal Section 7 consultation with the Services in the case of the listing of a new species or the designation of a critical habitat that may be affected by TVA's actions, 50 C.F.R. § 402.16, TVA should preemptively initiate consultation on these imperiled species because of the likelihood of a listing decision and/or critical habitat designation being made by the Services before TVA has a chance to act on its IRP. At a minimum, any proposal in the 2019 IRP for the use of coal as a fuel, or that would result in the use of coal as a fuel should have impacts to these species – and to species like them –fully addressed in the EIS.

1. Obey Crayfish (*Cambarus obeyensis*)
2. Tennessee Pigtoe (*Pleuronaia barnesiana*)
3. Cherokee Clubtail (*Gomphus consanguis*)
4. Spiny Riversnail (*Io fluvialis*)
5. Smooth Mudalia (*Leptoxis virgate*)
6. Sheepnose (*Plethobasus cyphyus*)
7. Tennessee Clubshell (*Pleurobema oviforme*)
8. Virginia Stone (*Acroneuria kosztarabi*)
9. Streamside Salamander (*Ambystoma barbourin*)
10. Tennessee Forestfly (*Amphinemura mockfordi*)
11. One-toed Amphiuma (*Amphiuma pholeter*)
12. Elk River Crayfish (*Cambarus elkensis*)
13. Spiny Scale Crayfish (*Cambarus jezerinaci*)
14. Big Sandy Crayfish (*Cambarus callainus*)
15. Guyandotte River Crayfish (*Cambarus veteranus*)

16. Hellbender (*Cryptobranchus alleganiensis*)
17. Crystal Darter (*Crystallaria asprella*)
18. Spectaclecase Pearly Mussel (*Cumberlandia monodonta*)
19. Cumberland Dusky Salamander (*Desmognathus abditus*)
20. Seepage Salamander (*Desmognathus aeneus*)
21. Lilyshoals Elimia (*Elimia annettae*)
22. Spider Elimia (*Elimia arachnoidea*)
23. Princess Elimia (*Elimia bellacrenata)*
24. Cockle Elimia (*Elimia cochliaris*)
25. Black Mudalia (*Elimia melanoides*)
26. Caper Elimia (*Elimia olivula*)
27. Compact Elimia (*Elimia showalteri*)
28. Elegant Elimia (*Elimia teres*)
29. Snuffbox (*Epioblasma triquetra*)
30. Ashy Darter (*Etheostoma cinereum*)
31. Candy Darter (*Etheostoma osburni*)
32. Shawnee Darter (*Etheostoma tecumsehi*)
33. Tippecanoe Darter (*Etheostoma tippecanoe*)
34. Chamberlain's Dwarf Salamander (*Eurycea chamberlaini*)
35. Oklahoma Salamander (*Eurycea tynerensis*)
36. Longsolid (*Fusconaia subrotunda*)
37. Tennessee Cave Salamander (*Gyrinophilus palleucus*)
38. West Virginia Spring Salamander (*Gyrinophilus subterraneus*)
39. Georgia Blind Salamander (*Haideotriton wallacei*)
40. Tennessee Heelsplitter (*Lasmigona holstonia*)
41. Rye Cove Isopod (*Lirceus culveri*)
42. Helmet Rocksnail (*Lithasia duttoniana*)
43. Large-flowered Barbara's-buttons (*Marshallia grandiflora*)
44. Cumberland Moccasinshell (*Medionidus conradicus*)
45. Black Warrior Waterdog (*Necturus alabamensis*)
46. Popeye Shiner (*Notropis ariommus*)
47. Orangefin Madtom (*Noturus gilberti*)
48. Round Hickorynut (*Obovaria subrotunda*)
49. Coal Darter (*Percina brevicauda*)
50. Longhead Darter (*Percina macrocephala*)
51. Laurel Dace (*Phoxinus saylori*)
52. Pyramid Pigtoe (*Pleurobema rubrum*)
53. Shortspire Hornsnail (*Pleurocera curta*)
54. Little Kennedy Cave Beetle (*Pseudanophthalmus cordicollis*)
55. Cumberland Gap Cave Beetle (*Pseudanophthalmus hirsutus*)
56. Hubricht's Cave Beetle (*Pseudanophthalmus hubrichti*)
57. Overlooked Cave Beetle (*Pseudanophthalmus praetermissus*)
58. Saint Paul Cave Beetle (*Pseudanophthalmus sanctipauli*)
59. Silken Cave Beetle (*Pseudanophthalmus sericus*)
60. Thomas' Cave Beetle (*Pseudanophthalmus thomasi*)
61. Maiden Spring Cave Beetle (*Pseudanophthalmus virginicus*)

62. Rabbitsfoot (*Quadrula cylindrica cylindrica*)
63. Domed Ancylid (*Rhodacme elatior*)
64. Salamander Mussel (*Simpsonaias ambigua*)
65. Purple Lilliput (*Toxolasma lividus*)

ii. Dams and Impoundments are Threatening Many Southeast Species with Extirpation or Extinction.

The most glaring environmental impact of dams and their associated impoundments is the complete eradication of previously suitable habitat via inundation. The scientific literature on this topic consistently indicates that when terrestrial and riparian habitats are submerged under dozens of feet of water, many aquatic species are unable to persist in these dramatically altered environments. Other species may hold on, but in an increasingly precarious position, imperiled by the genetic isolation of their sub-populations and the fragmentation of their dwindling suitable habitats by dams and impoundments.

Dams and impoundment are widely recognized as the primary extirpation and extinction threat for many aquatic species in the Southeast. Many imperiled Southeast aquatic plants, snails, fish, crayfish, and amphibians are pushed closer to the brink of extinction and extirpation by the myriad impacts of TVA's dams and impoundments, including, *inter alia*, alteration of vital stream flows; increased sedimentation; changes in water temperature; alteration of vital flood processes; reduction in habitat heterogeneity; declines in critical food sources; decreased dissolved oxygen levels; increased predatory fish populations; disruption of vital reproductive processes such as isolating mussel populations from their glochidial host species; and even chemical alteration of the aquatic habitat.

In 2010, the Center petitioned for the listing of the following species as Threatened or Endangered pursuant to the ESA. 5 U.S.C. § 553(e). These species: a) are nearly 7 years overdue to receive an ESA listing decision from the Services, 16 U.S.C. § 1533(b)(3)(B); and b) have been threatened with harm in the Southeast United States – directly or indirectly – by TVA's construction, maintenance, and operation of dams and impoundments, or by the type of dams and impoundments that TVA owns and maintains. In light of TVA's ongoing obligation to re-initiate formal Section 7 consultation with the Services in the case of the listing of a new species or the designation of a critical habitat that may be affected by TVA's actions, 50 C.F.R. § 402.16, TVA should preemptively initiate consultation on these imperiled species because of the likelihood of a listing decision and/or critical habitat designation being made by the Services before TVA has a chance to act on its IRP. At a bare minimum, any proposal in the 2019 IRP for dams or impoundment, or that would result in the construction of dams and impoundment, should have impacts to these species – and to species like them –fully addressed in the EIS.

1. Smooth Mudalia (*Leptoxis virgate*)
2. Sheepnose (*Plethobasus cyphyus*)
3. Tennessee Clubshell (*Pleurobema oviforme*)
4. Corpulent Hornsnail (*Pleurocera corpulenta*)
5. Water Stitchwort (*Stellaria fontinalis*)
6. One-toed Amphiuma (*Amphiuma pholeter*)
7. Elk River Crayfish (*Cambarus elkensis*)
8. Crystal Darter (*Crystallaria asprella*)
9. Spectaclecase Pearly Mussel (*Cumberlandia monodonta*)
10. Princess Elimia (*Elimia bellacrenata)*
11. Cockle Elimia (*Elimia cochliaris*)
12. Black Mudalia (*Elimia melanoides*)
13. Caper Elimia (*Elimia olivula*)
14. Compact Elimia (*Elimia showalteri*)
15. Elegant Elimia (*Elimia teres*)
16. Ashy Darter (*Etheostoma cinereum*)
17. Shawnee Darter (*Etheostoma tecumsehi*)

18. Tippecanoe Darter (*Etheostoma tippecanoe*)
19. Longsolid (*Fusconaia subrotunda*)
20. Tennessee Heelsplitter (*Lasmigona holstonia*)
21. Helmet Rocksnail (*Lithasia duttoniana*)
22. Large-flowered Barbara's-buttons (*Marshallia grandiflora*)
23. Cumberland Moccasinshell (*Medionidus conradicus*)
24. Black Warrior Waterdog (*Necturus alabamensis*)
25. Popeye Shiner (*Notropis ariommus*)
26. Orangefin Madtom (*Noturus gilberti*)
27. Frecklebelly Madtom (*Noturus munitus*)
28. Round Hickorynut (*Obovaria subrotunda*)
29. Coal Darter (*Percina brevicauda*)
30. Pyramid Pigtoe (*Pleurobema rubrum*)
31. Rabbitsfoot (*Quadrula cylindrica cylindrica*)
32. Domed Ancylid (*Rhodacme elatior*)
33. Salamander Mussel (*Simpsonaias ambigua*)
34. Purple Lilliput (*Toxolasma lividus*)

iii. TVA's Roads are Threatening Many Species with Extirpation or Extinction.

Roads can have serious deleterious effects on aquatic biota. Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation from roads can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park. (Langton 1989). Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles. Roads can also disrupt amphibian metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Roads appear to suppress populations of some aquatic species, both because of increased water pollution from the roads, and because of the induced development that follows the construction of new roads. One crayfish has been harmed by diesel and coal spills from big truck wrecks on the road alongside its habitat.

In 2010, the Center petitioned for the listing of the following species as Threatened or Endangered pursuant to the ESA. 5 U.S.C. § 553(e). These species: a) are nearly 7 years overdue in receiving an ESA listing decision from the Services, 16 U.S.C. § 1533(b)(3)(B); and b) have been threatened with harm in the Southeast United States – directly or indirectly – by TVA's construction, maintenance, and operation of roads, or by the type of roads that TVA owns and maintains. In light of TVA's ongoing obligation to re-initiate formal Section 7 consultation with the Services in the case of the listing of a new species or the designation of a critical habitat that may be affected by TVA's actions, 50 C.F.R. § 402.16, TVA should preemptively initiate consultation on these imperiled species because of the likelihood of a listing decision and/or critical habitat designation being made by the Services before TVA has a chance to act on its IRP. At a minimum, any proposal in the 2019 IRP for the construction, maintenance, or operation of roads, or that would result in the the construction, maintenance, or operation of roads, should have impacts to these species – and to species like them –fully addressed in the EIS.

1. Streamside Salamander (*Ambystoma barbourin*)
2. One-toed Amphiuma (*Amphiuma pholeter*)
3. Spiny Scale Crayfish (*Cambarus jezerinaci*)
4. Hellbender (*Cryptobranchus alleganiensis*)
5. Cumberland Dusky Salamander (*Desmognathus abditus*)
6. Seepage Salamander (*Desmognathus aeneus*)
7. Big Sandy Crayfish (*Cambarus veteranus*)
8. Chamberlain's Dwarf Salamander (*Eurycea chamberlaini*)
9. Oklahoma Salamander (*Eurycea tynerensis*)
10. Tennessee Cave Salamander (*Gyrinophilus palleucus*)
11. West Virginia Spring Salamander (*Gyrinophilus subterraneus*)
12. Georgia Blind Salamander (*Haideotriton wallacei*)

iv. TVA's Utility Infrastructure is Threatening Species with Harm.

TVA's construction, maintenance, and operation of its energy infrastructure has threatened several imperiled species with harm. Planned transmission line construction was described as permanently eradicating populations of one crayfish; across several states, one plant has been threatened with extirpation and even extinction by a substation, transmission lines, a natural gas pipeline *and* a coal-fired power plant. TVA has admitted that transmission line construction and maintenance disrupts aquatic ecosystems.

In 2010, the Center petitioned for the listing of the following species as Threatened or Endangered pursuant to the ESA. 5 U.S.C. § 553(e). These species: a) are nearly 7 years overdue in receiving an ESA listing decision from the Services, 16 U.S.C. § 1533(b)(3)(B); and b) have been threatened with harm in the Southeast United States – directly or indirectly – by TVA's energy infrastructure operations, or by the type of energy infrastructure operations that TVA engages in. In light of TVA's ongoing obligation to re-initiate formal Section 7 consultation with the Services in the case of the listing of a new species or the designation of a critical habitat that may be affected by TVA's actions, 50 C.F.R. § 402.16, TVA should preemptively initiate consultation on these imperiled species because of the likelihood of a listing decision and/or critical habitat designation being made by the Services before TVA has a chance to act on its IRP. At a minimum, any proposal in the 2019 IRP for the construction, maintenance, or operation of energy utility infrastructure, or that would result in the construction, maintenance, or operation of energy utility infrastructure, should have impacts to these species – and to species like them –fully addressed in the EIS.

1. Conasauga Blue Burrower (*Cambarus cymatilis*)
2. Obey Crayfish (*Cambarus obeyensis*)

3. Jackson Prairie Crayfish (*Procambarus barbiger*)
4. Water Stitchwort (*Stellaria fontinalis*)

v. TVA's Energy-Related Disposition of Public Lands Could Result in the Extirpation of Two Populations of the Hardin Crayfish.

Any disposition of TVA lands for the building of a new energy facility could result in harm to a species. For example, the Robinson Creek population of the petitioned-for Hardin crayfish (*Orconectes wright*) is only marginally protected from habitat degradation and extirpation by Pickwick Landing State Park and TVA Pickwick Reservoir Reservation, and the same is true for the Chambers Creek population. Were TVA to change the use of that land in order to facilitate the construction of an energy station thereon, such a decision could easily result in the extirpation of these populations of this imperiled species. Thus, while TVA seeks to segment the land use impacts of its IRP out from the 2019 IRP's EIS, any land use-associated impact flowing from TVA's IRP decisions must be analyzed in the 2019 IRP EIS. *Baltimore Gas & Elec. Co.*, 462 U.S. at 97.

CONCLUSION

NEPA dictates that TVA must resolve the serious concerns raised here regarding the purpose and effect of these rate changes. It must also consider a reasonable range of alternatives that would address any reasonable concerns TVA has about insuring its continued ability to provide electricity at reasonable rates in its service territory, while also maximizing our clean energy transition by encouraging energy conservation and the development of distributed solar resources as rapidly as possible.

Respectfully submitted,

/s Perrin W. de Jong

Perrin W. de Jong
Staff Attorney
Center for Biological Diversity

ADDENDUM: THE CLIMATE CRISIS AND THE URGENCY OF REDUCING U.S. CARBON EMISSIONS THROUGH A RAPID TRANSITION TO CLEAN ENERGY

1. The Scientific Consensus that Climate Change is Real

Just a few years ago, the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, concluded that:

> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, [and] [r]ecent climate changes have had widespread impacts on human and natural systems.

(IPCC 2014).

These dire findings were echoed in the United States' own 2014 Third National Climate Assessment (NCA), prepared by a panel of non-governmental experts and reviewed by the National Academy of Sciences and multiple federal agencies. The NCA concluded "[t]hat the planet has warmed is 'unequivocal,' and is corroborated though multiple lines of evidence, as is the conclusion that the causes are very likely human in origin," and "[i]impacts related to climate change are already evident in many regions and are expected to become increasingly disruptive across the nation throughout this century and beyond" (Melillo *et al*. 2014). The United States National Research Council similarly concluded that, "[c]limate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems" (NRC 2010a).

Most recently, in its 2017 "Our Changing Planet" Report, the U.S. Global Research Change Program, an inter-agency body mandated by Congress to research and understand climate change[49] reiterated its findings that:

> The global environment is changing rapidly. This century has seen 15 of the 16 warmest years since adequate thermometer records became available in the late 1800s; globally-averaged temperatures in 2015 shattered the previous record, which was set in 2014; and 2016 is on track to break the 2015 record. Arctic sea ice extent continues a dramatic, decades-long decline. Many independent lines of evidence show a long-term warming trend driven by human activities, with cascading impacts that may outpace the ability of human and natural systems to adapt to change.

(USGRP 2017 at 1).

Global GHG emissions continue to rise due to the U.S. and other nation-states' failures to adequately address climate change. Carbon dioxide (CO_2) is the dominant GHG driving the observed changes in the earth's climate (NRC 2011a). In March 2015, the monthly global average concentration of CO_2 surpassed 400 parts per million (ppm) for the first time since scientists began tracking CO_2 in the global atmosphere (NOAA 2015). This level is almost one and half times (143%) higher than the pre-industrial level of 280 ppm (Pachauri et al. 2014, NOAA National Climatic Data Center 2015a). The current atmospheric CO_2 level is higher than levels during the past 800,000 years, which have fluctuated between ~174 and 280 ppm (IPCC 2013), and may exceed concentrations during the past 15-20 million years (Tripati et al. 2009). Current annual emission growth rates – at an average of ~2.5% per year – are more than twice as large as in the 1990s, which averaged 1% per year (Friedlingstein et al. 2014), and in 2015, the annual CO_2 growth rate was the highest in the 56-year record (NOAA 2016). The atmospheric

49 *See* 15 U.S.C. § 2921, *et seq*.

concentrations of methane (CH_4) and nitrous oxide (N_2O), two other potent GHGs, are, respectively, 253% and 121% of their pre-industrial levels (WMO 2014).

The average global surface temperature has warmed by more than 0.85 degrees Celsius (1.5 degrees Fahrenheit) since the industrial revolution, most of which has occurred in the past three decades (IPCC 2013). In the U.S., temperatures have warmed by 0.72 to 1.1 °C (1.3 to 1.9ºF) since 1895, with most of this increase occurring since about 1970 (Melillo et al. 2014). Globally, the decade from 2000 to 2010 was the warmest on record (et al.*id*.), and 2016 was the hottest year on record and the third year in a row that record was broken (NASA 2017). By the end of this century, the average temperature in the United States is expected to increase by 2.2 to 3.6°C (3 to 5°F) under a lower emissions scenario and by 3.9 to 6.1°C (5 to 10°F) under a higher emissions scenario, with the largest temperature increases projected for the upper Midwest and Alaska (Melillo et al. 2014).

2. The U.S.'s Blown Carbon Budget

The United States has committed to the climate change target of holding the long-term global average temperature "to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" under the Paris Agreement. The United States signed the Paris Agreement on April 22, 2016 as a legally binding instrument through executive agreement,[50] and the treaty

[50] *See* United Nations Treaty Collection, Chapter XXVII, 7.d Paris Agreement, List of Signatories; U.S. Department of State, Background Briefing on the Paris Climate Agreement, (Dec. 12, 2015). Although not every provision in the Paris Agreement is legally binding or enforceable, the U.S. and all parties are committed to perform the treaty commitments in good faith under the international legal principle of *pacta sunt servanda* ("agreements must be kept"). Vienna Convention on the Law of Treaties, Art. 26.

entered into force on November 4, 2016. The Paris Agreement codifies the international consensus that climate change is an "urgent threat" of global concern.[51]

The IPCC Fifth Assessment Report and other expert assessments have established global carbon budgets, or the total amount of carbon that can be burned while maintaining some probability of staying below a given temperature target. When accounting for the projected warming effect of non-CO_2 forcing from shorter lived pollutants, total cumulative anthropogenic emissions of CO_2 must remain below about 1,000 gigatonnes ($GtCO_2$) from 2011 onward for a 66% probability of limiting warming to 2°C above pre-industrial levels, and to 400 $GtCO_2$ from 2011 onward for a 66% probability of limiting warming to 1.5°C (IPCC 2013, IPCC 2014). These carbon budgets have been reduced to 850 $GtCO_2$ and 240 $GtCO_2$, respectively, from 2015 onward (Rogelj et al. 2016a). Every year at current emissions (36 $GtCO_2$)[52] makes meeting this budget less feasible.

Scientific studies have estimated the United States' portion of the global carbon budget by allocating the remaining global budget across countries based on factors including equity and economics. Estimates of the U.S. carbon budget vary depending on the temperature target used by the study (1.5°C versus 2°C), the likelihood of meeting the temperature target (50% or 66% probability), the equity principles used to apportion the global budget among countries, and whether a cost-optimal model was employed. The U.S. carbon budget for limiting temperature rise to well below 2°C has been estimated at 38 $GtCO_2$ (du Pont et al. 2017), while the estimated budget for limiting temperature rise

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51 *See* Paris Agreement, at Recitals.

52 *See* Le Quéré, Corrine, et al., "Global Carbon Budget 2016," 8 Earth Syst. Sci. Data 605 (2016), www.globalcarbonproject.org/carbonbudget/16/data.htm.

to 2°C ranges from 34 $GtCO_2$ to 158 $GtCO_2$ (Raupach et al. 2014, Gignac et al. 2015, Peters et al. 2015, du Pont et al. 2017). Under any scenario, the remaining U.S. carbon budget consistent with limiting global average temperature rise to 1.5°C or 2°C is extremely small and is rapidly being consumed. In 2015 alone, U.S. emissions totaled 6.5 $GtCO_2eq$ (U.S. EPA, Inventory).

The build-up of CO_2 and other pollutants which have occurred, and are continuing to occur, are principally caused by our GHG emissions. For this reason, the Environmental Protection Agency (EPA) has unequivocally concluded that GHG emissions endanger the health and welfare of current and future generations (EPA 2009). Accordingly, as the Third NCA explains, "reduc[ing] the risks of some of the worst impacts of climate change" will require "aggressive and sustained greenhouse gas emission reductions" over the course of this century (Melillo et al. 2014 at 13, 14, and 649).

3. The Urgency For the U.S. To Swiftly Transition to a Clean Energy Economy

In order to preserve a likely chance of achieving our targets, and per U.S. commitments in the Paris Agreement, scientific assessments have found that global emissions should peak by 2020, decline sharply thereafter, and typically reach zero net emissions by 2050 (Rogeli et al. 2015, Rogeli et al. 2016b, UNEP 2015). Moreover, they must become *net-negative* after 2050 (*i.e.*, more carbon must be *removed* from the atmosphere than is *added*) (*Id.*).

Accordingly, it is absolutely critical that we rapidly transition to renewable energy in order to displace fossil fuel sources and slow GHG emissions as quickly as possible. Every additional contribution to GHG emissions, especially over the next few decades, means that meeting a 1.5°C, much less a 2°C, target becomes less likely, and pushes the earth further toward tipping points that will further aggravate positive feedback loops – which, in turn, will further amplify warming, and increase the probability of the most dangerous levels of changes to our climate.

The single biggest source of GHG emissions in the United States is electricity production (U.S. EPA, Sources). Thus, it is simply indisputable that rapidly transitioning electricity from GHG-emitting sources like coal and natural gas to appropriate renewable resources, like distributed solar PV generation, is critical to addressing climate change.

PETITION TO LIST 404 AQUATIC, RIPARIAN AND WETLAND SPECIES FROM THE SOUTHEASTERN UNITED STATES AS THREATENED OR ENDANGERED UNDER THE ENDANGERED SPECIES ACT

Center for Biological Diversity

April 20, 2010

April 20, 2010

TO: Mr. Ken Salazar
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Mr. Gary Locke
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Washington, DC 20230

Cynthia Dohner, Regional Director
U.S. Fish and Wildlise Service, Southeast Region
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Dear Secretary Salazar and Secretary Locke:

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), the Center for Biological Diversity, Alabama Rivers Alliance, Clinch Coalition, Dogwood Alliance, Gulf Restoration Network, Tennessee Forests Council, West Virginia Highlands Conservancy, Tierra Curry and Noah Greenwald hereby formally petition the Secretaries of Interior and Commerce to list 404 aquatic, riparian and wetland species from the southeastern U.S. as Threatened or Endangered species and to designate critical habitat concurrent with listing.

Petitioners file this petition under the Endangered Species Act, 16 U.S.C. sections 1531-1543 (1982). This petition is filed under 5 U.S.C. section 553(e), and 50 C.F.R. part 424.14 (1990), which grants interested parties the right to petition for issuance of a rule from the Assistant Secretary of the Interior. The petitioners request that Critical Habitat be designated as required by 16 U.S.C. 1533(b)(6)(C) and 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553). Petitioners realize this petition sets in motion a specific process placing definite response requirements on the FWS and very specific time constraints upon those responses.

The U.S. Fish and Wildlife Service (FWS) has long recognized the benefit of providing protection for multiple species for improving efficiency of listing and recovery and ultimately protection of ecosystems. In 1976, for instance, the FWS issued several proposed rules to list multiple species based on common threats, ecosystems, habitats, taxonomy, or other factors (e.g., USDI FWS 1976). In 1992, the FWS itself stated in a legal Settlement Agreement (1992) that:

> Defendants [FWS] recognize that a multi-species, ecosystem approach to their listing responsibilities under the ESA will assist them in better analyzing the common nature and magnitude of threats facing ecosystems, help them in understanding the relationships among imperiled species in ecosystems, and be more cost-effective than a species-by-species approach to listing responsibilities.

In 1994, the FWS (1994) specifically stated its policy to undertake "Group listing decisions on a geographic, taxonomic, or ecosystem basis where possible" (p. 34724). In furtherance of this policy, the FWS (1994) developed listing guidance that specifically encourages "Multi-species listings…when several species have common threats, habitat, distribution, landowners, or features that would group the species and provide more efficient listing and subsequent recovery" (p. iv). Accordingly, we hereby petition for 404 aquatic, riparian and wetland species under the Endangered Species Act.

PETITIONERS:

The Center for Biological Diversity is a nonprofit conservation organization with 255,000 members and online activists dedicated to the protection of endangered species and wild places. http://www.biologicaldiversity.org

The Alabama Rivers Alliance seeks to protect Alabama's rivers through water quality and quantity policy advocacy, grassroots organizing, and the providing of information to citizens in order to achieve clean and healthy watershed ecosystems, healthy people, strong economies, and a functioning democratic system of government in Alabama.

The Clinch Coalition is a grassroots organization located in Southwest Virginia committed to the protection and preservation of the forest, wildlife, and watersheds in our National Forest and surrounding communities for present and future generations.

Dogwood Alliance works to protect the forests and communities of the Southern United States by building diverse support to end destructive industrial forestry practices.

The Gulf Restoration Network, headquartered in New Orleans, works to unite and empower people to protect and restore the natural resources of the Gulf of Mexico for future generations. Founded in 1994, the Network has successfully established a unique regional alliance with over 40 group and thousands of individual members across the Gulf and established itself as a major participant in the debate over the environment of the region.

Tennessee Forests Council is a unification of citizens, environmental, conservation and grassroots organizations representing over 12,000 Tennesseans. These organizations have come together for the common purpose of protecting the forests of Tennessee through progressive forest policy reform that brings forest extraction methods and rates into balance with ecological integrity. TFC bases its positions on sound forest science and economic principles.

The West Virginia Highlands Conservancy was the first membership organization devoted to protecting the natural environment of the Mountain State. Since 1965, the Highlands Conservancy has worked to secure wilderness areas and special places on the Monongahela National Forest, and it has been has been a leader in the fight to rein in the worst practices of the coal industry. Protecting clean air, clean water, forests, streams, mountains, and the health and welfare of the people who live here is what the Highlands Conservancy is all about. It publishes a Hiking Guide and a monthly newspaper, The Highlands Voice.

Cover Photo: Holiday darter (*Etheostoma brevirostrum*) from Shoal Creek by Noel Burkhead.

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INTRODUCTION

North American freshwater ecosystems and the many species they support are one of the most threatened ecosystems on the planet. During the Twentieth Century, at least 123 species of freshwater fishes, mollusks, crayfishes, and amphibians went extinct in North America, and hundreds more aquatic species are now imperiled (Ricciardi and Rasmussen 1999, Williams et al. 1992). Based on current trends, Ricciardi and Rasmussen (1999) model a future extinction rate of four percent per decade for North American freshwater fauna, stating, "North American freshwater biodiversity is diminishing as rapidly as that of some of the most stressed terrestrial ecosystems on the planet" (Ricciardi and Rasmussen 1999, p. 1221). The projected extinction rate for U.S. freshwater animals is five times that of terrestrial animals, and is comparable to the extinction rate for tropical rainforests (Herrig and Shute 2002). Nowhere is this extinction crisis more apparent than in the southeastern United States where the combination of an incredibly rich fauna, pervasive threats and few existing protections are leading to the demise of hundreds of aquatic species.

In North America and indeed the world, the southeastern United States is a hotspot for aquatic biological diversity, containing an unparalleled diversity of fauna (Folkerts 1997, Neves et al. 1997, Stein et al. 2000). The southeast, for example, harbors 493 species of fish, which is 62 percent of all U.S. species, at least 269 species of mussel, which is 91 percent of all U.S. species, and 241 species of dragonflies and damselflies, which is 48 percent of all North American species (Folkerts 1997, Morse et al. 1997, Neves et al. 1997, Warren et al. 1997). The southeast also harbors over two-thirds of North America's 405 species and subspecies of crayfish, more aquatic reptiles than any other region with 30 species of aquatic turtle and 17 species of aquatic snake, and more amphibian species than any other region with 178 recognized species and new species continuing to be described (Buhlmann and Gibbons 1997, Dodd 1997, Taylor et al. 2007, Camp et al. 2009).

Unfortunately, much of the rich aquatic fauna of the southeast is threatened. Greater than 70 percent of mussels, 48 percent of crayfishes and 28 percent of fishes are considered endangered, threatened or of special concern by the American Fisheries Society (Williams et al. 1992, Taylor et al. 2007, Jelks et al. 2008). The major factors in this high degree of imperilment include dams, logging, urban sprawl, mining, poor agricultural practices, pollution, and invasive species (e.g. Folkerts 1997, Neves et al. 1997, Williams et al. 2008). The Coosa River in Georgia and Alabama, for example, is believed by scientists to "hold the dubious distinction of having more recent extirpations and extinctions of aquatic organisms than any other equally-sized river system in the United States," with the loss of 38 species of endemic aquatic snails and a number of fish species mostly caused by a series of large impoundments, pollution, and logging (Burkhead et al. 1997).

Despite the high rate of imperilment and imminent and growing threats to aquatic ecosystems in the southeast, the majority of southeastern aquatic species recognized to be imperiled are not afforded protection under the Endangered Species Act or other laws or regulations. To remedy this situation, provide greater protection to southeastern aquatic ecosystems and stave off a looming extinction crisis, the Center for Biological Diversity hereby petitions the U.S. Fish and Wildlife Service to list 404 southeastern aquatic, riparian and wetland species as threatened or endangered under the Endangered Species Act.

The U.S. Fish and Wildlife Service (FWS) has long recognized the benefit of protecting multiple species in a package for improving efficiency of listing and recovery and ultimately, protection of ecosystems. In 1994, the Service specifically stated its policy to undertake "Group listing decisions on a geographic, taxonomic, or ecosystem basis where possible" and developed listing guidance that specifically encourages "Multi-species listings…when several species have common threats, habitat, distribution, landowners, or features that would group the species and provide more efficient listing and subsequent recovery." This petition is consistent with this policy and we encourage the Service to group and process these species in any way that will further efficiency and timely protection.

METHODS

We identified species for petitioning based on an iterative process utilizing information from available databases and literature cataloging information on species' habitat preferences, status and threats, including NatureServe, IUCN and various American Fisheries Society (AFS) publications (Williams et al. 1992, Williams et al. 1993, Taylor et al. 2007, Jelks et al. 2008, NatureServe 2008). We formed an initial list by searching NatureServe for species that occur in the twelve states typically considered the southeast, occur in aquatic, riparian or wetland habitats and appeared to be imperiled.

We considered species imperiled if they were classified as G1 or G2 by NatureServe, near threatened or worse by IUCN, or a species of concern, threatened or endangered by AFS. Once we had an initial list, we searched for information on threats to species and only included those species where there was some information demonstrating threats to the species. We avoided species that have yet to be fully described.

Once we developed an initial list of species for inclusion in the petition, we consulted with numerous scientific experts specializing in various taxonomic groups, including fish, mollusks, insects, crayfish and plants, to obtain their feedback and whether listing of the species may be warranted. We removed many species based on expert advice.

Once species were identified for the petition, we created a database structured for entering the basic information necessary to show that listing of the species may be warranted, including fields on taxonomy, habitat, range, status, abundance, population trend and the five factors under the Endangered Species Act for determining whether a species is threatened or endangered. 16 U.S.C. § 1533(a)(1). We then searched available literature on the species and created the individual species accounts contained in this petition.

THREATS

The globally significant aquatic biota of the southeastern United States is threatened by a variety of factors. Habitat loss and degradation is the primary cause of extinction globally and for the petitioned species. Southeastern aquatic biota are also threatened by numerous other factors including pollution, global climate change, the spread of invasive species, overutilization, disease, predation, and the inadequacy of existing regulatory mechanisms to protect imperiled species and their habitats (Benz and Collins 1997, Ricciardi and Rasmussen 1999, Strayer 2006).

I. Present or threatened destruction, modification, or curtailment of habitat or range

The southeast has been identified as one of the regions in the United States where ecosystem losses have been most pronounced (Noss et al. 1995). Aquatic and riparian habitats in the southeast have been extensively degraded by direct alteration of waterways such as impoundment, diversion, dredging and channelization, and draining of wetlands, and by land-use activities such as development, agriculture, logging, and mining (Benz and Collins 1997, Shute et al. 1997). The degradation of aquatic habitats is a primary cause for the loss of biodiversity in streams and rivers (Allan and Flecker 1993). More than one-third of the petitioned species have experienced drastic range reductions, upwards of 90 percent range loss for many of the petitioned mussels and snails (Pyne and Durham 1993, Neves et al. 1997, NatureServe 2008). Because many of the aquatic species in the Southeast are very narrow endemics or have experienced dramatic range reductions, remaining populations are now susceptible to extinction from even relatively minor habitat losses (Herrig and Shute 2002).

Habitat loss and degradation is known to be causing the decline of southeastern biota, and threatens 98 percent of the petitioned species. Habitat degradation has been a contributing factor in nearly three-quarters of freshwater fish extinctions in North America (Miller et al. 1989). In the southeast, decreasing habitat area and increasing fragmentation are strongly correlated with regional loss of fish diversity, and Warren et al. (1997) cite "the engine of imperilment" for Southeastern freshwater fishes as the "pervasive, complex degradation of fish habitats across Southeastern drainages." Habitat loss is also driving the decline of reptiles, mollusks, and other aquatic taxa. Buhlmann and Gibbons (1997) found that 36 percent of analyzed imperiled aquatic reptiles are threatened because of the "continuing, cumulative abuse sustained by river systems," and that at least 22 Southeastern reptile taxa have declined due to degradation of rivers and streams (Buhlmann and Gibbons 1997). Habitat degradation is also the primary cause of imperilment for southeastern mollusks (Neves et al. 1997, Lysne et al. 2008), mammals (Harvey and Clark 1997), and plants (Stein et al. 2000).

Physical Alteration of Aquatic Habitats

In the southeast, nearly all of the major river and stream systems have been impounded, drained, channelized, or altered in some way (Schuster 1997). Concerning the challenges facing freshwater species conservation, Strayer (2006) declares, "It is difficult to overstate the extent to which humans have changed freshwater habitats" (p. 278). Forty-four percent of U.S. river miles are classified as impaired, primarily due to hydrologic modifications and agricultural runoff (EPA 2004).

Impoundment

Impoundment is a primary threat to aquatic species in the southeast (Benz and Collins 1997, Buckner et al. 2002, Herrig and Shute 2002). Nearly half of all the petitioned species are threatened by impoundment, including 83 percent of the fishes and 67 percent of the mollusks. Dams modify habitat conditions and aquatic communities both upstream and downstream of the impoundment (Winston et al. 1991, Mulholland and Lenat 1992, Soballe et al. 1992). Upstream of dams, habitat is flooded and in-channel conditions change from flowing to still water, with increased depth, decreased levels of dissolved oxygen, and increased sedimentation. Sedimentation alters substrate conditions by filling in interstitial spaces between rocks which provide habitat for many species (Neves et al. 1997). Downstream of dams, flow regime fluctuates with resulting fluctuations in water temperature and dissolved oxygen levels, the substrate is scoured, and downstream tributaries are eroded (Schuster 1997, Buckner et al. 2002). Negative "tailwater" effects on habitat extend many kilometers downstream (Neves et al. 1997). Dams fragment habitat for aquatic species by blocking corridors for migration and dispersal, resulting in population isolation and heightened susceptibility to extinction (Neves et al. 1997). Dams also preclude the ability of aquatic organisms to escape from polluted waters and accidental spills (Buckner et al. 2002).

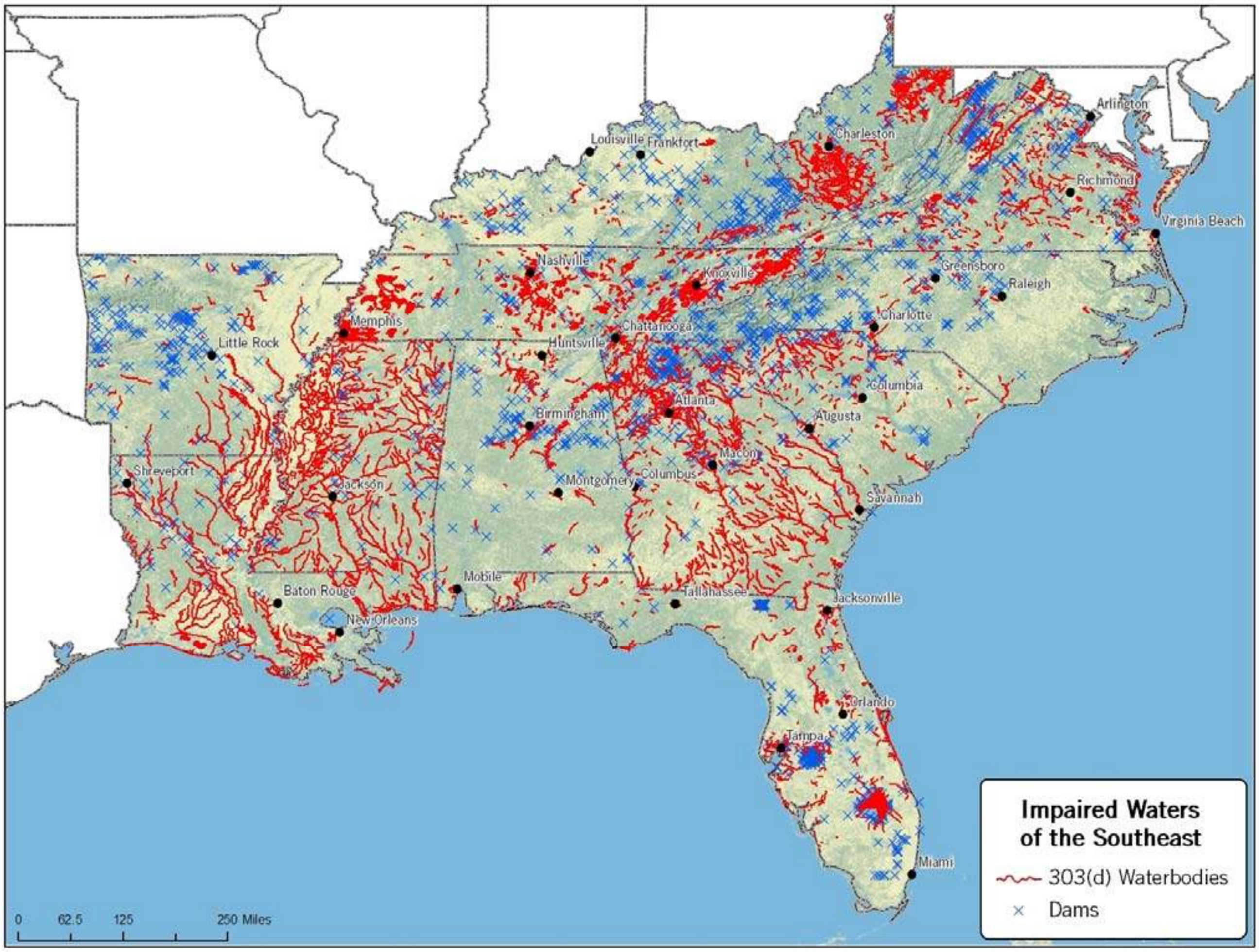

Fig. 1 Impaired Waters of the Southeast. Aquatic species are threatened by extensive impoundment and pollution.

There are few major rivers in the southeastern United States which haven't been impounded (Shute et al. 1997). Medium-sized rivers in particular have been heavily impounded (Etnier 1997). Impoundments have been constructed throughout the region by the Army Corps of Engineers, the Tennessee Valley Authority, electrical power companies, and municipalities (Morse et al. 1997, Buckner et al. 2002). As of the early 1990's, there were 144 major reservoirs in the southeast, including 26 in Tennessee, 19 each in Alabama and North Carolina, and 17 in Kentucky (Soballe et al. 1992). There are 36 dams on the mainstem and major tributaries of the Tennessee River (Neves et al. 1997), resulting in the impoundment of more than 20 percent of the Tennessee River and its major tributaries (Shute et al. 1997). The Tennessee and Cumberland River drainages have approximately 70 major dams and reservoirs (Buckner et al. 2002). Waterways in Alabama have also been extensively impounded, with 16 major lock and dam structures on six rivers, 21 hydroelectric power dams, and over 20 public water supply impoundments (Buckner et al. 2002). The Coosa and Tallapoosa rivers in Georgia and Alabama have been ranked among the most imperiled rivers in the nation due to damming (Buckner et al. 2002).

Although damming projects have been curtailed in many areas of the county, construction of impoundments is ongoing in the southeast (Folkerts 1997, Buckner et al. 2002). Folkerts (1997) states:

> "Proof of the Third World status of the Southeast lies in the fact that the damming era is not yet over in the area, as it essentially is in the rest of the nation. Plans to dam many of the remaining free-flowing rivers or reaches are in various stages of development even though not highly publicized" (p. 11).

In addition to rivers, damming of streams and springs is also extensive throughout the southeast (Etnier 1997, Morse et al. 1997, Shute et al. 1997). Shute et al. (1997) report that "few Southeastern streams are spared from impoundment" (p. 458). Noss et al. (1995) report that practically every stream in the Mississippi Alluvial Plain has been channelized, levied, or hydrologically altered. Morse et al. (1997) report that many streams have both small ponds in their headwaters and large reservoirs in their lower reaches. Small streams on private lands are regularly dammed to create ponds for cattle, irrigation, recreation, and fishing, with significant ecological effects due to the sheer abundance of these structures (Morse et al. 1997). Buckner et al. (2002) report that small headwater streams are increasingly being dammed in the southeast to supply water for municipalities. Etnier (1997) reports that many southeastern springs have also been impounded.

Dams are known to have caused the extirpation and extinction of many southeastern species, and existing and proposed dams pose an ongoing threat to many of the petitioned species (Folkerts 1997, Neves et al. 1997, FWS 2000, Buckner et al. 2002, Herrig and Shute 2002). Dams are a primary cause of imperilment for freshwater fish. Etnier (1997) found that impoundment and alteration of flow regime is responsible for 32 percent of fish imperilment in the southeast. The construction of ten lock and dam structures on the Tennessee-Tombigbee Waterway, which artificially connects the Tennessee River to the Gulf of Mexico, led to the extirpation of many species from the main river channel, including the Frecklebelly Madtom (*Noturus munitus)* (Bennet et al. 2008). The Frecklebelly Madtom was also extirpated from the Alabama River due to impoundments, and because this species is dependent on large-river gravel shoal habitat, it is "vulnerable to river modifications that will likely continue into the foreseeable future" (Bennett et al. 2008). In Florida and other Atlantic states, impoundment of large coastal tributaries has severely curtailed fish spawning runs (Gilbert 1992). Impoundment blocks migratory routes for fish and covers spawning areas with silt (Etnier 1997). Dams and resultant substrate changes have led to the disproportionately high imperilment of benthic fishes (Warren et al. 1997). Even small dams negatively affect aquatic fauna. In Oklahoma, populations of four species of cyprinids were extirpated when a small dam was constructed on the North Fork of the Red River (Winston et al. 1991).

Impoundments are one of the primary causes for the reduction in diversity and abundance of freshwater mussels in the southeast (Williams et al. 1993, Neves et al. 1997). Impoundments threaten freshwater mollusks via both direct and indirect mechanisms. Changes in the fish community jeopardize the survival of mussels because mussels are dependent on host fish to successfully reproduce, with some species of mussels being dependent on specific species of fish (Bogan 1993, 1996). If the fish species upon which a mussel is dependent to host its larvae goes extinct, then the mussel becomes "functionally extinct," even when there are surviving long-lived individuals (Bogan 1993). Impoundments can also separate mussel populations from host fish populations, resulting in the eventual extinction of the mussel species (Bogan 1993, 1996). Layzer et al. (1993) and Williams et al. (1992) report instances of 30 to 60 percent of the mussel fauna being lost as the result of dam construction. The loss of mussels can in turn negatively affect fish, because some species of fish use empty mussel shells as nest sites (Bennett et al. 2008).

Impoundment and the resultant loss of shoal habitat has caused range reduction or extinction for many species of Southeastern freshwater snails (Neves et al. 1997). Many snail species now exist primarily as "relict populations" which only survive immediately below dam sites (Neves et al. 1997). Impoundment is also one of the primary causes for the imperilment of crustaceans in the southeast (Schuster 1997). Dams have also destroyed habitat for many species of aquatic insects, with remaining populations being genetically isolated due to limited dispersal abilities (Herrig and Shute 2002). Impoundment has also contributed to the decline of forest-associated bird species in the southeast, particularly for species with narrow niches and low tolerance to disturbance (Dickson 1997).

Dredging and Channelization

Dredging and channelization have led to "incalculable loss of aquatic habitat in the Southeast" (Warren Jr. et al. 1997). Dredging and channelization projects are extensive throughout the region for flood control, navigation, sand and gravel mining, and conversion of wetlands into croplands (Neves et al. 1997, Herrig and Shute 2002). Many rivers are continually dredged to maintain a channel for shipping traffic (Abell et al. 2002). Dredging and channelization modify and destroy habitat for aquatic species by destabilizing the substrate, increasing erosion and siltation, removing woody debris, decreasing habitat heterogeneity, and stirring up contaminants which settle onto the substrate (Hart and Fuller 1974, Williams et al. 1993, Buckner et al. 2002, Bennett et al. 2008). Channelization can also lead to headcutting, which causes further erosion and sedimentation (Hartfield 1993b). Channel modification is one of the primary contributors to the decline of freshwater mollusks because of substrate instability, headcutting, sedimentation, and actual removal of mussels from their beds during dredging operations (Hart and Fuller 1974, Williams et al. 1993). Neves et al. (1997) describe dredging as "a perpetual problem for sedentary mollusks that are displaced and killed in dredge spoils," stating, "Endangered mussels of big rivers . . . have been under siege for decades by navigational dredging mostly by the U.S. Army Corps of Engineers. Even the presence of federally endangered species does not prevent the modification of habitats where these animals reside" (p. 71).

Dredging and channelization also threaten imperiled fishes, reptiles, crustaceans, and other species. Dredging removes woody debris which provides cover and nest locations for fish such as the Frecklebelly Madtom (Bennet et al. 2008). Flood control projects and channel maintenance operations in Mississippi threaten aquatic species in the Yazoo Basin (Jackson et al. 1993), including the petitioned Yazoo crayfish. Channelization is known to be a primary cause of imperilment for southeastern crustaceans (Schuster 1997). Dredging and channelization are also contributing to the decline of southeastern turtles (Buhlmann and Gibbons 1997). Many of the petitioned turtle species, including the highly imperiled map turtles, are threatened by the removal of woody debris on which they depend for basking.

Water Development and Diversion and Decreased Water Availability

The diminishing availability of freshwater poses a present and increasing threat to aquatic species globally and in the southeastern United States (Benz and Collins 1997, Buckner et al. 2002, Herrig and Shute 2002, Hutson et al. 2005, Lysne et al. 2008). Human population growth and increasing demand for freshwater resources has placed and will continue to place many aquatic species at risk (Jackson et al. 2001, Postel 2000, Gleick 2003, Strayer 2006). In the southeast, demands for freshwater for electricity production, irrigation, agriculture, and industrial and residential development are increasing (Herrig and Shute 2002, Hutson et al. 2005, Lysne et al. 2008). Limited water supply is already an area of conflict in Tennessee, Alabama, and Georgia in particular where rapidly growing metropolitan areas such as Atlanta, Birmingham, and Nashville have drastically increased the demand for freshwater for residential and industrial uses (Buckner et al. 2002). In the agricultural sector, the construction of numerous large Confined Animal Feeding Operations throughout the southeast has led to an increased demand for inter-basin water transfers (Buckner et al. 2002). Increasing drought due to global climate change is expected to exacerbate the threat of limited water availability to aquatic and riparian species in southeastern states (Karl et al. 2009).

Demand for freshwater for use in electricity production is also increasing in the southeast. Freshwater is used extensively in electrical power generation for emission scrubbing and cooling (DOE 2006). In the year 2000, thermoelectric power generation accounted for 39 percent of all U.S. freshwater withdrawals (Hutson et al. 2004). Existing and proposed coal-fired power plants in the southeast require and will continue to require significant amounts of water to operate. For example, the proposed East Kentucky Power Cooperative Smith coal-fired power plant will require 1,495 gallons of water per minute from the Kentucky River to control nitrous oxide emissions (Gilpin Group 2007). Water demands have also increased in the southeast to support the construction of gas-fired steam plants for electricity generation, which require millions of gallons of water per day, and which return only roughly a fifth of water back into waterways (Buckner et al. 2002). Water which is returned to the waterbody from which it is pumped tends to be thermally polluted and may be inadequate to meet the dissolved oxygen needs of aquatic species (Buckner et al. 2002).

Surface diversion of streams also threatens southeastern aquatic species (Etnier 1997, Abell et al. 2000, Buckner et al. 2002, Herrig and Shute 2002). An increasing threat for Southeastern species is the growing practice of damming small headwater streams to supply water for municipalities (Buckner et al. 2002). In addition to impoundment effects, water withdrawals reduce base flows and decrease habitat availability for aquatic species (Abell et al. 2000, Herrig and Shute 2002). Reduced water volume also increases the concentration of pollutants, posing another threat to species (Abell et al. 2000, Herrig and Shute 2002).

In addition to rivers and streams, many Southeastern springs have been drastically altered to supply water for human uses (Etnier 1997). Spring development and diversion can alter flow regime and water quality parameters, lead to substrate disturbance and erosion, and alter the structure and composition of vegetative cover with resultant effects on freshwater fauna (Shepard 1993, Frest and Johannes 1995, Frest 2002). In terms of the effects of spring diversion on aquatic species, Frest (2002) states, "[Spring] development can completely extirpate the native freshwater mollusks as well as reduce diversity in other animal and plant groups." An additional threat to southeastern species is groundwater overdraft, which threatens spring flow and species which are dependent on consistent spring flow conditions (Strayer 2006). The dewatering of groundwater systems in the southeast threatens rare species of isopods, amphipods, fish, crayfish, and amphibians which are dependent on stable spring and cave environments (Herrig and Shute 2002).

Loss of Wetlands

In the continental United States, over half of wetlands have been lost or severely degraded, and many southeastern states have lost the vast majority of their wetlands (Dahl 1990, Noss et al. 1995). More than 80 percent of the wetlands in Kentucky have been destroyed, as have more than 70 percent of Arkansas wetlands, nearly 60 percent of Tennessee and Mississippi wetlands, and half of Florida and Alabama wetlands (Dahl 1990). Arkansas, Florida, Georgia, Louisiana, Mississippi, and North and South Carolina have each lost more than 100,000 acres of palustrine forested wetlands (Dahl and Johnson 1991).

Through the mid-1980', wetlands were lost in the southeast at a rate of over 385,000 acres per year (Hefner and Brown 1984). In Florida alone, over nine million acres of wetlands have been lost (Cerulean 1991). In Arkansas, six million acres of Mississippi Delta wetlands had been converted to agricultural use by the mid-1980's (Smith et al. 1984). In the Lower Mississippi Valley region, over one-third of existing wetlands were destroyed from 1950-1970 (Mitsch and Gosselink 1986), with over 165,000 acres of wetlands continuing to be lost annually through the mid-1980's in this region (Tiner 1984). In Tennessee, up to 90 percent of upland wetlands on the Highland Rim have been destroyed, as have more than 90 percent of Appalachian bogs in the Blue Ridge Province (Pyne and Durham 1993). The destruction of pocosins (evergreen shrub bogs) has been extensive throughout the southeast, with greater than 90 percent loss in Virginia, nearly 70 percent loss in North Carolina, and nearly 70 percent loss on the Southeastern Coastal Plain (Noss et al. 1995).

Loss, degradation, and fragmentation of wetland habitat have negatively affected numerous southeastern freshwater species, and natural wetland habitats continue to be lost, placing more species at risk (Dodd 1990, Benz and Collins 1997, Semlitsch and Bodie 1998, Herrig and Shute 2002). Vegetated permanent wetlands are among the most jeopardized habitats in the southeast, causing fish families that are dependent on these wetland habitats, such as pygmy sunfishes, to have a disproportionately high level of imperilment (Etnier and Starnes 1991, Cubbage and Flather 1993, Dickson and Warren 1994, Warren et al.1997). Wetland destruction has also destroyed habitat for many bird species (Dickson 1997). Aquatic reptile species that depend on standing water habitats have been negatively affected by wetland loss and alteration, loss of beaver ponds, and removal of habitat features such as basking logs (Herrig and Shute 2002). Buhlmann and Gibbons (1997) found that 55 percent of imperiled aquatic reptile species in the southeast are declining due to loss of wetland habitats, including 34 taxa of aquatic snakes and turtles. For example, Dodd (1990) found that wetland fragmentation contributed to the decline of the flattened musk turtle. Wetland loss also threatens southeastern amphibians (LaClaire 1997). Habitat for the petitioned salamander, the Gulf Hammock Dwarf Siren, has been lost as wetlands have been drained for residential, agricultural, and silvicultural development (AmphibiaWeb 2009).

Many reptile and amphibian populations exist as metapopulations that rely on habitat connectivity to maintain genetic structure and provide recolonization opportunities in the event of localized extirpation (Buhlmann and Gibbons 1997, Semlitsch and Bodie 1998).
Habitat fragmentation and wetland isolation thus threaten the regional persistence of southeastern wetland herptile populations by cutting off opportunities for migration and dispersal and magnifying the likelihood of inbreeding depression and reproductive failure due to random environmental perturbation (Buhlmann and Gibbons 1997, Semlitsch and Bodie 1998). Small wetlands continue to be lost, and even the loss of small wetlands can have negative effects on the persistence of metapopulations (Semlitsch and Bodie 1998).

Land Use Activities that Decrease Watershed Integrity

Overview

Southeastern aquatic biota are threatened not only by direct physical alteration of waterways, but also by activities in the watershed that directly or indirectly degrade aquatic habitats such as residential, commercial, and industrial development, agriculture, logging, mining, alteration of natural fire regime, and recreation. Land-use activities can alter water chemistry, flow, temperature, and nutrient and sediment transport, and can interfere with normal watershed functioning (Folkerts 1997). Cavefishes, for example, have a disproportionately high level of imperilment due to habitat degradation because their food base is derived from surface inputs which are degraded by a variety of activities (Warren et al. 1997). The Service has acknowledged that the habitat needs of species extend beyond the water channel and include riparian and floodplain habitats which are integral to maintaining channel geomorphology, providing nutrient input, and buffering sediments and pollution (FWS 2004). Thus, when identifying habitat threats to aquatic species, entire watersheds must be considered and not just localized sites where species occur (Shute et al. 1997, Strayer 2006).

Residential and Industrial Development and Human Population Growth

Southeastern aquatic and riparian species are threatened by habitat loss and degradation from increased development and resource consumption to support rapidly growing human population in the region. Development threatens two-thirds of the petitioned species. The only known location of the petitioned Florida fairy shrimp was destroyed by development (Rogers 2002), and unless this species is discovered in new areas, it may already be extinct. The primary threat to the petitioned dragonfly, the purple skimmer, is lakeshore development. The Waccamaw fatmucket, a petitioned mussel, is threatened primarily by increasing development in its watershed. The Carolina pygmy sunfish, Chauga Crayfish, and many other petitioned species are also threatened primarily by development.

Human population nearly doubled in the southeast from 1970-2000 (Folkerts 1997). From 1990-2000, the population of Georgia increased by 26 percent, North Carolina by 21 percent, Tennessee by 17 percent, and the population of Virginia increased by 14 percent (Buckner et al. 2002). Southeastern states continued to experience significant human population growth from 2000-2007, with the population of Georgia increasing by 17 percent, Florida by 14 percent, North Carolina by 13 percent, South Carolina by 10 percent, Virginia by 9 percent, and the population of Tennessee increasing by 8 percent (U.S. Census Bureau 2009). Metropolitan areas in the southeast are among the fastest growing in the nation (Dodd 1997). The human population of Raleigh, NC, expanded by 31 percent from 2000-2007, with other metropolitan areas also experiencing significant population growth: Atlanta 24 percent, Charlotte 24 percent, Jacksonville 16 percent, Nashville 16 percent, Tampa 14 percent, Richmond 11 percent, Miami 8 percent, Louisville 6 percent, Memphis 6 percent, and Birmingham 5 percent (U.S. Census Bureau 2009). Population in the southeast is expected to increase to 78.2 million people by the year 2020, representing a nearly 30 percent population increase over a 25-year period (Tennessen 1997).

Population growth threatens biodiversity due to increased demand for land, water, and other resources. Southeastern metropolitan areas are adding urbanized land at an even faster rate than population is increasing, with developed land increasing by 47 percent from 1982-1997 (Buckner et al. 2002). The area of urbanized land in Nashville, TN, more than doubled during this 15-year period, representing nearly an acre of newly developed land per new resident (Buckner et al. 2002). Similarly, the area of developed land in Alabama increased by 19 percent from 1982-1992 (Buckner et al. 2002). The strong geographic focus of development around fresh waters concentrates human ecological impacts on freshwater ecosystems more than on any other part of the landscape (Strayer 2006). Throughout the southeast, increased development is creating water supply problems, stressing available water resources, and polluting aquatic habitats (Seager et al. 2009). For example, population growth in Birmingham is pushing development into the upper Cahaba River watershed where runoff, wastewater discharges, and water withdrawals directly threaten aquatic species (Buckner et al. 2002). During the dry season, the Cahaba River's entire flow may now be diverted for domestic use (Buckner et al. 2002). Global climate change is expected to lead to fluctuating water supplies in the southeast, and in conjunction with increasing human demand for freshwater, to place many aquatic species at heightened risk of extinction (Karl et al. 2009).

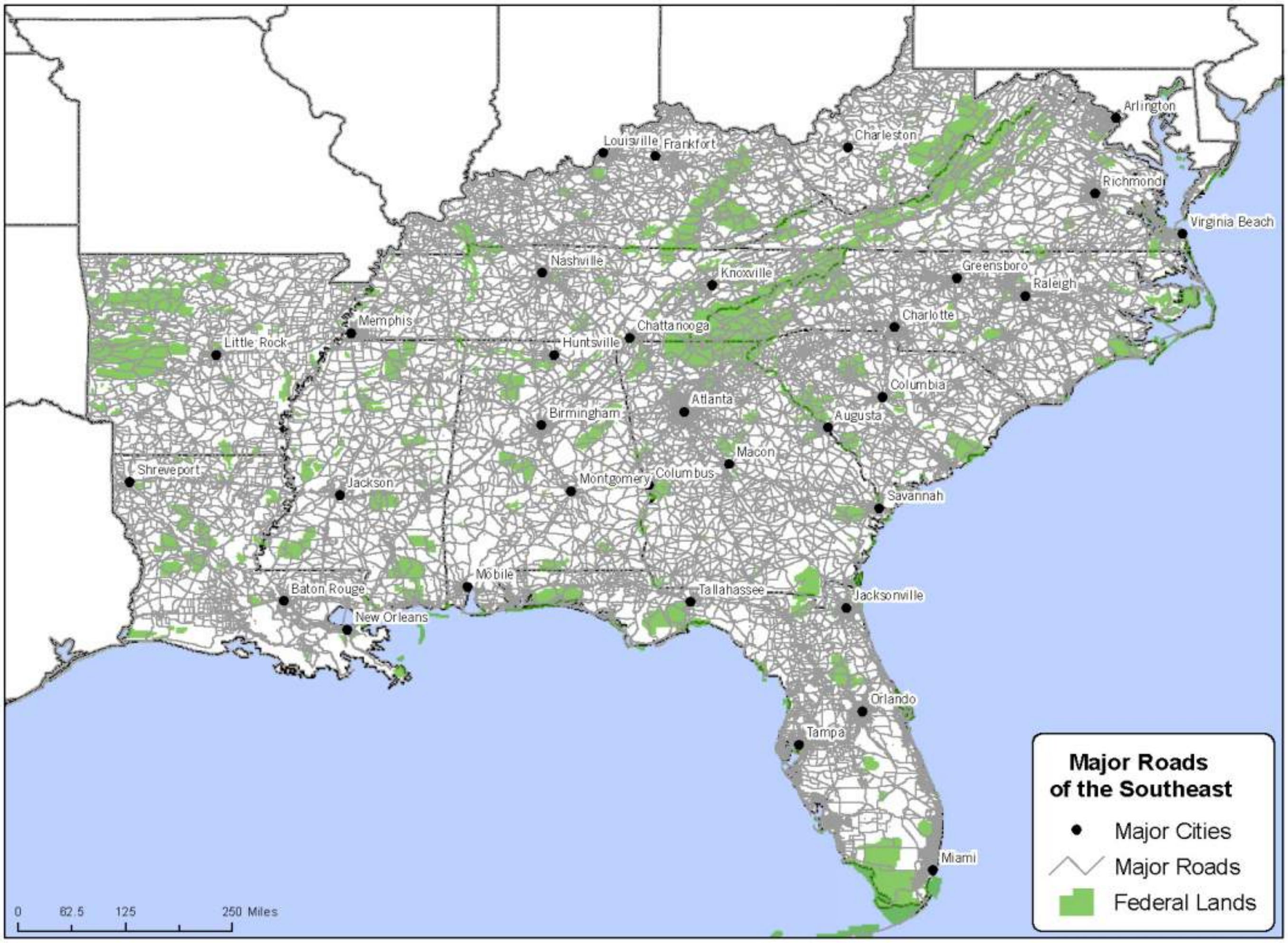

Fig. 2. Major Roads of the Southeast. Increasing development poses a major threat to Southeastern aquatic species.

Urbanization and residential, commercial, and industrial development threaten aquatic species in both direct and indirect ways. Habitat is directly lost and fragmented through land conversion and through water withdrawal and diversion (Benz and Collins 1997). Predation increases as populations of pets and synanthropic species increase (Marzluff et al. 2001). Point-source pollution from industry and runoff from parking lots, roofs, roads, and lawns degrade water quality and have lethal and sub-lethal effects on aquatic species. Urban runoff is associated with declines in macroinvertebrate diversity and with decreased mussel growth rates, and urban land use classes are associated with impairment of fish and macroinvertebrate communities (Soucek et al. 2003, Carlisle et al. 2008, see also petition section “Other Factors, Pollution”). Amphibians and reptiles are particularly threatened by development. Siltation and leachate from road runoff can be lethal for larval amphibians and other aquatic organisms (Dodd 1997). The construction of roads increases mortality and leads to population isolation and the disruption of the metacommunity structure on which the long term population persistence of many herptile species depends (Buhlmann and Gibbons 1997). Noise and light from roads and developments can interfere with behavior patterns and disrupt breeding and feeding activities, particularly for amphibians (Dodd 1997). Amphibian species richness is lower in urbanized areas, as many species cannot persist in urbanized sites (Delis 1993, Herrig and Shute 2002).

Habitat loss and degradation due to development is generally permanent and poses an increasing threat to southeastern aquatic species. Folkerts (1997) reports that in the southeast in particular, development threatens aquatic species more than in other areas due to lax enforcement of environmental laws in the region.

Recreation

Increasing human population is increasing the demand for recreational developments and activities. The development of smaller towns for retirement communities and recreational areas is increasing in the southeast and is threatening freshwater biodiversity. Housing developments, strip malls, and resorts are being constructed in very rural areas, and small towns are now burgeoning in previously undeveloped areas including the Knoxville-Chattanooga suburban corridor, on the Cumberland Plateau, in the Cahaba River headwaters outside Birmingham, and in the Mobile-Tensaw Delta (Buckner et al. 2002). Many rapidly developing small communities are constructing dams on headwater streams, often in areas that were recently remote and inaccessible, with resultant impacts on aquatic species (Buckner et. al 2002). The development of housing and recreational facilities on lakeshores and in riparian areas results in the degradation of water quality and aquatic habitat (Tennessen 1997). For instance, Morse et al. (1997) report the loss of rare stonefly species in a stream in North Carolina following the development of summer homes.

Recreational developments and activities threaten aquatic species for many reasons. Recreational developments foster air and water pollution, litter, and potentially high densities of recreationists (Houston 1971, White and Bratton 1980). Recreation can cause trampling of organisms and vegetation (Liddle 1975). The petitioned plant species *Plagiochila aspleniformis*, for example, is threatened by recreational use of its state park habitat (NatureServe 2008). Local habitat changes caused by trampling include simplification of vegetation and soil compaction which can result in overall loss of habitat diversity (Speight 1973, Liddle 1975). An egregious example of the potential impacts of recreation on aquatic species is off-road vehicle use. Off-road vehicle use can lead to severe degradation of aquatic and riparian habitats, the effects of which are well documented and include trampling of organisms, destruction of vegetation, erosion, and degraded water quality (Wuerthner 2007). Off-road vehicle use threatens imperiled mussels due to habitat degradation from riding in streams and along stream banks (Hanlon and Levine 2004). The riding of off-road vehicles near water can destroy the nests of egg-laying reptiles and can trample adults and young (Herrig and Shute 2002). Southeastern aquatic species are also threatened by other forms of motorized recreation, such as the use of motorized boats and jet-skis, which cause oil and gas contamination and bank erosion (Buckner et al. 2002). Poaching is also a threat to species in recreational areas. For instance, Garber and Burger (1995) document the extirpation of a turtle population in a protected area due to occasional removal of adults by recreational users.

Decreased water quality, trampling, or other recreational impacts threaten 22 percent of the petitioned species including the Bigcheek cave crayfish, Blue Spring hydrobe snail, and small-flower meadow-beauty.

Logging

Southeastern aquatic and riparian species are threatened by the loss of forests and the negative effects on water quality and aquatic habitats which result from logging activities and canopy removal. More than 95 percent of the original forest in the 48 conterminous states has been lost (Noss et al. 1995), including 99 percent of eastern deciduous forest (Allen and Jackson 1992). By the late 1920's, the majority of forested land in the southeast had already been logged (Neves et al. 1997). By the 1960's, clearcutting had became standard practice on southeastern forests and continues to the present (Morse et al. 1997). A region-wide cut is currently underway across the southeast, and the region now supplies nearly 70 percent of the nation's pulp and paper products (Buckner et al. 2002). The rate of deforestation in the southeast now exceeds that of any tropical area of comparable size (Folkerts 1997). The Tennessee, Cumberland, and Mobile basins have experienced a drastic increase in large clearcutting operations and chip mills, with 1.2 million acres of forest being cut annually to supply 150 regional chip mills, two-thirds of which have been built since the late 1980s (Buckner et al. 2002). In the area surrounding Great Smoky Mountain National Park, the rate of logging doubled from 1980-1990 (Folkerts 1997). Of the 70 million acres of longleaf pine forest which once covered over 40 percent of the Southeastern Coastal Plain, only one to two percent remains, and the remnant acreage is fragmented and "poorly-managed" (Noss et al. 1995, Dodd 1997). Clearcutting on the Coastal Plain has affected "virtually every aquatic habitat in the area" (Folkerts 1997, p. 11). Much forested land in the southeast is in private ownership, where "best management practices" to control erosion and protect aquatic habitats are not necessarily followed, which amplifies water quality degradation and threatens aquatic species (Morse et al. 1997).

Logging has multiple direct and indirect negative effects on aquatic biota, across taxa. Erosion from poor forestry practices degrades water quality (Williams et al. 1993). Increased sedimentation from logging can suffocate aquatic snails and their eggs, preclude their ability to feed, and extirpate populations: "As most (freshwater snails) are obligate perilithon grazers and require stable substrate, siltation, such as that resulting from clear-cutting, generally means loss of habitat and at least local extirpation" (Frest and Johannes 1993). Increased sedimentation is also harmful for freshwater mussels (Neves et al. 1997). Clearcutting and conversion of deciduous forest to pine plantations increases sedimentation and reduces the input of large woody debris and leaf litter into streams which are necessary to provide microhabitat and food for aquatic organisms (Morse et al. 1997, Herrig and Shute 2002). Clearcutting can lead to the disappearance of caddisflies and mayflies, with ramifications at higher levels of the food web (Morse et al. 1997). Amphibian diversity and abundance is reduced by clearcutting and the conversion of deciduous forests to pine plantations (Dodd 1997, Herrig and Shute 2002). Aquatic-breeding amphibians which depend on ephemeral ponds and/or which are dependent on forested habitats to complete their life cycle are particularly threatened by logging activities (Dodd 1997). Herbicides used after timber harvests also negatively affect amphibians and other aquatic organisms (Dodd 1997, Herrig and Shute 2002).

Fifty-one percent of the petitioned species are threatened by logging. Logging is the primary threat to the newly discovered patch-nosed salamander, and to many of the petitioned crayfishes including the Irons Fork Burrowing Crayfish, Kisatchie painted crayfish, and pristine crayfish. Logging also threatens the petitioned dragonflies including Westfall's clubtail and the Ozark emerald.

Agriculture and Aquaculture

Southeastern aquatic species are threatened by the loss and degradation of habitat due to poor agricultural practices. Agriculture is the most widely reported source of pollution in southeastern rivers (EPA 2004). Intensive agriculture began in the southeast in the 1930's, and agriculture continues to extensively impact southeastern aquatic ecosystems (Neves et al. 1997). Agriculture in the southeast has a tremendous impact on aquatic habitats both due to the extent of farmland and to farming practices (Buckner et al. 2002, Herrig and Shute 2002). In the Tennessee, Cumberland, and Mobile River basins, for example, farms cover nearly half the landscape. Throughout the southeast, fields are commonly plowed to the edges of waterways, causing sedimentation and bank collapse and facilitating the runoff of fertilizers and pesticides (Buckner et al. 2002). Both traditional farming practices and confined animal feeding operations contribute to water quality degradation and the imperilment of indigenous biota in the southeast through erosion, sedimentation, and chemical and nutrient pollution from point and non-point sources (Patrick 1992, Morse et al. 1997, Neves et al. 1997, Herrig and Shute 2002).

Fifty percent of the petitioned species are threatened by conversion of their habitat to agricultural use or by agricultural runoff including the striated darter, Logan's agarodes caddisfly, the Sevier snowfly, and the Tennessee clubtail dragonfly. Agriculture is known to be a major stressor for aquatic animals (Richter et al. 1997). In a biological assessment of Appalachian streams, Carlisle et al. (2008) found that agricultural land uses were associated with impairment of fish and macroinvertebrate communities. Agriculture is known to be contributing to the decline of sensitive fish species (Herrig and Shute 2002). Freshwater mollusks are threatened by silt loading and destabilized stream bottoms from agricultural runoff (Williams et al. 1993, Neves et al. 1997). Agricultural activities on the Atlantic and Gulf Coastal Plains threaten imperiled amphibians which are dependent on ephemeral pond habitats that are being lost to agricultural development (Herrig and Shute 2002).

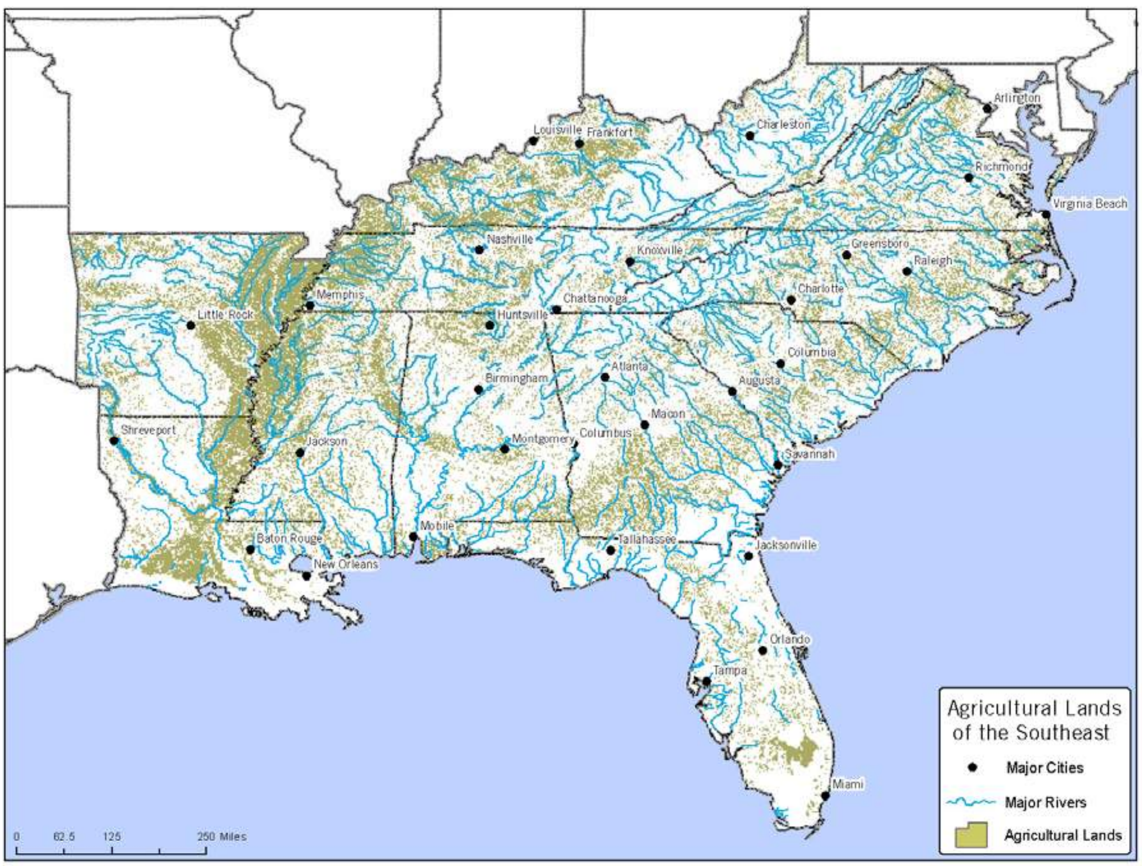

Fig. 3. Agricultural Lands of the Southeast. Half of the petitioned species are threatened by agricultural impacts.

Many of the petitioned species are specifically threatened by pollution from Confined Animal Feeding Operations (CAFOs), including the Carolina madtom fish, corpulent hornsnail, Neuse River waterdog salamander, and Ouachita creekshell mussel. CAFOs and feedlots have caused extensive degradation of southeastern aquatic ecosystems (Neves et al. 1997, Buckner et al. 2002, Mallin and Cahoon 2003). The number of CAFOs in the southeast has increased drastically since 1990 as livestock production has undergone extensive industrialization (Buckner et al. 2002, Mallin and Cahoon 2003). Alabama and Arkansas are now the nation's leading poultry producers, with Florida, Georgia, and Kentucky also ranking among the top ten states for poultry production (U.S. Census Bureau 2009). Poultry CAFOs are also abundant in North Carolina, Mississippi, and Virginia (Mallin and Cahoon 2003). There are extensive swine CAFOs on the North Carolina Coastal Plain, and North Carolina is now the nation's second largest pork producer (Mallin and Cahoon 2003, U.S. Census Bureau 2009). CAFOs threaten aquatic species both due to the vast amounts of freshwater necessary to support their operation and due to pollution (Buckner et al. 2002). CAFOs hold tens of thousands of animals and produce a large amount of waste which enters the environment either by being discharged directly into streams or constructed ditches, stored in open lagoons, or applied to fields in wet or dry form (Buckner et al. 2002, Mallin and Cahoon 2003, Orlando et al. 2004). CAFO wastes contain nutrients, pharmaceuticals, and hormones, and cause eutrophication of waterways, toxic blooms of algae and dinoflagellates, and endocrine disruption in downstream wildlife (Mallin and Cahoon 2003, Orlando et al. 2004, see also petition section "Other Factors, Pollution").

Both livestock holding lots and landscape grazing degrade aquatic habitats in the southeast (Buckner et al. 2002, Herrig and Shute 2002). Several southeastern states, including Tennessee, Kentucky, Alabama, and Florida, produce large amounts of cattle and horses both via grazing and holding lots (Buckner et al. 2002, U.S. Census Bureau 2009). Livestock are generally allowed to wade directly into streams, trampling habitat, and causing erosion and nutrient contamination (Buckner et al. 2002). A survey of peer-reviewed studies on the effects of livestock grazing on stream and riparian ecosystems found that grazing negatively affects water quality and quantity, channel morphology, hydrology, soils, instream and streambank vegetation, and aquatic and riparian wildlife (Belsky et al. 1999). Frest (2002) identifies livestock grazing as a primary factor in the extirpation of freshwater snail populations. Snails and their habitats are harmed via direct trampling, soil compaction, erosion, water siltation and pollution, and drying up of springs and seeps (Frest 2002). The Piedmont Pondsnail, *Stagnicola neopalustris,* which was known only from a single pond in Virginia, may have been driven to extinction due to cattle grazing (Herrig and Shute 2002, NatureServe 2009). Grazing threatens 14 percent of the petitioned species including the Virginia stone stonefly, Barrens darter fish, Cherokee clubtail dragonfly, Choctaw bean mussel, and many plants including the eared coneflower.

Aquaculture poses another threat for aquatic species in the southeast. The largest aquacultural enterprise in the United States is catfish (*Ictalurus punctatus*) farming, with 95 percent of production occurring in Alabama, Arkansas, Louisiana, and Mississippi (Tucker and Hargreaves 2003). Crayfish farming in Louisiana is the nation's second largest aquacultural enterprise, with the state holding over 49,000 hectares of crayfish ponds (Holdich 1993). Aquacultural operations can consist of constructed ponds or tanks, dammed waterways, enclosures in natural water bodies, or land-based tanks with flow-through of natural waters (Tacon and Forster 2003). Aquaculture threatens aquatic habitats due to habitat conversion, the withdrawal, diversion, or impoundment of natural waterways to support operations, and the release of effluent into waterbodies (Naylor et al. 2001). Trout farming, for example, requires large amounts of cold water and operations are generally constructed on "outstanding resource waterways" (Morse et al. 1997). Water-quality degradation from fish farms threatens southeastern aquatic insect populations (Herrig and Shute 2002). As discussed previously, impoundments and diversions alter water chemistry and flow and can be detrimental for native mollusks and fishes (Morse et al. 1997, Neves et al. 1997). The construction of shrimp farms in wetlands and estuaries also destroys and degrades habitat for native aquatic species (Hopkins et al. 1995).

Mining and Oil and Gas Development

Mining for coal, gravel, limestone, phosphate, iron, and other raw materials poses a dire threat to many aquatic species in the southeast (Dodd 1997, Buckner 2002). Past and present mining activities have caused extensive degradation of aquatic and terrestrial habitats and extirpation of aquatic populations (Neves et al. 1997). Twenty-nine percent of the petitioned species are threatened by mining and oil and gas development.

Extensive strip mining for coal is conducted in West Virginia, Kentucky, Virginia, Tennessee, and Alabama (Dodd 1997). As of 2004, more than 1.1 million acres of land in Appalachia were undergoing active mining operations (Loveland et al. 2003). The EPA projects that from 1992-2013, 761,000 acres of Appalachian forest will be lost to surface coal mining (Pomponio 2009). This figure does not include the forest lost prior to 1992. Nearly 7 percent of the forest that still existed in 1992 will be lost to coal mining by 2013 (Pomponio 2009). Mining has fragmented remaining forests, with resultant negative ecosystem effects (EPA 2005). Studies have shown that biodiversity and water quality are negatively affected when greater than 10 percent of the surface area of a watershed has been altered (Yaun and Norton 2003, Allan 2004, Morgan and Cushman 2005), yet up to 23 percent of the land area of some counties in Kentucky and West Virginia has been permitted for surface coal mining (U.S. Government Accountability Office 2009). Mining increases the potential for extreme flooding events, and reclamation does not restore pre-mining hydrologic characteristics or ecological functions (Townsend et al. 2009).

Mining often occurs directly through streams or ponds, and mine wastes are pushed directly into streams and rivers (Dodd 1997, EPA 2005). By 1973, it was estimated that over 18,000 miles of streams in Appalachia had already been degraded by underground coal mining (Ahmad 1973, Neves et al. 1997). From 1992-2002, more than 1200 miles of Appalachian streams were buried or degraded by mountaintop removal coal mining (EPA 2005). At this rate, by the end of 2010, over 2160 miles of stream will have been destroyed by mountaintop removal. This figure does not incorporate the thousands of miles of downstream reaches that have been substantially degraded by sedimentation and chemical pollution from coal mining (Palmer and Bernhardt 2009, Pomponio 2009, Palmer et al. 2010). In the Clinch and Powell watersheds in southwestern Virginia, where the highest concentration of imperiled species in the continental United States occurs (Stein et al. 2000), there were 287 active coal-mining point-source discharges as of 2002 (Diamond et al. 2002), which have been shown to be degrading habitat conditions for imperiled species (Ahlstedt et al. 2005). In the Laurel Creek watershed of the Big Coal River in West Virginia, nearly one-third of total stream length has been buried beneath valley fills or impacted by surface mines (Palmer and Bernhardt 2009). Thirty of the petitioned species are specifically threatened by mountaintop removal.

Coal mining negatively impacts aquatic species through direct habitat destruction, decreased water availability, variations in flow and thermal gradients, and chronic and acute pollution of surface and ground water (FWS 1996, Neves et al. 1997, Houp 1993, Pond et al. 2008, Palmer and Bernhardt 2009, Pomponio 2009, Wood 2009, Palmer et al. 2010). Pollution from mining negatively impacts invertebrates and vertebrates and leads to less diverse and more pollution-tolerant species (Naimo 1995, Cherry et al. 2001, EPA 2005, Lemly 2009, Pomponio 2009, see also petition section "Other Factors, Pollution"). Surface coal mining and associated road-building increase human access to imperiled species which can lead to poaching and contribute to the spread of invasive species (FWS 1996). Surface coal mining also causes long-term changes in land use and local ecology, and threatens the long-term viability of populations due to habitat fragmentation (FWS 1996).

Numerous scientific studies have reported declines in the diversity and abundance of aquatic organisms resulting from coal mining (Branson and Batch 1972, Vaughan 1979, Matter and Ney 1981, Dodd 1997, Folkerts 1997, Soucek et al. 2003). Diatom and macroinvertebrate communities are seriously degraded in mining tributaries (Serveiss 2001, Locke et al. 2006, Carlisle et al. 2008, Pond et al. 2008). Concerning the extirpation of macroinvertebrates due to surface mining, Wood (2009) states:

> "We now have clear evidence that in some streams that drain mountaintop coal quarry valley fills, the entire order *Ephemeroptera* (mayflies) has been extirpated, not just certain genera of this order. We also have evidence that some streams no longer support the order *Plecoptera* (stoneflies). . . The loss of an order of insects from a stream is taxonomically equivalent to the loss of all primates (including humans) from a given area. The loss of two insect orders is taxonomically equivalent to killing all primates and all rodents through toxic chemicals. Such adverse ecological impacts are most certainly significant, and they prevent affected streams from meeting their designated aquatic life uses."

The loss of macroinvertebrates directly and indirectly impacts stream ecology. Soucek et al. (2003) found a significant association between decreased abundance of indicator insect species and decreased growth rates of mussels. Locke et al. (2006) suggest that mining-influenced tributaries are negatively affecting downstream mussels. Field and laboratory studies implicate sedimentation from mining in the decline of mussels and snails (Aldridge et al. 1987, Neves et al. 1997). Neves et al. (1997) state, "Many species of mollusks have been extirpated from headwater streams where mining has been most intense" (p. 69). Numerous studies have attributed the decline in diversity and abundance of mussels to habitat loss and degradation resulting from coal mining (Neel and Allen 1964, Stansberry 1969, Ahlstedt and Brown 1979, Neves et al. 1980, Branson et al. 1984, Anderson 1989, Houp 1993, McCann and Neves 1992, Wolcott and Neves 1994, Naimo 1995, Ahlstedt and Tuberville 1997, Neves et al. 1997, Cherry et al. 2001, Ahlstedt et al. 2005, Warren and Haag 2005, Locke et al. 2006).

Amphibian diversity and abundance is lower on lands that have been mined (EPA 2005). Wood (2009) reports that salamanders in headwater stream ecosystems have been significantly negatively impacted by mountaintop removal coal mining. Concerning the concentration of endemic salamanders and mussels in coal mining areas, Palmer and Bernhardt (2009) state:

> "Where mining activities destroy stream habitat and degrade stream water quality, many of these taxa become locally extinct, and for species with small geographic distributions, mining activities will contribute to their global extinction."

Diamond and Serveiss (2001) found that proximity to mining had the greatest impact on the index of fish biotic integrity. They conclude, "Results may indicate that mining has a profound negative effect on fish communities." Lemly (2009) reports that selenium contamination from coal mining can eliminate entire communities of fish and cause reproductive failure in aquatic birds (Lemly 1985, Ohlendorf 1989). Recovery of aquatic life in mining-waste impacted streams has not been documented, effects are "pervasive and irreversible," and "mitigation cannot compensate for losses" (Palmer et al. 2010).

Other forms of mining and oil and gas development are also known to be causing severe degradation of aquatic habitats. In-stream gravel mining and rock removal fragment and destroy habitat for aquatic insects, mussels, crayfish, and fish (Buckner et al. 2002). Sand and gravel mining have been associated with both on and off-site mussel extirpation (Hartfield 1993) and with decreased downstream mussel growth rates (Yokley 1976). Many petitioned species are threatened by sand and gravel mining including the cobblestone tiger beetle, bluestripe darter, hellbender salamander, and many mussels and snails. As early as the 1920's, it was reported that phosphate and iron mines were causing a precipitous decline in mussel populations (Ortmann 1924). Mining of industrial minerals such as kaolin, mica, and feldspar also causes loss and degradation of habitat for aquatic species (Tennessee Valley Authority 1971, U.S. EPA 1977, Duda and Penrose 1980). Kaolin mining threatens the petitioned mussel, the Alabama spike, and the fish, the robust redhorse. Oil and gas development threaten many of the petitioned mussels.

In sum, many factors are causing the loss and degradation of aquatic habitats in the southeast including logging, mining, agriculture, development, and recreation. Habitat loss is the leading cause of extinction globally and poses a dire threat to almost all of the petitioned species.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Overutilization pushes imperiled species towards extinction, especially in conjunction with other threats. Thirty eight of the petitioned species are threatened by overutilization for commercial, recreational, scientific, or educational purposes. Overutilization is the primary threat for seven of the petitioned plants and for many of the petitioned turtles, particularly the map turtles. It is also a primary threat to the hellbender salamander, which is commonly killed by fishermen. Collection for the pet trade threatens a few of the petitioned fishes, crayfishes, and amphibians. Historical overuse greatly threatened many of the petitioned mussels, fishes, and the Florida sandhill crane.

Throughout the southeast reptiles are exploited for use as pets or food, or are killed forthright for recreational purposes, all which may cause significant population declines (Salzberg 1995, Williams 1995, Buhlmann and Gibbons 1997, Gibbons et al. 2001, Herrig and Shute 2002, Means 2009). Many southeastern turtle species, such as the Florida red-bellied turtle (*Pseudemys nelsoni*), are threatened by overcollection because they are commonly harvested for food (NatureServe 2008). Several southeastern freshwater turtle species are being driven to extinction by unregulated commercial harvest. The states of Arkansas, Kentucky, Georgia, Louisiana, and Tennessee allow unlimited harvest of freshwater turtles. The international trade in turtles for use as food, pets, or in traditional medicine is extensive and largely unregulated (Buhlmann and Gibbons 1997, Sharma 1999). Over the last decade conservation biologists have cautioned state wildlife agencies that freshwater turtles in North America are being increasingly targeted to supply food markets in Asia, particularly China, due to depletion of wild populations of Asian turtles (Behler 1997). Because the trade in turtles is not regulated, few records have been kept, but existing records indicate that the trade in live turtles from the United States to China is thousands of tons per year (Mockenhaupt 1999). According to the U.S. Law Enforcement Management Information System, from November 2002 to November 2005, nearly 733,000 wild-caught freshwater turtles were declared as exports from U.S. ports. This number likely underestimates the actual harvest because it includes only exports and does not include unreported collection. The Tennessee Wildlife Resources Agency reports that more than 25,000 turtles were reported as harvested in Tennessee from 2006-2007.

Overutilization of imperiled turtle species is especially problematic because the reproductive success of long-lived reptile species is dependent on high adult survivorship, and population declines occur when adults are harvested (Brooks et al. 1991, Heppell 1998, Pough et al. 1998, Congdon et al. 1993, 1994). Reed et al. (2002) found that the removal of as few as two female adult alligator snapping turtles could halve a population of 200 turtles within 50 years. Congdon et al. (1994) found that the removal of as few as 10 percent of the adults above 15 years of age could halve a snapping turtle population in 15 years. Garber and Burger (1995) documented the extirpation of a wood turtle (*Glyptemys insculpta*) population due to the occasional removal of adults by recreational users.

In the southeastern United States, shooting and/or harvesting have contributed to the decline of map turtles, musk turtles, snapping turtles, and pond turtles (Buhlmann and Gibbons 1997). The alligator snapping turtle (*Macroclemys temminckii*) has declined as the direct result of overharvest (Sloan and Lovich 1995). Map turtles in particular are threatened by commercial collection, with adults valuing hundreds of dollars each on the web (Center for Biological Diversity 2008). Herpetologists from the Tennessee Aquarium who have conducted map turtle surveys in Florida and Georgia for decades report drastic population depletion and even extirpation of most southern map turtle species, primarily attributable to overcollection for the pet trade (George, G.A. pers. comm. 2007). Barbour's map turtle (*Graptemys barbouri*) has declined due to human consumption and collection for the pet trade (NatureServe 2008). The Pascagoula map turtle (*Graptemys gibbonsi*) has declined due to commercial collection and recreational shooting (NatureServe 2008). The black-knobbed map turtle (*Graptemys nigrinoda*) is threatened by target shooting and exploitation for the pet trade (NatureServe 2008). The Escambia map turtle (*Graptemys ernsti*) is also threatened by shooting, trapping, and commercial collection (NatureServe 2008).

Overcollection and recreational killing are also a problem for some Southeastern snake and lizard species (Gibbons et al. 2000, Herrig and Shute 2002). The Apalachicola kingsnake (*Lampropeltis getula pop. 1*), Kirtland's snake (*Clonophis kirtlandii*), and the Florida Keys mole skink (*Eumeces egregius egregious*) are all threatened by overcollection (NatureServe 2008).

Southeastern mussels are also threatened by overutilization, though to a lesser extent than in the past (Neves et al. 1997). The harvest of southeastern mussel species for commercial purposes is well documented (Anthony and Downing 2001, Williams et al. 2008). Mussels are collected by humans for their pearls, meat, and shells, and many populations of mussels have been depleted by harvest in the last 200 years (Strayer 2006). In a single year in the mid-1910's, more than 13 million kg of mussel shells were harvested in the state of Illinois alone, and more than 100 million mussels were removed from a single 73-hectare bed on the Mississippi River (Claassen 1994, Carlander 1954). In 1960, more than 6,700 tons of shells were harvested from Tennessee Valley Authority reservoirs in northern Alabama (Williams et al. 2008). Although mussel fisheries targeted abundant species, the historical bycatch of rare species was likely substantial (Strayer 2006). Mussel collection declined by mid-century, but resurgence in the commercial harvest of native mussels has occurred since the 1960's to supply nucleus beads for the cultured pearl trade (Ward 1985, Williams et al. 1993). Wild U.S. populations are the preferred source for nucleus beads for the Japanese pearl industry, which has increased harvest pressure on southeastern mussel populations (Williams et al. 1993, Jenkinson and Todd 1997). In 1991 and 1992, 570 tons of shells were harvested from the Wheeler Reservoir on the Tennessee River (Williams et al. 2008). The cultured pearl industry is very unpredictable and cycles with fluctuating market demand (Williams et al. 2008). The spike in raw shell prices in the early 1990's resulted in up to 100 commercial boats simultaneously harvesting single reservoirs (Williams et al. 1993). Most harvested mussels are common species, but bycatch remains a threat to native mussels. Imperiled native mussels are threatened not only by the amount of harvest, but also by the method used to collect shells, which when conducted non-selectively, can result in substantial bycatch of non-target species and juveniles (Williams et al. 1993). Although unwanted mussels are thrown back, Sickel (1989) found that mortality of undersized mussels which are thrown back may be as high as 50 percent. Mussels are threatened not only by commercial collection, but also by collection from shell collectors and biologists. Very rare species are particularly threatened by overcollection. Overutlization for biological collections may have contributed significantly to the decline of the Suwannee Moccasinshell (*Medionidus walkeri*), for example (NatureServe 2008).

Other southeastern taxa are also threatened by overexploitation, including amphibians, fish, crayfish, butterflies, and plants. Amphibians are threatened by overcollection for use as food, for the pet trade, and for the biological and medicinal supply markets (Dodd 1997, AmphibiaWeb 2009). Southeastern fishes and crayfishes are vulnerable to overutilization. Crayfishes are threatened by collection for use as bait or food (Herrig and Shute 2002). The Carolina pygmy sunfish (*Elassoma boehlkei*) is threatened by overcollection for the pet trade (NatureServe 2008). The lake sturgeon (*Acipenser fulvescens*) remains vulnerable to harvest due to historical overuse (NatureServe 2008). Collection of invertebrates for bait or the pet trade can deplete populations (Strayer 2006). Collection of the Mitchell's satyr (*Neonympha mitchellii*) has contributed substantially to the decline of this rare butterfly (NatureServe 2008). Collection also threatens the rare skipper (*Problema bulenta*) (NatureServe 2008). White et al. (1992) document the removal of an entire population of Panhandle lily (*Lilium iridollae*) from the Conecuh National Forest by horticultural collectors.

Overutilization is a threat not just for rare species, but for some species which are currently abundant due to the magnitude of collection pressure. Buhlmann and Gibbons (1997) state that even presently abundant southeastern reptile species are of concern because of the vast numbers being removed from the wild for export.

Rare species which are not currently threatened by overutilization may become threatened at any time as their perceived value increases. In the proposed rule to list three rare mollusk species, FWS (2009) states:

> "While collection is not considered a current threat, the desirability of these species in scientific and commercial collections may increase as their existence and rarity becomes known, and their localized distributions and small population sizes leaves them vulnerable to overzealous recreational or scientific collecting" (74 FR 31114, p. 8).

The impacts of overutilization compound the threats facing imperiled southeastern species whose populations have already been reduced due to habitat loss and other factors. Overutilization may drive species which are already struggling to survive to extinction.

DISEASE AND PREDATION

Disease

Thirty six of the petitioned species are threatened by disease or predation. The spread of disease has contributed to the decline of aquatic species globally and in the southeastern United States (Daszak et al. 1999, Corser 2000, Gibbons et al. 2000, Cunningham et al. 2003). Amphibians in particular have been decimated by the spread of disease (Kiesecker et al. 2004). Numerous diseases are contributing to amphibian declines including infections of fungi (*Batrachochytrium dendrobatidis* "chytrid"; *Saprolegnia ferax),* ranaviruses, iridoviruses, mesomycetozoae, protozoae, helminthes, and undescribed diseases (Dodd 1997, Daszak et al. 1999, Briggs et al. 2005, Davis et al. 2007, Peterson et al. 2007). The most infamous of these, chytrid fungus, affects not only frogs but has also now been reported in both aquatic and terrestrial salamanders (Davidson et al. 2003, Cummer et al. 2005, Padgett-Flohr and Longcore 2007). In Alabama, Byrne et al. (2008) recently detected chytrid fungus in the southern two-lined salamander (*Eurycea cirrigera*). The decline of map turtles, musk turtles, snapping turtles, and pond turtles is partially attributable to disease (Dodd 1988, Buhlmann and Gibbons 1997). For instance, populations of Barbour's map turtle (*Graptemys barbouri*) have been afflicted by bacterial disease (Jacobson et al. 1989) and by a fatal disease of unknown etiology (NatureServe 2008). Southeastern freshwater fishes are also threatened by diseases, which are being spread by aquacultural operations and in shipments between fish hatcheries (Kautsky et al. 2000, Naylor et al. 2001, Strayer 2006, Green and Dodd 2007).

Other threats exacerbate the vulnerability of southeastern aquatic fauna to disease and population decline. The hellbender, which is direly threatened by both habitat loss and overuse, is also threatened by disease. Reptile declines have also been attributed to disease (Diemer Berish et al. 2000, Gibbons et al. 2000). In freshwater fishes, stress-related diseases are prevalent in polluted rivers where chronic, sub-lethal pollution has increased the susceptibility of organisms to infection (Moyle and Leidy 1992).

Predation

Predation threatens several of the petitioned species. Even natural levels of predation can push imperiled species towards extinction, especially in conjunction with other threats such as reduced habitat or stress from factors such as climate change and disease.
Predation threatens the petitioned species across taxa, including reptiles, birds, plants, amphibians, fishes, crayfishes, and mollusks. Browne and Hecnar (2007) report that heavy predation on turtle nests from raccoons can be a primary factor limiting recruitment of imperiled turtle populations. For example, effects of predation can be severe on populations of Florida red-bellied turtle (*Pseudemys nelsoni*), the juveniles and eggs of which are preyed upon by raccoons, fish, and corvids (NatureServe 2008). Drought magnifies the effects of predation on this species due to increased exposure resulting from reduced water levels (NatureServe 2008). At least two of the petitioned bird species are threatened by predation. The seaside sparrow (*Ammodramus maritimus macgillivraii*) is threatened by predation by rice rats (Post and Greenlaw 1994). The black rail is threatened by predation from various species during high tides when the rails are forced away from cover (Evens and Page 1986). Two of the petitioned plant species are known to be threatened by predation. Hall's bulrush (*Schoenoplectus hallii*) is threatened by predation from mute swans and Canada geese (McKenzie et al. 2007). The Panhandle Lily (*Lilium iridollae*) is threatened by cattle grazing and potentially by insect herbivory (Barrows 1989). Southeastern amphibians, fishes, and crayfishes are threatened by predation from native and non-native crayfishes and fishes (NatureServe 2008). The Lake Sturgeon (*Acipenser fulvescens*) is threatened by predation of eggs by round gobies (Hay-Chmielewski and Whelan 1997). The streamside salamander is threatened by predation from fish, flatworms, and water snakes (Petranka 1983, AmphibiaWeb 2009). Predation can contribute heavily to the decline of imperiled mussels because of their restricted distributions and small population sizes (NatureServe 2008, Rock Pocketbook species account). Imperiled southeastern mussels are threatened by predation from fishes, muskrats, racoons, otter, mink, turtles, and some birds (Neves and Odom 1989, Parmalee 1967, Snyder and Snyder 1969). A number of fish species, including catfishes (*Ictalurus* spp. and *Amieurus* spp.) and freshwater drum (*Aplodinotus grunniens*) consume large numbers of unionid mussels at certain life stages (NatureServe 2008).

Domestic and wild hogs tear up mussel beds by rooting (Meek and Clark 1912). As populations of imperiled mussels continue to shrink, predation becomes an increasing threat. For example, the only viable population of the Savannah lilliput (*Toxolasma pullus)* in North Carolina is threatened by predation from raccoons (Hanlon and Levine 2004). The petitioned fish, the barrens topminnow, is threatened by predation from introduced mosquitofish.

Disease and predation, alone and in conjunction with other factors, pose serious threats to the survival of many of the petitioned species. The risks posed by disease and predation are magnified by other environmental stressors such as habitat loss, pollution, invasive species, and climate change (Gibbons et al. 2000, Pounds et al. 2006).

INADEQUACY OF EXISTING REGULATORY MECHANISMS

There are no existing regulatory mechanisms at the federal, state, or regional levels that adequately protect the petitioned species, all of which are at risk of extinction.

Inadequacy of Existing Federal Regulatory Mechanisms

The Clean Water Act

Pollution and habitat loss are two of the largest threats facing the petitioned species, all of which are dependent on healthy riparian and aquatic habitat for survival. The federal Clean Water Act provides a basic level of water quality protection for imperiled southeastern species, but is inadequate to ensure their continued survival without the addition of Endangered Species Act protection and Critical Habitat designation. The provisions of the Clean Water Act are inadequate to protect the petitioned species because pollution from point and non-point sources is causing ongoing degradation of water quality, current water quality standards are not effectively protecting sensitive species or sensitive developmental stages of species, and loss of stream and wetland habitat continues.

The Environmental Protection Agency and individual states regulate point sources of pollution under the National Pollution Discharge Elimination System (NPDES), under which point sources are licensed and maximum pollutant discharge concentrations are set. The NPDES system is not adequate to protect the petitioned species from the negative effects of pollution because permits may be issued with few restrictions, cumulative effects of all the point sources within a watershed are not taken into consideration when permits are issued, and state governments often lack the resources or political will to monitor and enforce permits (Buckner et al. 2002). Concerning the failure of the current permitting system to protect aquatic habitats, Morse et al. (1997) state:

> "Industrial effluent provides point sources of pollution that can harm streams. Reducing or stopping these problems is often complicated by legal, political, and economic circumstances, with regulators, private citizens, lawmakers, employers, and employees often at odds. The wheels are turning very slowly to rectify existing legal uncertainties associated with industrial effluent" (p. 24).

In the Southeast in particular, adequate regulatory mechanisms to protect aquatic habitats from pollution are lacking due to jurisdictional issues and conflicting priorities:

> "Federal-state and intra- and interstate coordination is confounded within southeastern states primarily because jurisdiction over water, waterways, and the aquatic fauna is fragmented among agencies with different and often contradictory regulatory mandates (e.g., providing drinking water versus recreational fishing versus waste disposal)" (Warren et al. 1997, p. 124).

The southeast also has a history of lax enforcement of environmental laws:

> "In many ways, the southeastern United States has been treated as a Third World country by the rest of the nation, or, perhaps more accurately, by industrial interests throughout the world. Industrial sitings in the region have often been based on the same criteria used to site plants in Latin American countries, i.e., lower salaries can be paid, tax rates on industries are lower, and perhaps most importantly, pollution laws and other measures to preserve environmental integrity are poorly enforced and easily circumvented by using political pressure" (Folkerts 1997, p. 11).

The socioeconomic setting in the southeast is such that when conflicts arise between economic development and species protection, economic development generally prevails (FWS 1997).

Even if existing laws were strictly enforced, current water quality standards are not sufficient to protect sensitive species or sensitive life-stages of species. Water-quality standards are not based on toxicity testing of rare species, and some aquatic organisms are more sensitive to pollutants than the organisms which are used to establish the standards (Herrig and Shute 2002). Permitted activities may thus negatively affect rare aquatic species. Most species of mollusks are intolerant of chronic exposure to polluted water (Neves et al. 1997). Neves et al. (1997) state, "As judged by the decline and degree of rarity of mollusks in southeastern rivers, criteria to protect this faunal group are urgently needed" (p. 68). The glochidia of mussels may be more sensitive to pollution than adult forms (Neves et al. 1997). Further, current standards are for surface water quality, and because sediments store and accumulate toxins, benthic species are not adequately protected by existing criteria.

FWS has been aware for more than a decade that existing regulations are not adequately protecting imperiled mollusks. In a 1994 proposed rule to protect five species of southeastern mussels under the Endangered Species Act, FWS stated:

> "Existing authorities available to protect aquatic systems, such as the Clean Water Act, administered by the Environmental Protection Agency (EPA) and the Army Corps of Engineers, have not been fully utilized and may have led to the degradation of aquatic environments in the Southeast Region, thus resulting in a decline of aquatic species" (59 FR 35901).

In the 1997 final rule, responding to an EPA request for clarification concerning the above statement, FWS wrote:

> "Through EPA's implementation of the CWA, water quality has been improved and mussel populations have benefited. However, in spite of general water quality improvements, numerous freshwater mussel populations in the southeastern United States are continuing to decline even in areas that appear to have suitable physical habitat. The Service believes that it is likely that some insidious environmental factor(s), possibly contaminants, may be adversely affecting the growth, reproduction, or survival of these populations. Of all the potential impacts to mussels, less is known about the potential effects of

contaminants on these species. The Service believes that EPA could, through the CWA, play a more active role in identifying potential contaminant impacts to mussels" (62 FR 1647, p. 1653).

In 2009 in the proposed rule to list three imperiled southeastern mollusks, FWS acknowledged that water quality criteria and enforcement are still inadequate to protect sensitive aquatic species:

> "Current State and Federal regulations regarding pollutants are assumed to be protective of freshwater mollusks; however, these species may be more susceptible to some pollutants than test organisms commonly used in bioassays. For example, several recent studies have suggested that U.S. Environmental Protection Agency's (EPA) criteria for ammonia may not be protective of freshwater mussels (Augspurger et al. 2003, p. 2571; Augspurger et al. 2007, p. 2026; Newton et al. 2003, pp. 2559– 2560; Newton and Bartsch 2007, p 2057; Ward et al. 2007, p. 2075). In a review of the effects of eutrophication on mussels, Patzner and Muller (2001, p. 329) noted that stenoecious (narrowly tolerant) species disappear as waters become more eutrophic. They also refer to studies that associate increased levels of nitrate with the decline and absence of juvenile mussels (Patzner and Muller 2001, pp. 330–333). Other studies have also suggested that early life stages of mussels are more sensitive to metals and such inorganic chemicals as chlorine and ammonia than are common bioassay test organisms (Keller and Zam 1991, pp. 543–545; Goudreau et al. 1993, p. 221; Naimo 1995, pp. 354–355). Therefore, it appears that inadequate research and data prevent existing regulations, such as the Clean Water Act (administered by the EPA and the U.S. Army Corps of Engineers), from being fully utilized or effective in the management and protection of these species" (74 FR 31120).

Existing regulations are also inadequate to protect aquatic species from nonpoint sources of pollution such as agricultural, residential, and urban runoff, which are generally approached in a non-regulated, voluntary manner. Agricultural runoff accounts for over 70 percent of impaired U.S. river kilometers, yet is largely exempt from permitting requirements (Neves et al. 1997). Some Confined Animal Feeding Operations are considered to be non-point sources of discharge, with regulations varying from state to state which allows gross amounts of pollution to enter waterways (Mallin and Cahoon 2003). Lack of effective regulatory mechanisms to control non-point source pollution poses a dire threat to aquatic species:

> "Still lacking are the legislative means to significantly reduce nonpoint runoff from agricultural and urban areas. . . nonpoint problems . . . continue to degrade water quality and jeopardize all aquatic biodiversity in southeastern streams" (Neves et al. 1997, p. 66).

Existing regulations are also inadequate to protect Southeastern aquatic species from accidental spills from retention ponds which are used to store wastes from agriculture, coal-fired power plants, coal mining, and other activities (Herrig and Shute 2002).

Further, the Clean Water Act is not effective at preventing activities within a watershed which negatively impact water quality, and the health of aquatic systems needs to be evaluated and regulated on a watershed-wide scale:

> "Voluminous research and management experience have clearly documented the interdependence of terrestrial and aquatic ecosystems for the overall health of biota (Pajak et al. 1994). However, the implementation of this knowledge through effective and comprehensive policy change has been egregiously slow" (Neves et al. 1997, p. 66).

Under the Clean Water Act, loss of stream and wetland habitat is ongoing. In Appalachia, from 1992-2002 the EPA permitted the filling of more than 1200 miles of headwater streams for surface coal mining activities (EPA 2005). Headwater streams harbor unique aquatic species, diverse invertebrate assemblages, and provide nutrients that are critical for fish and other downstream organisms (EPA 2005). The permitted filling of streams for surface coal mining is causing permanent downstream pollution and loss of biodiversity (Neves et al. 1997, Pond et al. 2008, Pomponio 2009, Wood 2009, Palmer et al. 2010).

The permitted filling of wetlands is also ongoing. Section 404 of the Clean Water Act sets as a goal no net loss of wetlands, but this is not a required outcome of permit decisions (Connolly et al. 2005). In fiscal year 2003, the Army Corps of Engineers issued 4,035 permits for the destruction of natural wetlands, while denying only 299 permits (Connolly et al. 2005). Lost wetlands are required to be replaced by mitigation wetlands, but mitigation wetlands often differ in structure, function, and community composition from the natural wetlands which are destroyed (Holland et al. 1995). Mitigation requirements are also not strictly enforced. Mitigation "represents a promise that the permittees will perform the mitigation in the future. Unfortunately, permittees are often unable or unwilling to comply with compensatory mitigation requirements" (Connolly et al. 2005, p. 262). Mitigation is rarely effective in preserving biodiversity (Cabbage et al. 1993; Water Environment Federation 1993). Moreover, small, isolated wetlands which provide essential habitat for many species of amphibians and reptiles are not adequately protected under the Clean Water Act and continue to be lost:

> "[S]mall wetlands are extremely valuable for maintaining biodiversity . . . the loss of small wetlands will cause a direct reduction in the connectance among remaining species populations, and . . . both existing and recently proposed legislation are inadequate for maintaining the biodiversity of wetland flora and fauna" (Semlitsch and Bodie 1998).

Many species of amphibians, reptiles, and insects require both wetland and upland habitat to complete their life cycles, and wetland protection criteria don't protect the upland habitats these species need to survive (Dodd 1997). For instance, Burke and Gibbons (1995) documented turtles nesting and wintering in forested upland habitats outside the boundaries of federal wetland delineation lines.

In sum, the Clean Water Act is not adequate to protect the petitioned species from the threats of habitat loss and degradation and pollution.

The Surface Mining Control and Reclamation Act

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) is intended to prevent the degradation of aquatic habitats from coal mining activities. Due to increased demand for coal, lax enforcement of environmental law, and deference to economic development over species' protection, SMCRA is not adequately protecting aquatic species. For example, neither SMCRA nor the Clean Water Act have been effective in preventing the continued decline of the Black Warrior waterdog, a petitioned amphibian (Dodd et al. 1986, Mettee et al. 1989, Hartfield 1990, Bailey and Guyer 1998, U.S. Fish and Wildlife Service 1998). Further, sedimentation from active mines is a primary contributor to the decline of mollusks due to water quality degradation, shell erosion, and reproductive failure (Anderson 1989, Houp 1993, Neves et al. 1997). FWS has acknowledged that mining activities continue to be permitted even when imperiled species are placed at risk:

> “[I]t has been the Service’s experience, after dealing with hundreds of mining projects, that in nearly all cases where there is a conflict between endangered species and a mining project, the project is permitted with only minor modifications” (FWS 1997, p. 1651).

Reclamation required under SMCRA is not rigorously enforced (Ward 2009). Even when reclamation is conducted, it has not resulted in the restoration of pre-mining hydrologic characteristics or ecological functions (Townsend et al. 2009). Concerning the failure of the reclamation requirements of SMCRA to protect biodiversity or stream health, Palmer et al. (2010) state:

> “Current mitigation strategies are meant to compensate for lost stream habitat and functions but do not; water-quality degradation caused by mining activities is neither prevented nor corrected during reclamation or mitigation. Clearly, current attempts to regulate mountaintop mining/valley fill practices are inadequate. Mining permits are being issued despite the preponderance of scientific evidence that impacts are pervasive and irreversible and that mitigation cannot compensate for losses” (p. 149).

National Wildlife Refuges

Several of the petitioned species occur on National Wildlife Refuges. The species that occur on refuges enjoy some degree of habitat protection because refuges are managed by FWS primarily to conserve fish, wildlife, and plant resources. However, these species are still threatened with extinction for several reasons. Management priority is generally given to more charismatic species and conservation actions are limited by available funding and staffing. Refuges are managed under conservation plans that provide guidance for planning and management decisions but they do not constitute a commitment for staffing or funding, and refuge budget and staffing levels are usually inadequate to implement preferred management actions. Due to lack of fiscal resources, the implementation of conservation actions is thus uncertain. Species that occur on refuges also face threats from historical habitat degradation, climate change, invasive species, recreation, and poaching.

National Recreation Areas

National Recreation Areas are managed under broad guidelines which provide theoretical protections for species which occur within their boundaries, but their management plans are not focused on species’ protection. The implementation and effectiveness of actual protections for imperiled species is uncertain.

National Forests

Several of the petitioned species occur on National Forests. National Forest management plans provide guidelines for species’ protection, but these guidelines are generally discretionary. National forests are mandated to produce a specified amount of timber, which gives preference to resource extraction over species’ protection. Species which occur on National Forests are at heightened risk of habitat loss and degradation from timber harvest and recreation.

The Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act of 1968 protects selected rivers in free-flowing condition and protects their immediate environments to safeguard water quality and to fulfill national conservation purposes. Wild and Scenic designation provides some protection for the species which occur within these reaches.

It does not adequately protect the petitioned species, however, because there are very few designated Wild and Scenic stretches in the southeast, they do not provide habitat protection beyond a narrow corridor, and because many of the areas of highest aquatic biodiversity are not included in the system (Neves et al. 1997).

Inadequacy of Existing State Regulatory Mechanisms

State Fish and Wildlife Departments

Some of the petitioned species are listed as threatened or endangered by state fish, wildlife, and game departments, but state endangered and threatened species designations generally do not provide species with meaningful regulatory protection or with any habitat protection. Many of the species are classified as Species of Conservation Priority or Species of Greatest Conservation Need under state Wildlife Action Plans or Wildlife Conservation Strategies. These documents provide a framework for conservation, but are not regulatory documents and do not contain mandatory or enforceable provisions to protect species or their habitat. Further, the implementation of conservation strategies is dependent on the cooperation of resource managers and stakeholders, making their implementation and effectiveness uncertain. Partner involvement in recommended conservation actions is voluntary, and is limited by the statutory requirements and permitted degree of discretion of partner agencies.

State conservation priorities and initiatives are also sharply limited by funding, with charismatic and game species generally receiving the majority of resources. Warren et al. (1997) state:

> **"**[M]any state-based programs for non-game fishes are left to languish on "soft" money, are underemphasized, and lack the force of institutional will or statutory authority, short of federal mandate, to effect change" (p. 123).

The focus of conservation strategies is also generally on vertebrates, making them inadequate to protect imperiled invertebrate species:

> "Conservation of freshwater invertebrates has been hampered by the severity of human impacts to fresh waters and their inhabitants, the very limited resources (money, scientific effort) that have been applied to conservation problems, frequent adherence to a conservation approach that was developed largely for terrestrial birds and mammals, and an overly reactive approach, in which conservation activities often have been reactions to acute threats rather than actions designed to enhance long-term population viability. Consequently, conservation activities have been and will continue to be inadequate to protect freshwater invertebrate populations and species" (Strayer 2006, p. 272).

Concerning the lack of funding to protect imperiled southeastern mollusks, Neves et al. (1997) state:

> "With such an underfunded effort by regulatory agencies to maintain the biological diversity and integrity of rivers in this region, it is little wonder that the extirpation and extinction of mollusks is occurring at an accelerated pace" (p. 76).

Some states have regulations to protect some wildlife species from direct take, but these regulations are not comprehensive, are generally poorly enforced, and are not adequate to protect wildlife from other threats (FWS 1997). Even though states often prohibit the take of fish and wildlife without a collecting permit, permit enforcement is difficult (FWS 1997). Invertebrates are sometimes protected by harvest regulations such as bag limits, size regulations, and seasonal closures, but these regulations are challenging to enforce, and enforcement efforts are dependent on available funding.

Natural Heritage Programs

State Natural Heritage Programs maintain an inventory and database on the conservation status of species and biological communities and participate in and contribute to various conservation strategies. Natural Heritage Programs, however, lack regulatory authority. While their designations call attention to the plight of imperiled species, they do not convey any regulatory protection.

Other Regulatory Mechanisms and Protections

Convention on International Trade in Endangered Species

The Convention on International Trade in Endangered Species (CITES) is an international agreement between governments that aims to ensure that the international trade of wild animals and plants does not threaten their survival. CITES listing conveys some degree of protection to a few of the petitioned species, but is inadequate to ensure their continued survival. For example, highly sought after species, such as rare map turtles, are threatened by the international pet trade despite being protected under CITES (NatureServe 2008).

Inadequacy of Habitat Preserves

Habitat protection is an essential component of species' preservation. Habitat preserves alone, however, are insufficient to protect imperiled species due to threats from a host of other factors including climate change, poaching, pollution, and genetic isolation due to lack of habitat connectivity. The survival of species within refuges depends on the level of protection in the refuge as well as on a variety of external factors that influence habitat conditions. Browne and Hecnar (2007) document the decline of turtles in protected habitat due to low-level recreational collection. They conclude, "Our study illustrates that habitat protection provides no guarantee for species persistence when multiple threats exist." All activities within the watershed influence the quality of aquatic habitats in protected areas. As FWS acknowledged in the Mobile Basin Recovery Plan (2000), "stream and river refugia can only be maintained by appropriate land and water stewardship within their respective watersheds." For example, pollution entering protected areas from activities being conducted outside their boundaries threatens otherwise protected species. Neves et al. (1997) report that hazardous wastes and toxic chemicals are jeopardizing imperiled mussels at a state-designated mussel sanctuary at the confluence of the Tennessee and Ohio Rivers. As Folkerts (1997) surmises, "[I]t is clear that isolated preserves are not a long-term answer to the maintenance of aquatic biodiversity" (p. 12).

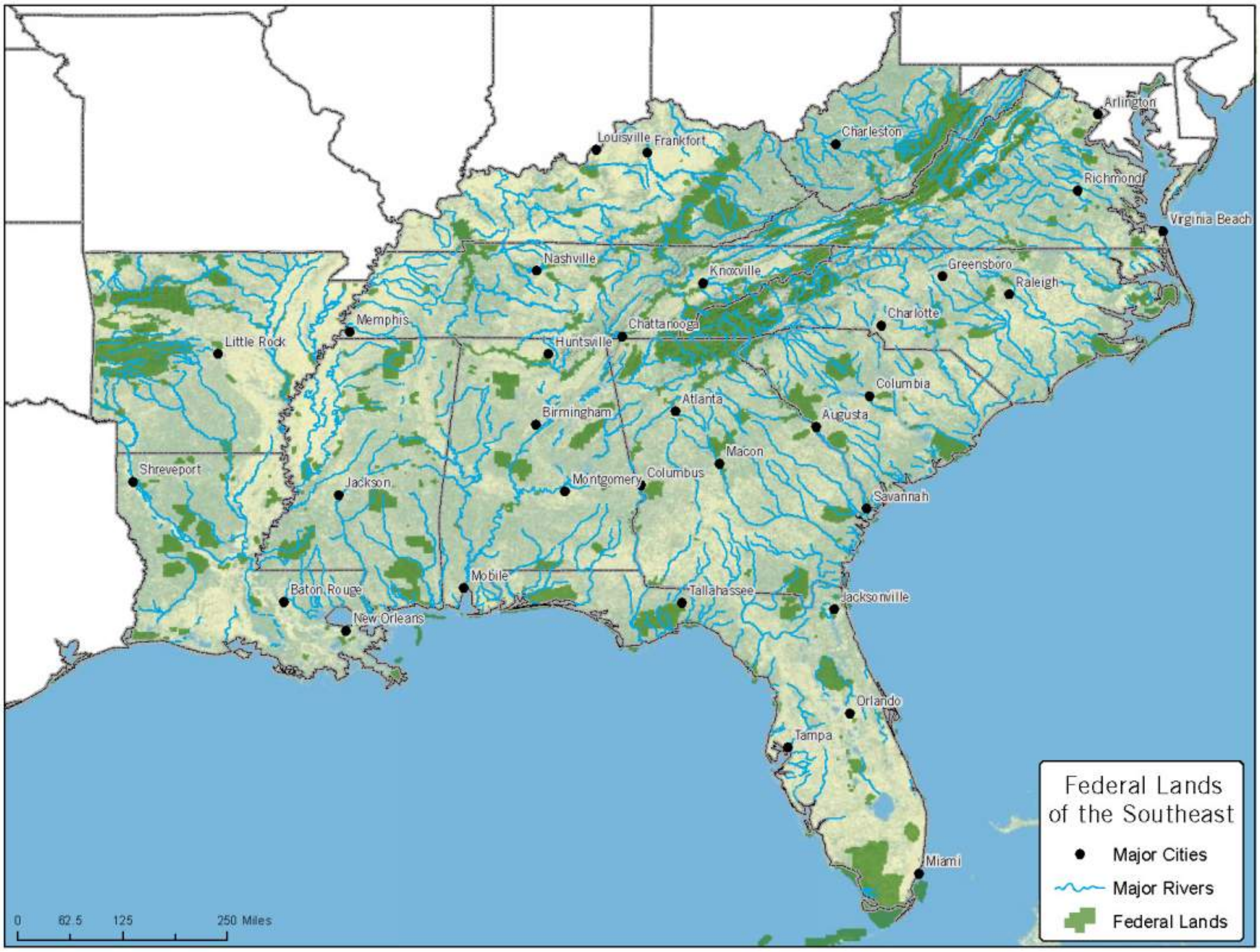

Fig. 4. Federal Lands of the Southeast. The majority of land in the Southeast is privately owned.

Land Ownership Patterns

The vast majority of land in the southeast is privately owned. In the Tennessee, Cumberland, and Mobile River basins, for example, more than 87 percent of land is privately owned (Buckner et al. 2002). Private land use is either not regulated or only loosely regulated throughout much of the region (Buckner et al. 2002). A great deal of the habitat for rare aquatic species in the southeast is not controlled by federal or state governments, and protection of the most biologically valuable watersheds is not available through governmental ownership (Neves et al. 1997). Most southeastern forests are in private ownership, including 70 percent of Alabama's forests and more than 80 percent of forests in the Tennessee and Cumberland basins (Buckner et al. 2002). Forestry "best management practices" to control erosion and protect aquatic species are not mandated or voluntarily followed in the majority of southeastern forests, and extensive clearcutting and poor logging practices threaten aquatic species due to sedimentation, landslides, and degraded water quality (Buckner et al. 2002). There are no existing regulatory mechanisms that protect imperiled species on private lands in the southeast.

In sum, existing regulatory mechanisms are not adequate to protect the petitioned species. Without the effective protection of the Endangered Species Act, these species are likely to become extinct.

OTHER NATURAL OR HUMAN CAUSED FACTORS

Southeastern aquatic and riparian species are threatened by multiple other natural and human-caused factors including pollution, global climate change, drought, invasive species, and synergies between multiple threats.

POLLUTION

Pollution threatens two-thirds of the petitioned species, including 81 percent of the animals. Throughout North America, the imperilment of freshwater fauna has been linked to extensive habitat degradation caused by pollution (Ricciardi and Rasmussen 1999). Southeastern waterways are degraded by point and non-point source pollution from a variety of sources including agriculture, forestry, urban and suburban development, coal mining, and coal combustion wastes. Non-point source pollution, or runoff, is difficult to document, but its impact on aquatic species is both pervasive and persistent (Schuster 1997). Neves et al. (1997) call non-point source pollution an “insidious factor in aquatic ecosystem degradation.” Non-point source pollution is the most common factor adversely impacting the nation’s fish communities, with more than 80 percent of fish being negatively affected (Judy et al. 1982). The Service has acknowledged that southeastern aquatic habitats are threatened by cumulative, progressive degradation from unregulated, non-point source pollution, the effects of which are contributing to the extirpation of aquatic species:

> “In many cases, it is small, everyday, nonregulated activities considered “insignificant” by most of us that will ultimately cause continued decline and extinction of the (Mobile) Basin’s aquatic species. . . While the detrimental effect of any one source or land use activity may be insignificant by itself, the combined effects of land use runoff within a watershed may result in gradual and cumulative
> adverse impacts to isolated populations and their habitats” (FWS 2000).

Both non-point and point source pollution are pushing southeastern aquatic species towards extinction by carrying sediments, contaminants, nutrients, and other pollutants into waterways.

Sedimentation, Contamination, and Nutrient Loading

Sedimentation is one of the primary causes of habitat degradation in southeastern waterways (Neves et al. 1997). Sedimentation and siltation result from a variety of activities including agriculture, forestry, development, and mining, with silt reaching waterways during both ground-disturbing activities and storm events (FWS 2000). Suspended sediment threatens the entire aquatic community, from fish to invertebrates to birds. Richter et al. (1997) identify sedimentation as the major stressor affecting the ability of aquatic animals to recover from declines.

In the southeast, sedimentation is responsible for nearly 40 percent of fish imperilment problems (Etnier 1997). Sedimentation has both direct and indirect negative effects on fish. Suspended sediments cut and clog gills and interfere with respiration. Sedimentation blocks light penetration, which interferes with feeding for species like minnows and darters which feed by sight (Etnier and Starnes 1993). For species which feed by flipping over rocks and consuming the disturbed insects, sedimentation increases the embededness of rocks, making them more difficult to move and decreasing habitat suitability for aquatic invertebrate prey (Etnier and Starnes 1993). Sedimentation also interferes with feeding behavior for nocturnal feeders like catfish and imperiled madtoms which catch aquatic insects by relying on the sensitivity of their barbels and on chemoreception, both of which are negatively affected by sedimentation (Todd 1973, Buckner et al. 2002). Benthic species require specific substrate conditions for spawning, feeding, and cover, all of which are degraded by sedimentation (Etnier and Starnes 1993, Warren et al. 1997).When sedimentation fills in the crevices between and beneath rocks, it decreases the availability of cover for resting and predator evasion (Herrig and Shute 2002). Madtoms, darters, suckers, and some minnows deposit their eggs on or near the substrate, and sedimentation interferes with their reproduction both by decreasing habitat suitability and by directly smothering eggs. Benthic fishes are also negatively affected by toxins which are stored in sediments (Reice and Wohlenberg 1993). Ultimately, excessive sedimentation can eliminate fish species from an area by rendering their habitat unsuitable (FWS 2000).

Likewise, excessive sedimentation has strong, persistent negative effects on freshwater invertebrates (Strayer 2006). Siltation is one of the primary factors implicated in the decline of freshwater mollusks (Williams et al. 1993). Neves et al. (1997) state, "[P]eriodic additions of sediment have profound effects on the long-term sustainability of mollusk populations" (p. 68). Suspended sediments have both direct and indirect negative affects on mollusks. Sedimentation clogs the gills of mussels and snails and can cause suffocation (FWS 2000). Sedimentation reduces feeding efficiency both by interfering with respiration for filter feeders and by coating the algae which snails scrape from rocks (FWS 2000). Decreased visibility due to sedimentation can interfere with mussel reproduction by making it difficult for host fishes to detect glochidia (Neves et al. 1997). Sedimentation also reduces substrate suitability (Herrig and Shute 2002).

Aquatic insects are also threatened by excessive sediment levels. Stoneflies (*Plecoptera)* and mayflies (*Ephemeroptera)* are intolerant of siltation and disappear from impacted streams (Morse et al. 1997). Increased siltation impacts the ability of dragonflies and damselflies to survive (Morse et al. 1997). Caddisflies, which require spaces among rocks for shelter and stable surfaces for grazing, are also negatively impacted by siltation (Morse et al. 1997). Sedimentation and other pollutants from mountaintop removal coal mining operations are completely extirpating aquatic macroinvertebrate communities. In some streams that drain mountaintop removal operations, the entire orders of *Plecoptera* and *Ephemeroptera* have been extirpated (Wood 2009). Sedimentation is also negatively impacting rare ground-water inhabiting species of isopods and amphipods (Herrig and Shute 2002).

In addition to sediments, contaminants, such as heavy metals, pesticides, and persistent organic pollutants, threaten aquatic species. In a nationwide assessment of streambed sediment contaminants, the EPA found that 43 percent of sediments are probably associated with harmful effects on aquatic life or human health, and that six to 12 percent of streambed sediment is sufficiently contaminated to cause significant lethality to benthic organisms (EPA 2004b). Southeastern rivers are laden with a variety of toxic chemicals, with the lower Mississippi receiving contaminants from half the continent (Folkerts 1997). Atlanta was recently named the most toxic city in America (Levy 2009). Contaminants have both lethal and sub-lethal negative effects on aquatic species and may interfere with immunity, growth, and reproduction (Colborn et al. 1993, Gibbons et al. 2000). Selenium contamination from surface coal mining is causing teratogenic deformities in larval fish (Palmer et al. 2010). Many contaminants have negative effects that will persist for centuries (Folkerts 1997).

Aquatic species are threatened both by chronic low-level contaminant pollution and acute exposure from accidental spills. For instance, in October 2009, a wastewater spill from a coal mine on the West Virginia-Pennsylvania border killed all the fish, salamanders, and mussels in 35 miles of 38-mile- long

Dunkard Creek (Hopey 2009). Endemic species in particular are at high risk from accidental spills. Because many aquatic species exist only in small, isolated populations, a single spill event could drive a species to extinction. Even in otherwise protected habitats, the survival of freshwater species is threatened by acute and chronic exposure to contaminants.

Contaminants threaten aquatic species across taxa. Declines in many fish species are attributed to chronic, sub-lethal pollution, which causes reduced growth, reduced reproductive success and increased risk of death from stress-related diseases (Moyle and Leidy 1992). Cavefishes and other species that are directly dependent on groundwater levels are disproportionately threatened by contaminants, which become concentrated if a drop in groundwater levels reduces the volume of springflow (Herrig and Shute 2002). Chemoreception in blind cavefishes can be disrupted by contaminants from surface aquifer recharge areas (Herrig and Shute 2002). Chronic low-level exposure to contaminants may be preventing the recovery of imperiled species of mollusks (FWS 1997). Juvenile mussels in particular are sensitive to heavy metals and other pollutants (Naimo 1995, Neves et al. 1997). Amphibians may be disproportionately threatened by contaminants. All life stages of many amphibian species are sensitive to toxins (AmphibiaWeb 2009). Many substances can be toxic for amphibians, including heavy metals, pesticides, phenols, fertilizers, roadsalt, mining waste, and chemicals in runoff (Dodd 1997). Changes in pH can adversely affect amphibian eggs and larvae, and can inhibit growth and feeding in adults (Dodd 1997). Amphibians are threatened by accidental and intentional pesticide treatments. For instance, in October 2009, a pesticide treatment intended to kill lampreys in the Lamoille River caused a large-scale die-off of mudpuppies (Johnson 2009).

Contaminants negatively impact aquatic species at the level of individuals, populations, and species. Fish, turtles, and other aquatic animals assimilate pesticides, heavy metals, and other persistent pollutants into their tissues (Buhlmann and Gibbons 1997, de Solla and Fernie 2004). Animals at higher levels of the food web can accumulate considerable levels of toxins. Significant concentrations of numerous contaminants have been detected in southeastern freshwater turtles including pesticides such as aldrin, chlordane, DDT, dieldrin, endrin, mirex, nonachlor, and toxaphene, and metals such as aluminum, barium, cadmium, chromium, cobalt, copper, iron, lead, mercury, molybdenum, nickel, strontium, and zinc (Meyers-Schöne and Walton 1994). Contaminant exposure can disrupt normal endocrine functioning, thus threatening survival and reproduction (Colborn et al. 1993). Turtles exposed to PCBs have exhibited sex reversal and abnormal gonadal development, and alligators exposed to various contaminants have shown altered testosterone levels and gonadal abnormalities (Guillette et al. 1994, 1995). Water snakes in wetlands that have been contaminated by coal ash exhibit altered metabolic activity (Hopkins et al. 1999). Endocrine disruption caused by contaminants can lead to demographic shifts in aquatic reptile populations (Gibbons et al. 2000). Bioaccumulation of contaminants has contributed to the decline of map turtles, musk turtles, snapping turtles, and pond turtles (Buhlmann and Gibbons 1997).

Nutrient loading also threatens southeastern aquatic species. Excessive nitrates and phosphates entering waterways from point and non-point sources can lead to algal blooms, eutrophication, and depleted dissolved oxygen, which can be lethal for aquatic organisms (Mallin and Cahoon 2003). Some algal blooms are toxic, and can cause direct mortality. The toxic dinoflagellates *Pfiesteria piscicida* and *P. shumwayae* have bloomed downstream of Confined Animal Feeding Operations in the Neuse, New, and Pamlico River estuaries in North Carolina (Mallin and Cahoon 2003). Even at sub-lethal levels, nutrient loading threatens aquatic species via many mechanisms. For example, excessive phosphate levels, especially in combination with the herbicide atrazine, have been shown to increase trematode infections in amphibians, leading to amphibian deformities (Johnson and Sutherland 2003, Rohr et al. 2008).

Nutrients, contaminants, sediments, and other pollutants reach southeastern waterways from a variety of sources, discussed below.

Agriculture

Non-point source pollution from agriculture is the leading source of water quality impairment in lakes and rivers in the United States, and is also a major contributor to groundwater contamination and wetlands degradation (EPA 2009). Agricultural pollution carries sediment, pesticides, fertilizers, animal wastes, pathogens, salts, and petroleum particles into waterways (Morse et al. 1997, EPA 2009). In the southeast, agricultural fields are commonly plowed to the edges of rivers and streams, which causes erosion and stream bank collapse and deposits tons of soil into waterways annually (Buckner et al. 2002).

Pesticide contamination is pervasive in agricultural areas, and the most commonly detected pesticide in U.S. waters is atrazine. In a U.S. Geological Survey study of agricultural areas, 75 percent of stream water samples nationwide contained atrazine (Gilliom et al. 2006). Based on Ecological Monitoring Program data from the U.S. Environmental Protection Agency, surface waters of the southern United States are pervasively contaminated with atrazine, with the chemical being detected in every watershed sampled (U.S. EPA 2007, Wu et al. 2009). In 63 percent of watersheds, atrazine was present at average levels greater than one part per billion (ppb), which is the level at which primary productivity of aquatic nonvascular plants is known to be reduced (Ibid.). In Kentucky, atrazine was detected in 69 and 97 percent of surface water in the two sampled watersheds, at average concentrations of 0.66 parts per billion (ppb) and 2.08 ppb, and maximum concentrations of 19 and 22 ppb, which is many times above the threshold for negative affects in aquatic biota (U.S. EPA 2007, Wu et al. 2009). Atrazine was also detected at high frequencies and levels in surface water in Tennessee and in drinking water in Louisiana (Ibid.). Atrazine contamination threatens southeastern aquatic species, with the toxic and endocrine disrupting effects of atrazine being well established (Wu et al. 2009). Detrimental reproductive effects have been detected in amphibians and mammals at very low exposure levels-- concentrations as low as 0.1 ppb are known to cause endocrine disruption in amphibians (Hayes et al. 2002). Moreover, developmental timing of exposure can increase susceptibility to adverse effects, as can synergistic interactions with other contaminants (Colborn et al. 1993, Colborn 2004, 2006, Wu et al. 2009).

Animal holding lots and confined animal feeding operations (CAFOs) are a major source of pollution in the southeast (Neves et al. 1997). Animal wastes may be discharged directly into streams, applied to fields, or stored in lagoons (Buckner et al. 2002). CAFOs produce enormous amounts of nitrogen and phosphorus. On the Coastal Plain of North Carolina, CAFOs produce 124,000 metric tons of nitrogen and 29,000 metric tons of phosphorus on an annual basis (Mallin and Cahoon 2003). In 1998, 41,000 metric tons of nitrogen and 16,000 metric tons of phosphorus entered the Neuse River watershed from CAFOs (Glasgow and Burkholder 2000). These nutrients enter the environment and contribute to the eutrophication of waterbodies via runoff, volatilization of ammonia, or by percolating intro groundwater (Mallin and Cahoon 2003). CAFOs cause both chronic and acute pollution. Extreme weather events, lax management, and lagoon ruptures have led to acute pollution events from CAFOs. In 1995, lagoon ruptures spilled millions of gallons of swine and poultry wastes into the New River and Cape Fear River basins in North Carolina, causing fish kills and algal blooms (Mallin and Cahoon 2003). Decaying animal carcasses are also a significant source of nutrient pollution from CAFOS, especially following extreme weather events (Mallin and Cahoon 2003). Within the area flooded by Hurricane Floyd in 1999, there were 241 CAFOs and numerous livestock were drowned and their carcasses entered the environment via floodwaters (Wing et al. 2002). In addition to nutrient loading, CAFOs release pharmaceuticals and hormones into aquatic habitats (Orlando et al. 2004). Significant amounts of estrogens and androgens have been detected in waterways that receive runoff from fields where animal wastes are applied (Finlay-Moore et al. 2000). Growth promoters and antibiotics have been detected in both surface and groundwater in agricultural areas (Peterson et al. 2000).

Pollution from agriculture has profound negative effects on water quality and aquatic species (Patrick 1992). Sediments and contaminants from agricultural runoff are contributing to the decline of sensitive fish and mussels (Neves et al. 1997, Herrig and Shute 2002). Algal blooms and lower dissolved oxygen concentrations due to nutrient loading can kill sessile benthic organisms such as mollusks and can create zones in which fish cannot survive (Mallin and Cahoon 2003). Chemicals in the effluent from CAFOs and feedlots can disrupt the endocrine and reproductive systems of wild species. Orlando et al. (2004) documented significant alterations in the reproductive biology of wild minnows (*Pimephales promelas*) exposed to feedlot effluent, including demasculinization of males and defeminization of females. Hormones in ponds below cattle holding facilities have been associated with endocrine disruption in female turtles (Irwin et al. 2001).

Aquacultural operations also contribute significant amounts of pollution to southeastern aquatic habitats. Wastewaters from aquacultural operations contain sediments, nutrients, pharmaceuticals, and pathogens, all of which threaten native aquatic biota (Tacon and Forster 2003). Catfish farms, the biggest aquacultural enterprise in the nation, release effluents into the environment during heavy rainfall events and during pond draining (Tucker and Hargreaves 2003). Trout farms generate large amounts of nutrient pollution and are generally built on outstanding resource waterways (Morse et al. 1997).
Louisiana is the world’s largest producer of farm-raised crayfish, with crayfish ponds being drained annually releasing effluent into the environment (Holdich 1993).
Shrimp pond effluent leads to hypernutrification of estuaries (Hopkins et al. 1995).

Forestry

Pollution from logging poses a dire threat to southeastern species. The Alabama Department of Environment Management cites sediment from silviculture as one of the major contributors to water quality impairment in the Mobile Basin. Logging contributes sediments and herbicides to waterways, degrading habitat for aquatic organisms. Erosion from deforestation and poor forestry practices increases silt loading and makes stream bottoms unstable, both of which threaten mollusks and other aquatic organisms (Williams et al. 1993). Herbicides used to kill hardwoods and herbaceous vegetation may be harmful to amphibians and other species (Dodd 1997). Some herbicides used in forestry operations are toxic to algae and interfere with aquatic ecology (Austin et al. 1991). Effluent from pulp mills where logging products are processed also threatens southeastern aquatic species (Folkerts 1997).

Urban and Industrial Development

Pollution from urban, suburban, and industrial development is a major threat to aquatic species in the southeastern United States. Point source pollution from manufacturing sites, power plants, and sewage treatment plants is a major cause of aquatic habitat degradation (Morse et al. 1997). In southeastern watersheds, point sources of pollution are “remarkably dense and coincide heavily with critical conservation areas identified at expert workshops” (Buckner et al. 2002). Non-point source pollution from urban and industrial areas contributes sediment, contaminants, nutrients, and other pollutants to waterways. Runoff from urban and suburban areas includes many substances which are harmful for aquatic organisms including petroleum particles, highway salts, silt, fertilizers, pesticides, surfactants, and pet wastes (Neves et al. 1997, Buckner et al. 2002).

Many municipalities have inadequate sewage treatment systems which can release raw sewage into waterways during heavy rainfall events (Buckner at al. 2002). Chemicals in both raw and untreated sewage can negatively affect aquatic organisms. Many waterbodies are now known to be polluted with pharmaceuticals such as caffeine, pain killers, antibiotics, antihistamines, antidepressants, and oral contraceptives, the effects of which on aquatic wildlife are poorly understood (Kolpin et al. 2002). In an EPA pilot study of the occurrence of pharmaceuticals and personal care products in wild fish, antidepressants, antihistamines, and fragrances were all detected in fish tissues (EPA 2009b). Many common chemicals are now known to cause endocrine disruption in wildlife (Colborn et al. 1993). Endocrine mimics can cause thyroid dysfunction, metabolic aberrations, lowered fertility, birth defects, decreased immunity, and abnormal sexual development (Dodd 1997). Pharmaceutical estrogens in sewage effluent have been shown to negatively affect fish development and reproductive activity (Orlando et al. 1999).

Coal Mining and Processing

Coal mining and coal processing is a major source of water pollution in West Virginia, Kentucky, Tennessee, Virginia, Alabama, and Georgia. Contaminants from coal mining and processing operations include sediments, metals, hydraulic fluids, frothing agents, modifying reagents, pH regulators, dispersing agents, flocculants, and media separators (Ahlstedt et al. 2005). Coal mining and processing degrades water quality and results in lasting impairments to aquatic biota (Carlisle et al. 2008, Pond et al. 2008, Pomponio 2009, Wood 2009). Sediments, heavy metals, and other pollutants from mining are one of the causal factors in mussel declines (Houp 1993, Neves et al. 1997, Locke et al. 2006). Ahlstedt et al. (2005) report that the permitted and illegal discharge of coal fines is polluting some of the best remaining mussel habitat in the Clinch River, which is a global hotspot for mussel diversity.

Coal mining and processing release heavy metals into the environment including aluminum, cadmium, copper, iron, manganese, mercury, selenium, sulfate, and zinc, which act as metabolic poisons in freshwater species (Earle and Callaghan 1998). Mussels exposed to high concentrations of metals in the laboratory exhibited mortality, weight loss, altered enzyme activity and filtration rate, and behavioral modifications (Naimo 1995). The effects of metals on mussel feeding, growth, and reproduction can have significant consequences for mussel populations (Naimo 1995). Naimo (1995) concludes that the widespread decline in species diversity and population density of U.S. freshwater mussels is partially attributable to chronic, low-level exposure to toxic metals.

Selenium pollution from coal mining is causing deformities and reproductive failure in aquatic species and leading to less diverse and more pollution-tolerant species assemblages (Lemly 2009, Pomponio 2009). Lemly (2009) states:

> “Once in the aquatic environment, waterborne selenium can enter the food chain and reach levels that are toxic to fish and wildlife. Impacts may be rapid and severe, eliminating entire communities of fish and causing reproductive failure in aquatic birds.”

Effluent from a mountaintop removal mine in West Virginia was found to contain as much as 82 ug/L selenium, which is over fifteen times the threshold for toxic bioaccumulation, and which caused elevated levels of selenium in fish tissues in the Mud River with associated deformities and other toxic effects

(Lemly 2009). Selenium and other pollutants from surface coal mining operations pose a persistent toxic hazard for aquatic species (Palmer et al. 2010).

Pollution from abandoned mined lands is also a major threat for southeastern aquatic species. Sediments, metals, acids, and other pollutants in mine drainage negatively impact aquatic species in a variety of ways from acute toxicity to physical impacts from solid precipitates (Cherry et al. 2001, Soucek et al. 2003). Surface waters receiving mine discharge commonly have extremely low pH levels, below 3.0, with toxic impacts extending several miles downstream (Soucek et al. 2003). Acid mine drainage has a major negative influence on aquatic communities that are directly impacted by low-pH waters. Acid mine runoff from abandoned mines has completely destroyed stream biotas in many areas (Folkerts 1997).

Coal Combustion

Pollutants from coal-fired power plants threaten aquatic species nationwide and in the southeast. Coal combustion produces nitric and sulfuric acids, mercury, and coal ash, all of which negatively impact aquatic species (Fleischer et al. 1993). Nitric and sulfuric acids released from coal-fired power plants cause acidification of water bodies. Streams and lakes in Great Smoky Mountain National Park and elsewhere have been degraded by acid precipitation (Morse et al. 1997). Acid precipitation and deposition directly threaten aquatic organisms (Strayer 2006). Phytoplankton are negatively affected by acidification, which has ramifications throughout the food web (Dodd 1997). Acid precipitation harms caddisflies and stoneflies (Morse et al. 1997). Several of the petitioned insects are threatened by acid deposition including the Smokies snowfly and Smokies needlefly. Acidity in aquatic habitats can cause direct amphibian mortality, and plays a major role in limiting amphibian distribution (Dodd 1997).

Coal combustion also releases mercury into the environment. The U.S. Geological Survey examined mercury in fish, sediment, and water drawn from 291 rivers and streams between 1998 and 2005 and found detectable mercury contamination in every single fish sampled (Scudder et al. 2009). The study found that 25 percent of fish are contaminated with mercury at levels above the safe standard for human consumption (0.3 parts per million wet weight). Atmospheric deposition of mercury is responsible for the contamination of most waterways. Wetlands, forests and organic soils can enhance the conversion of mercury to highly toxic methylmercury which accumulates in the food web. The highest concentrations among all sampled sites occurred in fish from blackwater coastal-plain streams draining forested land or wetlands in Louisiana, Georgia, Florida, and North and South Carolina, and from basins in the West with gold mines and/or mercury mines. Total mercury concentrations greater than 0.2 micrograms per gram wet weight were detected in game fish in every southeastern state, with total concentrations greater than 0.3 micrograms/gram being detected in Tennessee, Virginia, North and South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Florida. Mercury concentrations in fish at over 70 percent of the sites exceeded the value that is of concern for the protection of fish-eating mammals. Negative physiological effects of mercury on aquatic species have been demonstrated at low concentrations, with elevated concentrations being detected at the top of the food web due to bioaccumulation (Scudder et al. 2009).

Coal combustion waste, or coal ash, poses an acute and chronic threat to aquatic species in areas where wastes are stored. The combustion of coal produces over 129 million tons of solid waste annually (Eilperin 2009). Coal ash contains concentrated levels of chlorine, zinc, copper, arsenic, lead, selenium, mercury, and other toxic contaminants, and improper storage of coal combustion waste has caused pollution of ground and surface waters (EPA 2007b). The

EPA reports that there are at least 584 coal ash dumps across the country, including many in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North and South Carolina, Tennessee, Virginia, and West Virginia (EPA 2009c). Indiana and Kentucky have the most coal ash ponds, 53 and 44 respectively. The New York Times reports that there are more than 1,300 coal ash dumps across the country, most of which are unregulated and unmonitored (Dewan 2009). Many coal ash ponds were constructed without the guidance of trained engineers and are aging and at high risk of leaking (EPA 2009c).

Coal combustion wastes threaten aquatic communities. Most coal ash storage sites are on waterways, so that they can take in and release water (Dewan 2009). In some areas, entire fish populations have been lost due to pollution from coal combustion wastes (Cherry 1999). Fish consumption advisories have been issued for areas where waterbodies are contaminated with selenium from coal ash disposal sites (Skorupa 1998). Hopkins et al. (1999) reported behavioral, developmental, and metabolic abnormalities in amphibians and reptiles in wetlands that have been contaminated with coal combustion waste in South Carolina. Aquatic communities downstream of coal combustion storage sites are at high risk from accidental spills. In December 2008, a coal ash pond in Kingston, Tennessee ruptured and released over a billion gallons of toxic-laden sludge into the Emory River (Dewan 2009b). Sampling of the spill has shown heavy metal contamination in aquatic habitats, including arsenic, lead, thallium, cadmium, chromium, barium, and nickel (Smith 2009). Another coal ash spill occurred in January 2009 near Stevenson, Alabama.

In sum, southeastern aquatic species are threatened by acute and chronic pollution from a variety of sources. Pollution can undermine efforts to protect species and can drive species to extinction (Neves et al. 1997, FWS 1997).

Global Climate Change and Drought

As aquatic and riparian species, global climate change threatens all of the petitioned species. Climate models project both continued warming in all seasons across the southeast, and an increase in the rate of warming (Karl et al. 2009). The warming in air and water temperatures projected for the southeast will create heat-related stress for fish and wildlife. Increasing water temperatures and declining dissolved oxygen levels in stream, lakes, and shallow aquatic habitats will lead to fish kills and loss of aquatic species diversity (Folkerts 1997, Karl et al. 2009). Climate change will alter the distribution of native plants and animals and will lead to the local loss of imperiled species and the displacement of native species by invasives (Karl et al. 2009). Concerning the effects climate change is expected to have on southeastern environments, Karl et al. (2009) state, “Ecological thresholds are expected to be crossed throughout the region, causing major disruptions to ecosystems and to the benefits they provide to people.”

Climate change will increase the incidence and severity of both drought and major storm events in the southeast (Karl et al. 2009). The percentage of the southeast region experiencing moderate to severe drought has already increased over the past three decades. Since the mid- 1970s, the area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively. Fall precipitation tended to increase in most of the southeast, but the extent of region-wide drought still increased by 9 percent (Karl et al. 2009). For example, from 2007-2008, the Coosa River watershed in Alabama and Georgia experienced severe drought, and streamflow in the Conasauga River was the lowest recorded in nearly 70 years (U.S. Geological Survey 2007). The threat to aquatic ecosystems posed by drought is magnified both by climate change and by human population growth. A drought in the southeast from 2005-2006 caused more than a billion dollars in lost crops and "placed massive strain on the water supply system of the affected states, pitting state against state and user against user . . ." (Seager et al. 2009). Decreased water availability coupled with human population growth will further stress natural systems. Human response strategies to decreased water availability will likely include the construction of more dams, which threatens wildlife species which are negatively affected by impoundment, and increased groundwater pumping, which threatens spring and cave obligate species (Karl et al. 2009). Drought, and increased evaporation and evapotranspiration due to warmer temperatures will lead to decreased groundwater recharge and potential saltwater intrusion in shallow aquifers in many parts of the southeast, further exacerbating threats to aquatic organisms (Karl et al. 2009).

Drought inexorably threatens aquatic species. Intense droughts and increasing temperatures resulting from climate change will cause the drying of waterbodies and the local or global extinction of riparian and aquatic species (Karl et al. 2009). Declines of mollusks as a direct result of drought have already been documented (Golladay et al. 2004, Haag and Warren 2008). Populations of amphibians which are dependent on consistent rainfall patterns for breeding, such as those that breed in temporary ponds, could be extirpated by drought (Dodd 1997). Amphibian declines are already linked to climate change globally (Pounds et al. 2006) and in the southeastern United States (Daszak et al. 2005).

The warming climate will likely cause ecological zones to shift upward in latitude and altitude and species' persistence will depend upon, among other factors, their ability to disperse to suitable habitat (Peters and Darling 1985). Human modifications to waterways, such as dams, and changes to the landscape including extensive development, will make species' dispersal to more suitable habitat difficult to impossible (Strayer 2006, Buhlmann and Gibbons 1997, FWS 2009). Many species of freshwater invertebrates are likely to go extinct due to climate change (Strayer 2006). Freshwater mussels and snails are capable of moving only short distances and are unlikely to be able to adjust their ranges in response to climactic shifts (FWS 2009). For example, populations of wetland species must be able to disperse if their habitat becomes unsuitable, but wetland habitats are increasingly isolated and surrounded by a hostile landscape matrix (Buhlmann and Gibbons 1997). Deteriorating habitat conditions and obstacles to dispersal place all of the petitioned species at risk of extinction due to global climate change.

Several of the coastal petitioned species are threatened by sea-level rise and increased storm intensity resulting from global climate change including the Florida Keys mole skink, MacGillivray's seaside sparrow, and Louisiana eyed silkmoth.

Invasive Species

Invasive species are a major threat to native aquatic plants and animals in the southeast, and are a known threat for 96 of the petitioned species (24 percent). The spread of invasive species has been identified as a primary factor in the imperilment of freshwater fauna and the loss of aquatic biodiversity (Allan and Flecker 1993, Ricciardi and Rasmussen 1999). Invasive species negatively affect native species through competition, predation, and disease introduction. In the southeast, the rate of invasion by exotic species is increasing and placing native freshwater fauna at risk (Folkerts 1997).
Aquaculture is a leading vector of aquatic invasive species including fishes, invertebrates, and plants (Naylor et al. 2001). Introduced Asian carp, which are used to control trematodes in catfish ponds, have become established in rivers throughout the Mississippi Basin where they consume native mollusks and compete for resources with native fishes (Naylor et al. 2001). There are at least 30 species of invasive fish in the Tennessee and Cumberland river basins, including carp, alewife, rainbow and brown trouts,

striped bass, yellow perch, and non-native forms of muskellunge and walleye (Etnier 1997). Nonnative mosquitofish (*Gambusia holbrooki*) have been widely introduced for vector control and now compete with native species for resources (Buckner et al. 2002). Gamefish such as trout and bass have been widely introduced and prey on native fish, invertebrates, and amphibians (Herrig and Shute 2002, Kats and Ferrer 2003, Strayer 2006). Native fish fauna in southern Florida have been displaced by tropical species (Folkerts 1997). Further, more than 60 indigenous southeastern fish species have been introduced to drainages where they are not native (Warren Jr. et al. 1997).

Freshwater mollusks are threatened both by invasive fish and by invasive mollusks. The introduction of nonnative fishes such as the round goby (*Neogobius melanostomus*) has indirect negative affects on native mussels due to negative impacts on their host fishes (NatureServe 2009). The invasion of nonindigenous mollusks is one of the primary reasons for the decline of freshwater mussels (Williams et al. 93). Invasive mussels can reach densities of thousands per square meter, outcompeting and literally covering native species (Williams et al. 1993).

The infamous zebra mussel (*Dreissena polymorpha*) uses both rivers and creeks and has been detected in Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, Virginia, and West Virginia (NatureServe 2009). Zebra mussels now infest most major Mississippi River tributaries, including the Ohio, Tennessee, Cumberland, and Arkansas Rivers (NatureServe 2009). Zebra mussels are expected to eventually spread to all the navigable rivers in the southeast as well to tributary reservoirs and smaller streams (Jenkinson and Todd 1997). Zebra mussels, and other invasive mollusks, compete with native mussels for food and space, attach to native mussels and weaken or kill them, and alter the suitability of the substrate for native species (Herrig and Shute 2002). Where zebra mussels establish large populations, they are likely to destroy native mussel and snail populations (Jenkinson and Todd 1997). Williams et al. (1993) state that the spread of nonnative mollusks appears “poised to decimate many of the remaining native mussel populations.” Concerning the risk posed to native mussels by the spread of zebra mussels, Neves et al. (1997) state:

> “It is almost inevitable that zebra mussel-infested waters will occur in nearly all southeastern states, and that some level of effect will occur to native mollusks. The zebra mussel will probably be the final nail in the coffin of several federally protected mussels that succumb to infestations in large rivers. Other commercial and rare mussels may require endangered species status if the zebra mussel infestations extirpate river and reservoir populations and drastically reduce the ranges of one-time widespread big-river species. The urgency of protection and conservation of native mussels cannot be overemphasized. Natural resource agencies in the southeast must be proactive in efforts to prevent the wholesale extinction of mussels in the direct path of the zebra mussel invasion” (p. 73).

Native southeastern mollusks are also threatened by the invasion of Asian clams (*Corbicula fluminea).* Asian clams spread rapidly throughout every major drainage in the southern United States following their introduction in the 1960’s. Asian clams threaten native mussels due to competition for space and food. Neves et al. (1997) caution that juvenile native mussels “may become victims of stress from the highly mobile and abundant young Asian clams” (p. 72).

In addition to fish and mollusks, other southeastern taxa are also known to be threatened by the spread of invasive species. Native crayfishes are threatened by invasive mussels, which can attach to their exoskeletons, and by invasive species of crayfishes and fishes which compete with and prey on native crayfish species (Schuster 1997). Nonnative crayfishes are commonly introduced via “bait-buckets” and are contributing to the decline of native species (Taylor et al. 1996). Several species of nonnative snails have also invaded the southeast (Neves et al. 1997). Native amphibians are threatened by invasive fish and invasive amphibians which can act as predators, competitors, and disease vectors (Dodd 1997). Additionally, exotic cattle egrets, armadillos, and wild hogs can "exact a substantial toll" on amphibian populations (Dodd 1997). Fire ants also threaten amphibians, as they have been reported to kill metamorphosing individuals (Freed and Neitman 1988).

Many invasive plant species are wreaking havoc on aquatic habitats in the southeast. Species such as Eurasian watermilfoil (*Myriophyllum spicatum*), alligatorweed (*Alternanthera philoxeroides*), hydrilla (*Hydrilla verticillata*), and water hyacinth (*Eichhornia crassipies*) are thriving in aquatic and wetland habitats and negatively impacting native species (Folkerts 1997, Buckner et al. 2002). Invasive plants displace native plants, alter substrate availability for aquatic invertebrates, and interfere with the food web (Folkerts 1997). Invasive plants threaten several of the petitioned plants including Apalachicola wild indigo, Carolina bishopweed, and Harper's heartleaf.

Outbreaks of both invasive and native forest-destroying insects have weakened and killed trees in riparian areas and reduced nutrient inputs to aquatic systems (Morse et al. 2007). The petitioned Carolina hemlock is threatened by hemlock woolly adelgid (Adelges tsugae). Streamside habitat degradation due to exotic pests also threatens aquatic insect populations in the Southeast due to altered microhabitat conditions (Herrig and Shute 2002).

Invasive species currently pose a critical threat to native aquatic species in the southeast, and this threat is expected to increase in the future as the climate warms and as habitat availability shrinks. Even taxa which are not currently threatened by invasive species are expected to disappear due to future biological invasions as species adjust their ranges and humans continue to accidentally and intentionally transport nonnative species (Ricciardi and Rasmussen 1998).

Inherent Vulnerability of Small Isolated Populations

Two hundred and twenty-four of the petitioned species (55 percent) now exist primarily in small, isolated populations which heightens their risk of extinction. Small, isolated populations are vulnerable to extirpation due to limited gene flow, reduced genetic diversity, and inbreeding depression (Lynch 1996). Population isolation also increases the risk of extinction from stochastic genetic and environmental events including drought, flooding, and toxic spills (FWS 2009). Habitat modification and cumulative habitat degradation from non-point source pollution are also major threats for species which exist in isolated populations. Due to blocked avenues of dispersal or limited dispersal ability, isolated populations "gradually and quietly perish" as habitat conditions deteriorate (FWS 2000).

Synergies and Multiple Causes

The risk of extinction for the petitioned species is heightened by synergies between threats as most species face multiple threats and these threats interact and magnify each other. For example, as habitat availability shrinks, species become more vulnerable to threats from invasive species, pollution, climate change, disease, and other factors. Across taxa, interactions among threats place southeastern aquatic biota at increased risk of extinction. Reptiles are threatened by habitat loss and degradation, invasive species, pollution, disease and parasitism, unsustainable use, global climate change, and synergies between these factors (Gibbons et al. 2000). Freshwater snails are threatened by the combined effects of habitat loss, pollution, drought, and invasive species (Lydeard et al. 2004). Likewise, amphibians are imperiled by multiple, interacting threats. Stress from the effects of increased UV-b radiation, pollution, and climate change has made amphibians more vulnerable to the spread of disease (Gendron et al. 2003, Pounds et al. 2006). The interaction between climate change and compromised immunity due to various stressors threatens both amphibian populations and entire species (Green and Dodd 2007). Similarly, threats to freshwater fish are “many, cumulative, and interactive” (Herrig and Shute 2002), and fish extirpation is “nearly always attributable to multiple human impacts’ (Warren et al. 1997). Any factor which causes the decline of the host-fishes on which mussels depend for reproduction also threatens the mussels, which themselves face multiple threats including impoundment, pollution, and invasive species (Neves et al. 1997). In addition to overarching threats, species are threatened by the combination of “relatively minor but cumulative factors” (Shute et al. 1997). Because of the multifaceted ecological relationships among species, the extirpation of a species can have effects that cascade throughout the community. For example, the decline of bats due to disease, habitat loss, and pollution has cut off the nutrient supply on which many other cave organisms depend, and the decline of mollusks has eliminated a primary food source for freshwater turtles. Shute et al. (1997) state that there has been “a collapse of the complex interactions between the diverse organisms that coevolved in southeastern riverine ecosystems” (Shute et al. 1997, p. 446). The loss of a single species can imperil associated species, highlighting the need to protect entire communities of species simultaneously.

CONCLUSION

The aquatic and riparian species of the Southeastern United States are of global biodiversity significance. Unfortunately, these species face numerous and interactive threats including habitat loss, pollution, climate change, disease, predation, overuse, and the spread of invasive species. Existing regulatory mechanisms are inadequate to prevent the extinction of the hundreds of unique Southeastern species presented in this petition. They merit immediate Endangered Species Act protection to ensure their survival and recovery.

REQUEST FOR CRITICAL HABITAT DESIGNATION

We request and strongly recommend that all known locations for all petitioned species be designated as critical habitat concurrent with species’ listing. Because the survival of the petitioned species is dependent on healthy aquatic and riparian habitat, critical habitat designation should include terrestrial areas within watersheds which are critical to maintaining integral aquatic environments and also water rights to ensure continued surface flows in light of diminishing water resources.

As required by the Endangered Species Act, the Secretary shall designate critical habitat concurrent with determination that a species is endangered or threatened (16 U.S.C. 1533(a)(3A)). Critical habitat is defined by Section 3 of the ESA as:

(i) the specific areas within the geographical area occupied by the species,
at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and

(ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.16 U.S.C. §1532(5).

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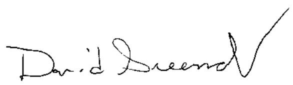
For all Parties to the Petition:



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SPECIES ACCOUNTS

Scientific Name:
Acroneuria kosztarabi
Common Name:
Virginia Stone

G Rank:
G1

Range:
This stonefly occurs in Lawrence County, Kentucky and Tazewell County, Virginia (NatureServe 2008).

Populations:
This species is known from two counties. Total range is less than 100 square km. This species is known from five specimens.

Status:
NatureServe (2008) ranks this stonefly as critically imperiled in Virginia and Kentucky. It is a Special Concern Species in Kentucky.

Habitat destruction:
This species is threatened by heavy grazing by beef cattle (NatureServe 2008). It also occurs in an area with extensive surface coal mining (EPA 2005) and could be threatened by coal mine runoff. Acroneuria kosztarabi and its habitat will be adversely impacted by the implementation of projects under the Jefferson National Forest plan (USFS 2008).

Inadequacy of existing regulatory mechanisms:
This species occurs on the Jefferson National Forest, where it is a Regional Forester Sensitive Species (USFS 2008), but this designation conveys only discretionary protection. This stonefly is a species of concern in Kentucky, but this designation provides no habitat protection.

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Scientific Name:
Aeschynomene pratensis
Common Name:
Meadow Joint-vetch

G Rank:
G1

Range:
In the United States, this species occurs only in Collier, Dade, and Munroe counties, Florida (Wunderlin 1998). It is also present in parts of the Caribbean and South America (NatureServe 2008)

Habitat:
This plant is found in pine rocklands, marl prairies, cypress domes, and swales (Wunderlin 1998).

Populations:
There are only 11 known occurrences of this species in the United States, and most of these are composed of just a few individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the species seems to be stable in the short-term, but long-term population trends are not known.

Status:
This rare species is endemic to a very small range within Florida, and exhibits narrow habitat preferences. Its preferred habitat is extremely vulnerable to degradation. Only 11 occurrences are known as of May 2000, and all populations are small. NatureServe (2008) ranks the meadow joint-vetch as critically imperiled in Florida, where it is also state-listed as endangered.

Habitat destruction:
This plant is threatened by drainage and conversion of wetlands, particularly for development (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in the state of Florida, this designation offers this species no substantial regulatory protections; no existing regulatory mechanisms adequately protect the meadow joint-vetch or its habitat.

Other factors:
Meadow joint-vetch is potentially threatened by invasive exotic species (NatureServe 2008).

References:

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Scientific Name:
Agarodes logani
Common Name:
A Caddisfly

G Rank:
G1

Range:
NatureServe (2008) estimates the range of this species is less than 100 square km (less than about 40 square miles). It appears to be restricted to one stream in Gadsden County, Florida (Rasmussen 2004).

Populations:
This caddisfly was described from specimens collected from a ravine within the Florida A&M University Farm Stream, northeast Florida panhandle (NatureServe 2008). The ravine was revisited by Rasmussen (2004) who surveyed throughout the entire panhandle and only found five specimens in the FAMU Farm Stream.

Status:
Agarodes logani is only known from one stream in Gadsden County, Florida, on an active farm (Rasmussen 2004). It is critically imperiled (NatureServe 2008).

Habitat destruction:
This species occurs in a single stream on a university farm where it is subject to agricultural impacts. Any activity that adversely affects water quality, such as pollution or siltation, could extirpate this species.

Inadequacy of existing regulatory mechanisms:
The lone occurrence of this species is not appropriately protected (NatureServe 2008).

References:

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Scientific Name:
Alasmidonta arcula
Common Name:
Altamaha Arcmussel

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	EN - Endangered

Range:
The Altamaha Arcmussel is endemic to the Altamaha River system including the Ocmulgee, Little Ocmulgee, Ohoopee, and Altamaha rivers (Heard 1975), and as of 2000 was reported as extant in the Altamaha, Ocmulgee, and Little Ocmulgee Rivers (Gene Keferl, Coastal Georgia Community College pers. comm., 2000 in NatureServe 2008).

Habitat:
The Altamaha Arcmussel inhabits sandy mud below sand bars in eddies and slow waters (Johnson 1970), sand bars in mid-channel areas in shallow water (less than 1 m) (Clarke 1981), and backwaters of mainstem rivers in silty sand and detritus (J. Brim Box, pers. obs. in NatureServe 2008).

Populations:
There are an estimated 6-20 populations of Altamaha Arcmussel (NatureServe 2008). This species is known from one river system in Georgia where it occurs on three tributaries-- two sites on the Ocmulgee, three sites on the Altamaha, and one site on the Ohopee. This mussel is known from approximately 12 historical occurrences in the Ocmulgee, Little Ocmulgee, Ohoopee, and Altamaha Rivers of Georgia (Clarke 1981). In a 1990s survey of 276 sites throughout the Altamaha River drainage, this mussel was detected at 17 sites (Gene Keferl, Coastal Georgia Community College, pers. comm. 2000 cited in NatureServe 2008). Triannual Unionid Report (1995) reports this species at 43 of 131 stations (33 percent) surveyed in the Altamaha River system.

Historical information on abundance is lacking, but this mussel is known to be rare. NatureServe (2008) states: "Heard (1975) reported Alasmidonta arcula as very rare and only known from a few sites. Johnson (1970) also commented on the rarity of this species, and noted that "not more than a few specimens have ever been collected at any station in this century save for a series of twenty-two specimens collected by H. D. Athearn in 1962 in the Ocmulgee River, below Lumber City, Telfair Co., Georgia." Gene Keferl, Coastal Georgia Community College (pers comm., 2000 cited in NatureServe 2008), reported that about 170 specimens (1.1 percent of all living mussels) were collected from a total of 276 sites surveyed from 1993 to 1997 in the Altamaha River system. In 1996, 26 A. arcula were collected from a single site on the main stem of the Altamaha River in about 45 minutes. In a survey of 131 stations (93 Altamaha River, 19 Ocmulgee River, 5 Oconee River, 4 Ohoopee River, 10 Little Ocmulgee River), 126 specimens were found at 43 stations (anonymous, 1995)."

This mussel may be undersampled because it occurs it backwater sloughs which can be difficult to access.

Population Trends:

The Altamaha Arcmussel is declining (decline of 10-30 percent) in the short-term and has

Status:

The Altmaha Arcmussel is imperiled in Georgia (NatureServe 2008).This species is endemic to only three rivers in the Altamaha River drainage, was historically somewhat rare, and has experienced substantial long-term decline. It was ranked as threatened by the American Fisheries Society (Williams et al. 1993), but its status is being changed to vulnerable (2010 draft, in review). It is classified as endangered by the IUCN.

Habitat destruction:

Loss and degradation of habitat is an imminent and ongoing threat to the Altamaha Arcmussel. There is less than 500 km length of river system which supports this mussel, and adjacent land is being cleared for agriculture. Excessive sedimentation from agriculture, poor land practices, and bank and streambed destabilitzation threaten the survival of this species. This mussel is also threatened by pollution, eutrophication, and extremely low water levels (NatureServe 2008).

The Georgia Dept. of Natural Resources (Wisniewski 2008) cites excessive sedimentation due to inadequate riparian buffer zones as a threat to this mussel, as sedimentation both covers suitable habitat and potentially suffocates mussels.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Altamaha Arcmussel, and no occurences are appropriately protected and managed (NatureServe 2008). This mussel is listed as Threatened in the state of Georgia, but this designation does not confer substantial regulatory protection.

Other factors:

Any factor which reduces water quality or negatively affects host fish populations threatens the Altamaha Arcmussel. NatureServe (2008) states that deterioration in water quality and pollution threaten this mussel. This species is also potentially threatened by the invasive Asian clam, Corbicula fluminea, which is present in some streams which support this species (NatureServe 2008). The Georgia Dept. of Natural Resources (Wisniewski 2008) reports that direct and indirect competition from the introduced flathead catfish may be reducing native mussel populations through direct consumption of mussels and their host fishes. This species is also particularly vulnerable to extinction due to rarity.

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Scientific Name:
Alasmidonta triangulata
Common Name:
Southern Elktoe

G Rank:
G1

Range:
The range of the Southern Elktoe covers 250-1000 square km in the Apalachicola Basin (NatureServe 2008). This mussel is found in the Chattachoochee River system in Alabama and Georgia, the Flint River sytem in Georgia (Athearn 1998), and the Apalachicola and lower Chipola rivers in Florida (43 historic records) (Brim Box and Williams 2000). It is likely extirpated from the main channel of the Apalachicola and Chattahoochee Rivers (Brim Box and Williams 2000). In Alabama, it is still extant in Lee and Russel counties in Uchee and Little Uchee creeks (Mirarchi et al. 2004).

Habitat:
This species' habitat includes larger creeks and rivers in moderate currents in sand substrate in the vicinity of rocks (Heard 1979, Clench and Turner 1956). In Chattahoochee River tributaries, this mussel was detected in sand bars, but was not detected in muddy sediments or near rocks. It has also been detected in sand and silt substrate (Brim Box and Williams 2000).

Ecology:
Mirarchi et al. (2004) report that the Southern Elktoe is a long-term brooder with glochidia present year round. Glochidial hosts are unknown.

Populations:
There are less than five extant populations of Southern Elktoe, and these populations are very small. Historically this species was known from 29 sites in the four major rivers of the Appalachicola basin of Florida, Alabama, and Georgia. It still exists at only 3 or 4 sites, at one of which, Lake Blackshear, there are only dead shells (Brim Box and Williams 2000, Battle et al. 2003, NatureServe 2008).

Total population size for the Southern Elktoe is estimated at 50 - 1000 individuals, but this is likely an overestimate, as only 14 individuals have been recently reported. This rare species was not historically abundant (Clench and Turner 1956). There are no remaining populations with significant numbers. Brim Box and Williams (2000) only detected two live specimens from a single location in Potato Creek, a tributary of the Flint River in Alabama. Battle et al. (2003) report that nine individuals were found in a survey of six sites in the Elmodel Wildlife Management Area in Ichawaynochaway Creek in southwest Georgia. Only two other specimens have been reported from the Flint River basin since 1991 (Battle et al. 2003). A single live mussel was also detected in Uchee Creek, Alabama, in 1994 (Brim Box and Williams 2000).

Population Trends:
This mussel has "suffered severe declines across its limited range" (NatureServe 2008). It has severely declined in the short term (decline of more than 70 percent in population, range, area occupied, and/or number or condition of occurrences), and has experienced a long-term decline of 75 to 90 percent (NatureServe 2008). Of 29 known sites, this mussel is now only extant at three, and in very low numbers.

Status:
The Southern Elktoe is critically imperiled in Alabama and Georgia (S1), and is not ranked in FL (SNR), where only one live individual has been detected in the past 20 years (NatureServe 2008). It is being ranked as endangered by the American Fisheries Society (2010 draft, in review).

Habitat destruction:
The habitat of the Southern Elktoe is known to be degraded and fragmented (Brim Box and Williams 2000). This species is threatened by dredging activities in the Apalachicola River (Brim Box and Williams 2000). In Georgia, this mussel is threatened by drought and water withdrawals (Battle et al. 2003). The Georgia Dept. of Natural Resources (Wisniewski 2008) reports that this mussel is threatened by habitat fragmentation, population isolation, impoundments, water withdrawals, drought, and sedimentation, stating, "Excessive water withdrawals in the lower Flint River basin coupled with severe drought could cause this species to become extirpated from Georgia." Other potential threats include activities that degrade water quality (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect this species, and no sites are appropriately protected and managed. This mussel is Endangered in Georgia, and is a Priority 1 Species of Greatest Conservation Need in Alabama, but these designations do not provide substantial regulatory protection. This species has been detected on the Elmodel Wildlife Management Area in Georgia (NatureServe 2008).

Other factors:
This mussel is threatened by any activity which degrades water quality. It is now inherently vulnerable to extinction due to rarity and drastically reduced range and population size.

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Scientific Name:
Alasmidonta varicosa
Common Name:
Brook Floater

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	DD - Data deficient

Range:
The brook floater is historically known from Connecticut, Delaware, Washington, D.C., Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, and West Virginia (NatureServe 2008). Currently, populations are known in Maine's Aroostook, Cumberland, Hancock, Kennebec, Knox, Lincoln, Penobscot, Piscataquis, Somerset, Waldo, and Washington Counties, but this species is extirpated from the Dennys and Presumpscot Rivers (Nedeau et al. 2000). In Massachusetts, populations are reported from the Connecticut River, and possibly the Merrimack drainage, though this species has been extirpated from the Charles River drainage (Smith 2000). In Vermont, the brook floater is present in the lower reaches of the West River, and was historically known in the Connecticut River (Fichtel and Smith 1995, Johnson 1915). In Connecticut, it is known in a few streams in the Connecticut and Thames River watersheds (Nedeau and Victoria 2003, pers. obs. as cited in NatureServe 2008). It is known in Pennsylvania's Potomac, Susquehanna, and Delaware River basins (Bogan 1993). In the Delaware River basin, the brook floater has been observe in the Middle Delaware-Mongaup-Broadhead drainage that runs from New York to the Pennsylvania border (Strayer and Ralley 1991). In New Jersey, it is reported from the Stony Brook, Musconetcong, Raritan, Lamington, and upper Delaware Rivers. In Maryland, the North Branch of the Potomac, Upper Potomac, Middle Potomac, and Washington Metro drainages support populations of the brook floater (Bogan and Proch 1995). In Virginia, it is present in the middle James-Willis, the North Fork of the Shenandoah, and parts of the Potomac River, but has been extirpated from the Middle Potomac-Anacostia-Occoquan, the South Fork of the Shenandoah, and the Shenandoah drainages (VA NHP 2007 as cited in NatureServe 2008). West Virginia's Patterson Creek (part of the North Branch Potomac drainage) and Cacapon Town drainages support populations of the brook floater (Clayton et al. 2001, Taylor 1985, WV NHP as cited in NatureServe 2008). Four populations in South Carolina are known in the Beaverdam, Stevens, Turkey, and Mountain Creeks (Alderman 1998); the brook floater is extirpated from the Cooper Santee River basin (Bogan and Alderman 2004). North Carolina hosts 12 populations: the Roanoke, Neuse, Cape Fear, Pee Dee, and Catawba River basins are known to contain the brook floater (Bogan 2002), as are Anson, Burke, Caldwell, Chatham, Forsyth, Granville, Moore, Orange, Randolph, Surry, and Yadkin Counties (LeGrand et al. 2006). This mussel is found rarely at the southernmost edge of its range in the Savannah River basin on the border between South Carolina and Georgia (GA NHP as cited in NatureServe 2008). A fairly large population (less than 1,000 individuals) was recently located in the Suncook River of New Hampshire (Conaboy 2006).

There are fewer than 15 populations of the brook floater in Canada: it is found in parts of New Brunswick's Bay of Fundy drainage (Athearn 1961, 1963) and in few locations in Nova Scotia. This species is considered rare in Canada and listed under COSEWIC as a species of special concern (NatureServe 2008).

Habitat:
A. varicosa inhabits creeks and small rivers, prefers the stable bank conditions afforded by gravel substrates or sandy shoals, and is generally found in riffles and moderate rapids (Nedeau et al. 2000, Clark and Berg 1959, Strayer and Ralley 1993).

Ecology:
Brooding period is approximately May-August, but the length of time required for glochidia to complete metamorphosis to juvenile form is unknown. Species known to host glochidia include the long-nose dace (Rhinichthys cataractae), golden shiner (Notemigonus crysoleucas), pumpkinseed (Lepomis gibbosus), marginated madtom (Noturus insignis), yellow perch (Perca flavescens), blacknosed dace (Rhinichthys atratulus), and slimy sculpin (Cottus cognatus) (Schulz and Marbain 1998). Juveniles disperse via host fish vectors (lodged in gills), and adults are sessile, though passive movement by water currents may occur (NatureServe 2008).

Populations:
Approximately 150 historic occurrences are known, 60 - 80 of which have been extirpated. It is believed that more populations have been destroyed than will be discovered in the future (NatureServe 2008). Global population size is unknown (NatureServe 2008). Though the brook floater occurs over a wide geographic range, populations are sparsely distributed, generally small, and of dubious viability.

Population Trends:
The brook floater has disappeared from up to 80 sites across its range, and remaining populations are experiencing steep declines (NatureServe 2008). NatureServe (2008) reports that the brook floater has experienced substantial decline of up to 75 percent.

The brook floater is exirpated in Rhode Island (Raithel and Hartenstein 2006). Only a few populations of this species remain in Connecticut, and they are small and show little evidence of successful reproduction (Connecticut Department of Environmental Protection 2003). It is extirpated in the Cooper-Santee and Pee Dee River basins in South Carolina (Bogan and Alderman 2004). Reproductive success in the Potomac River is reportedly negligible.

This mussel has declined drastically in New Hampshire. The New Hampshire Fish and Game Department (2006) states: "Based on evidence of recruitment and abundance observed during CPUE surveys in 1993 and 1995, the Blackwater, Suncook, Soucook, and the North Branch Sugar River populations appear the most robust. Nevertheless the North Branch Sugar River population is small and insular and therefore at risk of harm from pollution and habitat degradation. Mussel populations end abruptly at the North Branch and Sugar River confluence where water quality is low (von Oettingen, USFWS, personal communication). Long-term monitoring of the Piscataquog River Henry Bridge population shows a decline in mussel density from 0.4 per meter squared in 1996 to 0.02 in 1999 (Wicklow, Saint Anselm College, unpublished data). A mussel bed on the South Branch of the Piscataquog River, monitored periodically since 1993, has been nearly extirpated. The coastal watershed populations are at high risk of extirpation."

This species is nearly extirpated in New York. The New York Natural Heritage Program states: "Formerly widespread in southeastern New York, this species has disappeared from many sites since the 1950's and is now extremely rare in the state. Populations in the Housatonic and Passaic basins have apparently disappeared and surveys of nearly a dozen historical populations throughout the Susquehanna River watershed in 1991 turned up only 1 living animal. Populations in the Shawangunk Kill and Delaware River basins (Lellis 2001) are sparse and limited in extent. Only the Neversink River population currently appears healthy although it also apparently declined by an estimated 38,000 individuals during the mid-1990's (Strayer and Jirka 1997)."

There are only four remaining populations of this species in Massachusetts, and their viability is questionable. The Massachusetts Division of Fisheries and Wildlife (2009) states: "Recent studies indicate that the extant populations in Massachusetts are significantly fragmented, low in density, and prone to mortality due to old age and poor condition. A few patches of brook floaters with densities high enough to be considered viable exist, however, they exhibit a high degree of spatial clustering and are significantly isolated from one another. There is growing concern that some populations have dwindled to the point where reproduction is unlikely and persistence beyond the life span of the remaining individuals is improbable."

Status:
NatureServe (2008) lists the brook floater as critically imperiled in Connecticut, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Vermont, Virginia, and West Virginia, imperiled in Georgia, and Pennsylvania, vulnerable in Maine, and extirpated from Delaware. It is not ranked or currently under review in Washington, D.C. and South Carolina. It is state-listed as endangered in Connecticut, Delaware, Maryland, North Carolina, New Hampshire, New Jersey, and Virginia, and as threatened in Maine, New York, and Vermont. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Across its range, habitat degradation from impoundments, channel alteration, logging, mining, agriculture, and development is a primary threat to this species and has already resulted in the extirpation of many populations (New Hampshire Fish and Game Department 2006, Massachusetts Division of Fisheries and Wildlife 2009, New York Natural Heritage Program 2009, Virginia Department of Game and Inland Fisheries 2010). Habitat fragmentation further threatens the brook floater. Long-term studies indicate that stream fragmentation disrupts Alasmidonta life cycles, prevents host fish migration, blocks gene flow, and prohibits recolonization, resulting in reduced recruitment rates, decreased population densities, and a higher probability of extirpations (Wicklow 2004).

Overutilization:
Collection of local populations for biological supply or other purposes may be a localized threat to this species (NatureServe 2008). The population in the Penobscot River in Maine is thought to have been harvested in 1993 (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No occurrences are known to be adequately protected at this time (NatureServe 2008). Some populations in North and South Carolina occur on unmanaged Forest Service land, and one Maryland population is located within the Sideling Hill Creek Bioreserve managed by the Nature Conservancy (NatureServe 2008). Though the brook floater is listed as threatened or endangered in several states, these designations afford it no substantial regulatory protection.

Other factors:

Pollution is a primary threat to the brook floater because it appears to be highly sensitive to low dissolved oxygen levels, pollution, and siltation (Connecticut Department of Environmental Protection 2003). Toxic releases from wastewater treatment plants, poultry and hog processing plants, and siltation and pesticide runoff from a variety of sources threaten this species' survival (Virginia Department of Game and Inland Fisheries 2010). Displacement by the Asiatic clam, Corbicula fluminea, and the zebra mussel, Dreissena polymorpha, may also threaten this species (Clarke 1984, Connecticut Department of Environmental Protection 2003). Remaining populations of A. varicosa are generally small and isolated and thus may be vulnerable to extirpation by local stochastic events or inbreeding depression. The Massachusetts Division of Fisheries and Wildlife (2009) states: "The persistence of brook floaters in Massachusetts seems to be closely tied to its survival and reproduction within isolated areas that are highly vulnerable to random events such as mortality related to floods, droughts, predators, poorly planned development or disturbance, pollution, or even trampling." The darter and sculpin host fishes of this species are also sensitive to water quality, and the floater is threatened by any factor which threatens the fish populations on which it depends for reproduction. In New York, this species is threatened by hybridization with A. marginata; many intermediate individuals, not assignable to either species, were found in the Susquehanna River basin in the mid 1990's (Strayer and Fetterman 1999).

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Scientific Name:
Allocapnia brooksi
Common Name:
Sevier Snowfly

G Rank:
G2

Range:
This species is known from four occurrences in Hawkins Co., Sevier Co., and Sullivan Co., Tennessee (NatureServe 2008).

Populations:
There are four occurrences of this stonefly. Population information is not available.

Status:
NatureServe (2008) ranks this species as imperiled.

Habitat destruction:
All populations of this species are experiencing severe impacts from poor agricultural practices and development (Kondratieff and Kirchner 1999).

According to Kirchner et al (2002), "all the areas in Tennessee where the above species [including A. brooksi] have been collected are highly impacted by past and current agricultural practices and other disturbances. These species are, no doubt, imperiled throughout their ranges, and it is strongly suggested that potential listing should be considered."

Inadequacy of existing regulatory mechanisms:
This species is not protected by any existing regulatory mechanisms.

References:

Kirchner, R.F. B.C. Kondratieff and R.E. Zuellig. 2002. The Tennessee Type Locality Of Allocapnia Perplexa And A New Kentucky Location For Allocapnia Cunninghami. Entological News v.113 n.5 pp.332-335, November & December.

Stark, B.P. 1996. Last updated 16 February 2001. North American Stonefly List. Online. Available: http://www.mc.edu/campus/users/stark/Sfly0102.htm.

Scientific Name:
Allocapnia cunninghami
Common Name:
Karst Snowfly

G Rank:
G1

Range:
Allocapnia cunninghami is known from three occurrences in Sumner Co., Tennessee, one in Cumberland Co., Kentucky, and more recently it was found in Adair, Allen, Metcalfe, and Monroe counties, Kentucky.

Habitat:
According to Kirchner et al. (2002), "Allocapnia cunninghami has been taken only in spring-fed streams."

Populations:
Population information is not available for this species. It is now known from six counties.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks A. cunninghami as critically imperiled in Kentucky and Tennessee. According to Kirchner et al. (2002), "all the areas in Tennessee where the above species [including A. cunninghami] have been collected are highly impacted by past and current agricultural practices and other disturbances. These species are, no doubt, imperiled throughout their ranges, and it is strongly suggested that potential listing should be considered."

Habitat destruction:
This snowfly is threatened across its narrow range. All known sites for this species are experiencing severe impacts from poor agricultural practices and development (Kirchner et al. 2002, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species.

References:

Kirchner, R.F., B.C. Kondratieff and R.E. Zuellig . 2002. The Tennessee Type Locality Of Allocapnia Perplexa And A New Kentucky Location for Allocapnia Cunninghami (Plecopteraicapniidae). Entonological News 113(5): 332-335.

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Scientific Name:
Allocapnia fumosa
Common Name:
Smokies Snowfly

G Rank:
G2

Range:
According to NatureServe (2008), Allocapnia fumosa is known from high elevation rheocrenes of the Mt. Rogers National Recreation Area (Grayson Co., Smyth Co.), Virginia and Great Smoky Mountain National Park (Haywood Co., Macon Co., North Carolina; Sevier Co., Tennessee).

Habitat:
This stonefly is restricted to high elevation springs that flow directly from the ground.

Populations:
NatureServe (2008) inidcates that the Smokies Snowfly is known from less than 20 occurrences in high elevations in VA, NC and TN.

Status:
NatureServe (2008) ranks A. fumosa as critically imperiled in Virginia and vulnerable (S3?) in Tennessee. It is not ranked in North Carolina.

Habitat destruction:
The habitat for A. fumusa is threatened by logging and acid deposition (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
A. fumosa occurs in the Great Smoky Mountains National Park (Parker et al. 2007). Occurrences outside the park are not protected, and even within the park the species is threatened by acid deposition.

References:

Parker, C.R., et al. 2007. Ephemeroptera, Plecoptera, Megaloptera, and Trichoptera of Great Smoky Mountains National Park. Southeastern Naturalist, Vol. 6, Special Issue 1: The Great Smoky Mountains National Park All Taxa Biodiversity Inventory: A Search for Species in Our Own Backyard, pp. 159-174.

Stark, B.P. 1996. Last updated 16 February 2001. North American Stonefly List. Online. Available: http://www.mc.edu/campus/users/stark/Sfly0102.htm.

Scientific Name:
Alnus maritima
Common Name:
Seaside Alder

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The seaside alder is native to the southeastern United States, and is present across a disjunct range in small areas of Oklahoma, southwestern Delaware, eastern Maryland, and one location in Georgia. The largest populations occur along the Nanticoke River in Delaware and eastern Maryland, and others are known elsewhere on the Delmarva Peninsula (NatureServe 2008). Natural heritage records indicate this species is present in Delaware's Kent and Sussex Counties, in Georgia's Bartow County, in Maryland's Dorchester, Wicomico, and Worcester Counties, and in Oklahoma's Johnston and Pontotoc Counties. Though formerly present there, it is reportedly extirpated from Maryland's Cecil County (NatureServe 2008).

Habitat:
It is found along streambanks and pond edges, often in standing water (NatureServe 2008).

Ecology:
This species often reproduces clonally: a single occurrence may be comprised of hundreds of individuals originating from the same root system (NatureServe 2008).

Populations:
It is believed that there are approximately 50 occurrences across this species' range, but determining total population size is difficult due to clonal reproduction (NatureServe 2008).

Population Trends:
Population trends are not reported.

Status:
Though this species is locally abundant in some small areas, including parts of the Nanticoke River, there are few occurrences overall. NatureServe (2008) reports that the seaside alder is critically imperiled in Georgia, imperiled in Oklahoma, and vulnerable in Maryland and Delaware. It is categorized as near threatened by the IUCN.

Habitat destruction:
This tree species is highly sensitive to the impacts of channelization, damming, drainage of marshy and riparian areas, and to the effects of residential, industrial, and agricultural development on the semi-aquatic habitat that it requires. NatureServe (2008) reports that it is resilient to some environmental change if suitable habitat remains, but if significant alterations to habitat occur, it is susceptible to exclusion by changed successional patterns.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the seaside alder.

References:

Scientific Name:
Alosa alabamae
Common Name:
Alabama Shad

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	EN - Endangered

Range:
The shad is an anadromous species that occurs in Alabama, Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Missouri, Mississippi and Oklahoma. It used to occur in Iowa and Tennessee (NatureServe 2008). NatureServe (2008) lists historical range as including the Gulf Coast from the Suwannee River, Florida, to the Mississippi River, westward in the Ouachita River system to eastern Oklahoma. Remaining populations occur in the Apalachicola River system below Jim Woodruff Lock and Dam, in the Pascagoula River drainage of Mississippi, in the Conecuh and Choctawhatchee rivers in southcentral and southeastern Alabama, and the Mobile River drainage of Alabama (Robison and Buchanan 1988, Mettee et al. 1996, Ross 2001, Boschung and Mayden 2004, Mettee 2004, NatureServe 2008). The species has undergone major range contraction with records in Mobile Bay and the Alabama River limited to single adults (Mettee et al. 1996). The shad used to occur as far north as Keokuk, Iowa in the Missssippi, at Louisville in the Ohio River, and in eastern Oklahoma (Evermann 1902, Coker 1930, Moore 1957, Miller and Robison 2004). Today, spawning populations of the shad are believed to still occur in the Apalachicola, Choctawhachee, Conecuh, Pasgacoulah, Ouachita, Missouri, Gasconade, Osage, and Meramec Rivers (NMFS 2008).

Habitat:
This species migrates from the ocean to medium to large coastal rivers to spawn (Etnier 1997). In Florida, spawning occurred at 19-22 C over coarse sand and gravel in moderate current (Laurence and Yerger 1966, Mills 1972). Young have been observed in swift water over rocky shoals (NatureServe 2008).

Populations:
NatureServe (2008) estimates only six to 20 populations. Mettee et al. (1996) observed that there are only two known extant spawning runs in the Mississippi River System with other spawning runs occurring in the Florida Panhandle and southern Alabama. Populations are small and the species is considered very rare in large portions of its historic range (Lee et al. 1980, Robison and Buchanan 1988, Etnier and Starnes 1993, Pflieger 1997, NatureServe 2008). Based on their own and others surveys, Mettee and O'Neil (2003) concluded that spawning populations of shad are "relatively small."

Population Trends:
NatureServe (2008) lists decline in short-term trend of as much as 30 percent, further noting that the shad is probably declining in number of populations and population size at an unknown rate. The shad has likely experienced dramtic long-term declines (see below in status).

Status:
The Alabama shad was once an abundant species that supported commercial fisheries in Alabama, Arkansas, Kentucky, Indiana and Iowa (NMFS 2008). The species has declined dramatically because of habitat loss and degradation caused by impoundments, pollution, dredging and other factors (NatureServe 2008, NMFS 2008). It is considered severely depleted in the Mississippi River System

with small numbers of fish found sporadically and is likely limited to only two spawning runs (Meramec River, Missouri, and Ouachita River, Arkansas) (Lee et al. 1980, Page and Burr 1991, Pflieger 1997, NatureServe 2008). Surveys in Arkansas in both the Arkansas and Mississippi Rivers did not yield any specimens (Buchanan 1976, Sanders et al. 1985, Carter 1984; Pennington et al. 1980, 1983; Beckett and Pennington 1986). It is likely extirpated in Oklahoma, Tennessee, Iowa and Louisiana, and severely reduced in Alabama, where it may be extirpated from the upper Tombigbee, Cahaba, Coosa, and upper Alabama rivers (Etnier and Starnes 1993, Ross 2001, Metee and O'Neil 2003, Miller and Robison 2004, Mirarchi et al. 2004). Mettee (2004) classify this fish as a "high conservation concern taxa." It is categorized by the IUCN as endangered, and by the American Fisheries Society (Jelks 2008) as threatened due to habitat loss and overutilization. In a meeting between the Southeastern Fishes Council and the Center for Biological Diversity, there was a unanimous consensus that the shad should be listed as threatened (SFC and CBD 2010).

AFS (2008) lists as threatened because of threats to habitat and over-exploitation.

NatureServe (2008) ranks this species as critically imperiled in Arkansas, Georgia, Kentucky, Lousiana, and Mississippi, imperiled in Alabama, Missouri, and Oklahoma, historical or extirpated in Iowa, Indiana, and Tennessee, and not rated in Florida or Illinois.

Habitat destruction:

The Alabama shad has experienced widespread declines because of loss of habitat to dams, rapid urbanization, pollution and other factors (Mettee and O'Neil 2003, Mirarchi et al. 2004, NMFS 2008). The shad has been cut-off from many historical spawning areas by dams and locks (Robison and Buchanan 1988, Etnier 1997, Mirarchi et al. 2004). For example, dams on the lower Tombigbee and Alabama Rivers built in the 1960's resulted in steep declines in shad populations in the Mobile River Basin due to loss of spawning areas (Barkuloo et al. 1993, Mettee and O'Neil 2003, NMFS 2008, NatureServe 2008). Mettee (2004) list agricultural operations, dredging, and possible reservoir construction for water supply on major tributaries as major threats to remaining populations in Alabama. Similarly, Metee and O'Neil (2003) list construction of locks and dams and dredging as causes of decreasing shad populations. These threats likely apply throughout the species' range. Jelks et al. (2008) lists the Alabama shad as threatened because of the present or threatened destruction, modification or reduction of habitat and range.

There are currently new reservoirs proposed on Murder Creek, the Little Choctawhatchee and on smaller tribs that further threaten the shad (SFC and CBD 2010).

Overutilization:

NatureServe (2008) notes that commercial fishing in the Ohio River was a threat historically, but with the crash in fish numbers, there is no longer a commercial fishery. Jelks et al. (2008) describe this species as threatened in part because of over-exploitation for commercial, recreational, scientific, or educational purposes including intentional eradication or indirect impacts of fishing.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) states that it is unknown whether any occurrences of Alabama shad are appropriately protected and notes that a "primary management need is the creation of fishways so that shad can migrate through or around locks and dams."

Mississippi lists the shad as a tier 1 "species of greatest conservation need." Tier 1 species are those "that are in need of immediate conservation action and/or research because of extreme rarity, restricted distribution, unknown or decreasing population trends, specialized habitat needs and/or habitat vulnerability. Some species may be considered critically imperiled and at risk of extinction/extirpation." This designation, however, provides no regulatory protection for the shad.

Alabama also lists as a "species of greatest conservation need" with a priority of 2. Although the state of Alabama has developed a "comprehensive wildlife comprehensive strategy," this strategy is entirely voluntary and provides no regulatory protection for the shad (see http://www.outdooralabama.com/research-mgmt/cwcs/outline.cfm; accessed March 12, 2009). There is also no evidence that it will ensure the survival and recovery of the shad and indeed, the strategy does not provide any specific protections for the shad.

The shad is also listed as a species of special concern by the state of Georgia and the National Marine Fisheries Service. As above, these designations do not provide any regulatory protection.

Other factors:

The Alabama shad is threatened by pollution from a variety of sources and by drought. Mettee (2004) list increased sedimentation, pesticide runoff from agricultural operations, and prolonged drought as major threats to remaining populations in Alabama. Similarly, Metee and O'Neil (2003) list siltation and water pollution as causes of decreasing shad populations.

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Scientific Name:
Amblyopsis spelaea
Common Name:
Northern Cavefish

G Rank:	AFS Status:	IUCN Status:
G4	Threatened	VU - Vulnerable

Range:
The northern cavefish occurs in underground waters of the Pennyroyal and Mitchell plateaus, from the Mammoth Cave karst ecosystem in Kentucky north into southern Indiana (Pearson and Boston 1994). This fish is not known to occur in caves north of the East Fork of the White River in Indiana or in caves south or west of the Mammoth Cave system (Keith 1988). The species occurs across its historic range, but has been lost from many sites (FWS 2003).

Habitat:
This fish occurs in cave streams, springs, and spring basins (Keith 1988).

Populations:
Pearson and Boston (1994) documented this fish in just over 100 caves, and estimate total population size as at least 5600 individuals. This estimate is considered to be conservative based on limited underground habitat accessibility. Population sizes are small, and typically range from 1-23, and at some sites up to 220 individuals (Keith 1988, NatureServe 2008).

Population Trends:
Trend information is unavailable for this species. Pearson and Boston (1994) report that two populations have been lost. Culver and Pipan (2009) report the extirpation of this fish at a site in Indiana that was destroyed by quarrying. FWS (2003) report that 49 historical sites have been lost.

Status:
Within this species' very limited range, many historical sites have been extirpated. NatureServe (2008) ranks the northern cavefish as critically imperiled in Indiana and vulnerable in Kentucky. This fish is classified as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat degradation and narrow range. It is listed as endangered by the state of Indiana.

Habitat destruction:
This species' highly restricted habitat is located at or near local base level and is vulnerable to virtually any natural or anthropogenic disturbance (Keith 1988). Threats to karst ecosystems, including the Mammoth Cave Karst Aquifer, come from a variety of agricultural, urban, and transportation landuse practices.Clearcuts and logging roads threaten this fish due to sedimentation and reduced liter input (Pearson and Boston 1994). Mining is a known threat to this fish. Zink Cave, Indiana, was almost completely quarried away, resulting in the extirpation of a population of this species (Culver and Pipan 2009). The northern cavefish is threatened by impoundment. The construction of dams on the Green River in Kentucky raised the water level in Mammoth Cave which increased silt deposition and reduced the input of particulate organic matter, a major food supply in the aquatic environment (Proudlove 2001). Threats to this species from habitat loss and degradation are ongoing. The Blue River basin in Indiana and the Kentucky Karst have been identified as "very endangered" ecosystems by the Karst Waters Institute (in Proudlove 2001). Jelks et al. (2008) list habitat loss as a threat to this species.

Overutilization:
Collection is a documented threat to this species (Keith 1988).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. This fish occurs in Mammoth Cave National Park, which provides some degree of habitat protection but leaves the fish vulnerable to recreational impacts. Occurrence in a National Park also does not provide protection from water quality degradation, the primary threat to this species. This fish is listed as endangered by the state of Indiana, but this designation does not provide substantial protection for the species' habitat. It is a special concern species in Kentucky.

Indiana and Kentucky both have cave protection laws that prohibit a number of activities in caves, including dumping or burning in caves and removing, killing, harming, or otherwise disturbing naturally occurring cave dwelling organisms (IC 35-43-1-3 "The Indiana Cave Protection Law"; Ky. Acts ch. 168, sec. 7, effective July 15, 1988). These laws do provide some protection for the northern cavefish. They do not, howerver, prohibit the many activities that occur outside caves, but severely affect the cave environment, including impoundment, logging, agricuture and other activities.

Other factors:
The northern cavefish is highly threatened by water pollution. Karst aquifers are unique in that runoff enters the aquifer with little or no infiltration through sinkholes, springs, and underground streams. Karst groundwater travels at very high velocities, comparable to surface streams which can cause re-entrainment of cave sediments. Karst groundwater may also permeate bedrock features which can act as storage reservoirs, keeping contaminants stagnant for long periods of time. Due to these features, groundwater found in karst is highly susceptible to contamination (Webster et al. 2003). This fish is threatened by urban and suburban development and road runoff, sedimentation from logging, mining, impoundments, and other activities, and alteration of surface runoff patterns (Keith 1988, Pearson and Boston 1994). Pollution from municipal sewage treatment plants, confined animal feeding operations, and pesticides from agriculture and lawns also threaten this species (Keith and Poulson 1981, Aley and Aley 1997). Keith and Poulson (1981) identified pesticides as the cause of “broken back syndrome” in a population of this fish.

A looming and severe threat to the northern cavefish is a recently discovered disease called "white-nose syndrome," which has decimated bat populations in caves across the Northeast and is rapidly spreading south and west (see http://www.srs.fs.usda.gov/news/443). White-nose syndrome has already been documented in Tennessee and is expected to reach Kentucky in the near future (Ibid.) Because bats are a primary source of nutrients to cave ecosystems their loss could have wide ranging consequences for many if not all other cave residents, including the northern cavefish.

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Scientific Name:
Amblyscirtes linda
Common Name:
Linda's Roadside-skipper

G Rank:
G2

Range:
Linda's Roadside skipper is endemic to a small area of the lower Midwest, centered in and near the Ozarks. This butterfly is found in the southern 60 percent or so of Missouri and immediately adjacent parts of Illinois, Kentucky, Tennessee, Arkansas and Oklahoma (NatureServe 2008).

Habitat:
This butterfly is found only along streams in undisturbed hardwood forests in and near the Ozark region. Populations are extremely localized and individuals usually stay near the foodplant, Indian woodoats (Chasmanthium latifolium).

Ecology:
All stages of this species' lifecycle are above ground. Presumably immatures have some adaptation to withstanding periodic short term flooding (NatureServe 2008).

Populations:
There are an unknown number of occurrences of this species, which is rare and localized within its very limited range. Most of its range is in the Missouri Ozarks, and the Missouri NHP reports there is little chance it has over 100 viable metapopulations and a good chance it has fewer than 20.

Population Trends:
Population data are not available for this species. It is expected to decline precipitously due to escalating gypsy moth eradication efforts.

Status:
This taxon has a very limited range and is rare within it, so much so that its status is unknown. The Missouri Natural Heritage Program ranks this species as "imperiled?"(S2?), which forms the basis of its imperiled global rank. It is ranked as imperiled in Tennessee and as S1S3 in Arkansas (critically imperiled to vulnerable). It is not ranked in other states. NatureServe (2008) states, "This taxon is not secure, and may be imperiled." Illinois' Department of Natural Resources rates it as a Conservation Priority Invertebrate in the state's Comprehensive Wildlife Conservation Plan. In Kansas it is rated a Species of Greatest Conservation Need.

Habitat destruction:
Because this rare butterfly is a habitat specialist which occurs only in riparian areas of undisturbed hardwood forests in the Ozarks, it is highly vulnerable to habitat loss and degradation from logging and fire.

According to Vaughan and Shepherd (2005), A. linda "requires fairly undisturbed stream side habitat in deciduous forests and its major threats are from forest management operations, especially logging and spraying… It is likely that with the spread of gypsy moth, Btk spraying will become a particular threat. There is also concern about the impacts on larvae of pollen drifting from adjacent fields planted with Bt corn. Because this butterfly occurs in small, isolated populations, it is probably more susceptible to habitat disturbance and fragmentation."

Other factors:

NatureServe (2008) reportst that this butterfly will probably become highly threatened by gypsy moth spraying in another 20 or 30 years.

Because of its rarity and limited distribution, it is vulnerable to stochastic events and natural disturbances. Fires may threaten some occurrences, and floods may also pose a threat to some populations but many skipper larvae seem to tolerate some flooding (NatureServe 2008).

This butterfly is also threatened by gypsy moth eradication efforts and by drift of Bt pesticides used in agriculture (NatureServe 2008).

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Scientific Name:
Ambystoma barbouri
Common Name:
Streamside Salamander

G Rank:
G4

IUCN Status:
NT - Near threatened

Range:
The Streamside Salamander occurs in Indiana, Ohio, Kentucky, Tennessee, and West Virginia. The core of this salamander's range occurs in north-central Kentucky, southeastern Indiana, and southwestern Ohio. Disjunct populations occur in western Kentucky, westernmost West Virginia, and central Tennessee on the Inner Nashville Basin subregion of the Interior Plateau (Scott et al. 1997, Watson and Pauley 2005, Niemiller et al. 2006, NatureServe 2008). The range of the species is further described in Kraus and Petranka (1989) and Kraus (1996).

Habitat:
The Streamside Salamander is found in upland forests in close proximity to streams (Conant and Collins 1998). It occurs in regions of rolling topography, largely in areas with limestone bedrock, but has also been found in areas with sandstone and shale (Kraus and Petranka 1989). Adult Streamside Salamanders use underground burrows and above ground cover objects such as rocks, downed wood, and leafy debris for cover and to stay moist. Breeding occurs most often in first and second-order streams with limestone substrate. Breeding can also occur in ponds. In one study, larval abundance was highest in stream pools with filamentous green algae (Cladophora sp.) which provides both cover from predators and microhabitat for prey (Holomuzki 1989).

Ecology:
In autumn, the Salamander migrates from deciduous forests to breeding streams where the prolonged breeding season extends from December to April regardless of precipitation (Conant and Collins 1998). The Streamside Salamander generally breeds in first and second-order streams with limestone bedrock, and females deposit eggs singly as opposed to similar species which breed in streams and ditches and lay eggs in clumps (Conant and Collins 1998). Streamside Salamanders also deposit fewer eggs and larvae are larger than similar species. Eggs are deposited on the underside of flat rocks, most often in pools but occasionally in runs. The Streamside Salamander selects breeding sites that reduce exposure of larvae to predatory fish (Kats and Sih 1992). Reproductive success is higher in ephemeral streams with natural barriers to block fish (Kraus and Petranka 1989).

Populations:
More than 80 sites were mapped of this species by Kraus (1996), but not alll of these may represent distinct occurrences, and there may be more sites for this species (NatureServe 2008). Some Ambystoma barbouri populations may have been misidentified as A. texanum (Watson and Pauley 2005). Total population size is unknown for this salamander. NatureServe (2008) estimates that adult population likely exceeds 10,000 salamanders.

Population Trends:
NatureServe (2008) reports the short term trend for this species as declining to stable, and the long term trend as moderately declining to relatively stable. The species appears to be declining in Tennessee. Niemiller et al. (2006) found Streamside Salamanders at only four of six known breeding locations, and at only 5 of 40 surveyed sites in southern Rutherford, northern Bedford,

and northeastern Marshall counties (NatureServe 2008).

Status:
The Streamside Salamander is critically imperiled in West Virginia, imperiled in Tennessee, vulnerable in Indiana, apparently secure in Kentucky, and unassessed in Ohio (NatureServe 2008). It has experienced widespread habitat loss and degradation over its relatively small extent of occurrence (NatureServe 2008). It is categorized as Near Threatened by the IUCN.

Habitat destruction:
The Streamside Salamander has declined due to the loss of native forests for agriculture and urban development (Petranka 1998, NatureServe 2008, AmphibiaWeb 2009). This salamander's habitat in Kentucky is undergoing rapid development (Petranka 1998), and one of the two known populations in West Virginia was lost due to urbanization (Watson and Pauley 2005). In Tennessee, what is possibly the last remaining population in the state is imminently threatened by development (Niemiller et al. 2006). Deforestation is also a threat to this species. Where surrounding land has been logged, this salamander is usually not detected (Petranka 1984). Dodd (1997) lists silation as a threat to the Streamside Salamander. The Ohio Division of Wildlife reports that the Streamside Salamander is threatened by logging, urbanization, pollution of stream habitats by acid mine drainage, pesticides, and the channelization and scouring of streams (http://www.ohioamphibians.com/salamanders/Streamside_Salamander.html).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous” (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: “There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations” (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: “Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: "Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:

Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:

Petranka (1984) identifies predation as a significant source of mortality for Streamside Salamander populations. Fish predation may restrict this species to upper portions of breeding streams (Petranka 1983). Sih et al. (1992) report that of the 30-40 percent of larvae which drifted into pools with fish, that only 6-8% survived to drift out. Flatworms and water snakes are also known to prey on Streamside Salamander larvae (Kats 1986, Petranka et al. 1987, Sih and Moore 1993 in AmphibiaWeb 2009). In conjunction with other threats, natural predation could increasingly threaten this species.

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002).

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to amphibian population declines (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009: (http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and it is imperative that equipment be disinfected so that research efforts to protect species do not inadvertently introduce this fungus or other pathogens to imperiled amphibian populations.

In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that several occurrences of this species are found on small preserves in Kentucky, but that additional protection is needed (Petranka 1998). There are no existing regulatory mechanisms to protect this species. The Streamside Salamander does not have state protection in Indiana, Ohio, Kentucky, or West Virginia. It is a species of Management Concern in Tennessee, but this does not provide the Salamander with any tangible protection.

Other factors:
Stochastic weather events pose a threat to the Streamside Salamander. Petranka (1984) reports that stream drying and flooding are significant mortality sources for this species.

Other factors which may threaten the streamside salamander include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations” (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians. Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets “may exact a substantial toll on amphibian populations” (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: “Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Ammodramus maritimus macgillivraii
Common Name:
MacGillivray’s Seaside Sparrow

G Rank:
T2

Range:
This subspecies is patchily distributed within a narrow coastal fringe on the Atlantic coast from Dare County in northeastern North Carolina south to Duval County in northeastern Florida (NatureServe 2008). Ammodramus maritimus macgillivraii (Audubon, 1834) includes A. m. waynei (Oberholser, 1931), A. m. pelonotus (Oberholser, 1931), and A. m. shannoni (Bailey, 1931) (Post et al. 2009). This subspecies no longer occurs in the southern extent of its historical range, and now ranges only south to the St. John's River (Kale 1983).

Habitat:
The seaside sparrow is a habitat specialist of salt and brackish marshes that generally requires nest sites above spring tides, and openings in vegetation such as pools and creek edges, so that the birds can forage on open mud and at the bases of rooted vegetation (Post et al. 2009). Optimum habitats for this species contain contiguous nesting and feeding areas (Post et al. 2009). MacGillivray's seaside sparrow uses extensive stands of Spartina and/or Juncus. Some birds will nest behind the marsh or up tidal rivers when tidal amplitude is high (Sprunt 1927, Tomkins 1941, Post and Greenlaw 1994).

Populations:
The number of populations of MacGillivray's seaside sparrow is unknown. Based on a very crude estimate made using 1:250,000 scale map series of the Atlantic Coast Ecological Inventory (U.S. Fish and Wildlife Service 1980), there are sixteen estimated elemental occurrences between Dare County, North Carolina, and Duval County, Florida. Total population size is also unknown. The distribution of this subspecies is limited by tidal extremes and abundance of predatory rice rats (Post and Greenlaw 1994). The Florida population is estimated at 750-1,000 pairs (McDonald 1988, Kale 1996).

Population Trends:
Population trend information is unavailable for this subspecies. Breeding Bird Survey data indicate that the seaside sparrow species as a whole is stable to increasing, but these data are based on a limited number of routes and do not cover the range of the macgillivray subspecies (Post and Greenlaw 1994, Post et al. 2009). It is known that this subspecies has been extirpated from the southernmost portion of its range. MacGillivray’s seaside sparrow once ranged into Volusia County, but now occurs only as far south as Duval County (Kale 1983).

Status:
This habitat specialist is patchily distributed within a narrow stretch of southeastern Atlantic coastline, and its distribution is limited by tidal extremes and predation. Populations south of the St. John's River have been extirpated. NatureServe (2008) ranks the subspecies as imperiled in Florida (T2S2). The seaside sparrow species as a whole is designated as a high priority landbird by South Carolina Partners in Flight and South Atlantic Migratory Bird Initiative. It does not have protective status in any state.

Habitat destruction:

MacGillivray's seaside sparrow is a habitat specialist that needs extensive areas to survive and is thus particularly vulnerable to habitat loss and degradation. Loss of coastal wetlands is ongoing due to development and other factors. Wetland loss in the U.S. coastal zone has accelerated about 0.5 percent percent annually since the mid-1950s, and Florida is one of the states where tidal wetland loss has been greatest (Post et al. 2009). NatureServe (2008) reports that occurrences of this subspecies have been destroyed and degraded by development of marshes, development of adjacent uplands, bridge building, and invasion of marsh land by woody vegetation. Kale (1996) reports that this subspecies is threatened by invasion of tidal marshes by woody vegetation and by management activities which artificially prolong the impoundment of marshes for waterfowl or mariculture.

The Florida Fish and Wildlife Conservation Commission (2005) reports that the sparrow's salt marsh habitat is very highly threatened by fragmentation, coastal development, and sedimentation, and highly threatened by the construction of roads, bridges and causeways, incompatible industrial operations, dam operations and the incompatible release of water, climate variability, inadequate stormwater management, surface water withdrawal, channel modification, and incompatible wildlife and fisheries management strategies.

In the 1970's, this subspecies disappeared from seemingly suitable habitat south of the St. Johns River (Kale 1983, Kale 1996). It is hypothesized that invasion of the marsh habitat by mangroves and DDT spraying for mosquito control contributed to the extirpation (Enge et al. 2003).

Disease or predation:

Predation is a primary threat to MacGillivray's seaside sparrow, and rice rat nest predation presumably limits the distribution of this subspecies (Post and Greenlaw 1994). The main known cause of nest failure in north Florida is assumed to be predation by rice rats, which accounted for 28 percent of losses in a field study (Post 1981). Fish crows also predate on seaside sparrow nests, and were responsible for 12 percent of losses in the 1981 study (Post 1981).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which adequately protect MacGillivray's seaside sparrow or its habitat. NatureServe (2008) states that it is unknown whether any occurrences are appropriately protected, and that extensive tracts of habitat are necessary to protect this bird. The Florida Natural Areas Inventory (2001) reports that Nassau County, where the major portion of the population resides, has very little marsh under state or federal ownership. Audubon (2002) reports that Duval and Nassau tidal marshes support virtually the entire Florida population of MacGillivray's seaside sparrow, but that the Nassau marshes are mostly unprotected. Root and Barnes (2006) report that 46 percent of the sparrow's potential habitat is in public ownership. There are no existing requlatory mechanisms which adequately protect this subspecies.

Other factors:

MacGillivray's seaside sparrow is threatened by several other factors including hurricanes, global climate change, human disturbance, pollution, unknown factors, and population sensitivity to adult survivorship.

Seaside sparrows are vulnerable to local extirpation by hurricanes or other severe storms that cause tides to inundate all the marsh vegetation (Enge et al. 2003). The hurricane of August 1992 is estimated to have reduced the Mirabilis subspecies of seaside sparrow from 6,000 to 4,000 individuals (Pimm et al. 1994). Global climate change is expected to increase both the frequency and intensity of hurricanes on the Atlantic coast (Karl et al. 2009). In addition, this subspecies is threatened by projected sea-level rise due to climate change (Audubon 2002). During the next century, a predicted sea-level rise of 2-4 plus millimeters per year, in conjunction with increased storm frequency, will accelerate loss of tidal marshes (Erwin et al. 2006). Climate change is also expected to favor the invasion of salt marshes by mangroves, which can make the habitat unsuitable for use by seaside sparrow (Kale 1983, Enge et al. 2003). Long-term changes in sparrow productivity resulting from succession can be expected even in protected tidal wetlands (Enge et al. 2003). High marshes provide only marginal sparrow habitat (Reinert et al. 1981).

Pollution, such as oil spills, also threatens this subspecies (NatureServe 2008). It is hypothesized that DDT spraying contributed to the extirpation of this subspecies south of the St. Johns River (Enge et al. 2003).

Root and Barnes (2006) developed population models for this subspecies and found adult survivorship to be the most influential parameter on population growth, with a 5 percent reduction in fecundity resulting in a 50 percent decline in abundance.

Unknown factors may be responsible for inexplicable absences in seemingly suitable habitat (Kale 1983, Kale 1996, NatureServe 2008).

The Florida marshes which support this subspecies are also threatened by human disturbance (Audubon 2002).

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Scientific Name:
Amorpha georgiana var. georgiana
Common Name:
Georgia Leadplant
G Rank:
T2
Range:
Also known as the Georgia indigo bush, this species was historically documented from the Inner and Middle Coastal Plain of North Carolina, the South Carolina Sandhilll region, and the Altamaha Grit region of Georgia, but is now thought to be restricted to North Carolina because no occurrences have been confirmed in other states since the mid-20th century (NatureServe 2008, SCHT 1993). In North Carolina, natural heritage records indicate the species is present in Cumberland, Harnett, Hoke, Lee, and Moore Counties, and possibly in Pender, Richmond, Robeson, and Scotland Counties (TNC 1991-1993, NCNHP 1993, NatureServe 2008).

Habitat:
This plant occurs primarily on pine, shrub, and wiregrass (Aristida stricta) terraces along rivers and/or large streams, and also in low flatwoods, creek swamps, and low pastures (NatureServe 2008, NCU 1992-93). Almost all currently known occurrences are found along the Little River in Fort Bragg, NC, close to the annual high water mark; this species usually occurs at or near the ecotone between flood-prone banks and mesic terrace habitat above. Dominant co-occurring tree species are loblolly (Pinus taeda) and longleaf pine (P. palustris) and various oak species (e.g., Quercus marilandica, Q. falcata, Q. incana, Q. stellata, and Q. nigra). The shrub layer may vary from dense to sparse, and is commonly composed of summersweet (Clethra alnifolia), huckleberries (Gaylussacia spp.), and Rhododendron species (NatureServe 2008). This plant favors clearings, such as small gaps created by treefall, selective cutting, flooding, or fire.

Ecology:
The leadplant is a perennial, clonal shrub (NatureServe 2008)
Populations:
There are currently 17 known occurrences of Georgia leadplant, all in North Carolina. Global population size is unknown and is difficult to estimate given the clonal pattern of spread exhibited by this species (NatureServe 2008).

Population Trends:
This species is in decline, and occurrences are no longer known in two states where the species was formerly present (NatureServe 2008).

Status:
This plant is rare and declining throughout its range; only 17 known occurrences remain. Is restricted to sensitive habitat threatened by numerous factors. NatureServe (2008) ranks the Georgia leadplant as critically imperiled in Georgia and South Carolina, and imperiled in North Carolina.

Habitat destruction:
Threats to the Georgia leadplant include damming and diversion of rivers or other water bodies and correspondent changes in local hydrology, conversion of upland terraces to agricultural or silvicultural uses, fire suppression, and, particular to populations on Fort Bragg, the effects of military training activities (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the Georgia leadplant or its habitat; though it is listed as a species of special concern in South Carolina, this designation offers it no substantial regulatory protection.

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Scientific Name:
Amphinemura mockfordi
Common Name:
Tennessee Forestfly

G Rank:
G2

Range:
This stonefly is known from Grundy Co., Tennessee, on the Cumberland Plateau, and more recently from Madison Co., Alabama (NatureServe 2008).

Habitat:
Nelson (1997) describes the habitat of A. mockfordi as "small headwater streams or seeps of the Cumberland Plateau."

Populations:
This species is known from two counties. Population data are not available.

Population Trends:
Morse et al. (1993) believe A. mockfordi may be extirpated.

Status:
NatureServe ranks this stonefly as imperiled in Tennessee and not rated in Alabama.

Habitat destruction:
NatureServe (2008) states that this species' habitat in Tennessee is "greatly impacted by poor landscape management practices," which likely includes threats from logging, agriculture, and potentially coal mining.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

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Scientific Name:
Amphiuma pholeter
Common Name:
One-toed Amphiuma

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The One-toed Amphiuma occurs on the lower Gulf Coastal Plain of Florida, Alabama, Georgia, and southeastern Mississippi in a narrow area from Jackson County, Mississippi, to Levy and Hernando counties, Florida, in an area 80-120 km inland from the seashore (Means 1996, 2005, Floyd et al. 1998). In Georgia, there are two known locations in the Ochlockonee River drainage (Means 1996). There are also two known locations in Alabama, and approximately 40 known locations in Florida (Means 2005, NatureServe 2008).

Habitat:
AmphibiaWeb (2009) provides the following description of One-Toed Amphiuma habitat: "Means (1977) analyzed the habitat qualities of 13 localities of one-toed amphiumas and found that individuals are primarily found in deep, liquid, amorphous mucks derived from hardwood and cypress litter. The most important habitat variables associated with one-toed amphiumas are (1) streams of low–moderate gradient; (2) swampy and periodically inundated floodplains; (3) mixed bottomland hardwoods and cypress; (4) seepage; and (5) vulnerability to drought. Muck, as compared with peat, is usually liquid, and decomposition of the organic material in it has progressed so far that it is relatively amorphous, not having large pieces of wood and leaf litter. Amphiumas cannot locomote through fibrous peat and are rarely found in shallow muck deposits of < 15 cm (6 in) deep (personal observations), presumably because it increases their vulnerability to predators such as raccoons" (http://www.amphibiaweb.org).

Ecology:
Conant and Collins (1998) describe the One-Toed Amphiuma as "a secretive salamander of muck-bottomed stream floodplains and other mucky habitats where it feeds on insects and other invertebrates" (p. 426). Embyros and hatchlings of this species have not been detected, but it is possible that brooding females coil around eggs during development (Means 1996, AmphibiaWeb 2009). Amphiuma species are obligate neotenes and hatchlings likely have thin, feathery gills and a brief larval period before metamorphosing into air-breathing juveniles (AmphibiaWeb 2009). Amphiumas might undergo seasonal migrations. AmphibiaWeb (2009) states: "Means (2001a) noted that in winter, one-toed amphiumas were occasionally found under large logs buried along stream courses in first-order stream valleys where the species is not found in the spring, summer, or fall. Means (2001a) speculated that some individuals migrated upstream into seepage heads of first-order valleys to find protection from cold weather in warm seeps."

One-toed Amphiumas consume small invertebrates including the follwing organsims reported from stomach content analyses (Means 2001a in AmphibiaWeb 2009): sphaeriid clams, physellid snails, aquatic earthworms (Sparganophilus spp.), asellid isopods, the larvae of mayflies, tipulid flies, chironomid midges, culicid mosquitoes, stoneflies, megalopterans, tabanid flies, adults and larvae of small aquatic beetles, planarians, and occasional terrestrial beetles and lepidopteran larvae that drop onto the surface of the muck. Amphiumas are potentially eaten by reptiles and other amphibians including common snapping turtles (Chelydra serpentina), mud turtles (Kinosternon subrubrum), mud snakes (Farancia abacura), red-bellied water snakes (Nerodia erythrogaster), brown water snakes (N. taxispilota), queen snakes (Regina septemvittata), ring-necked snakes (Diadophis punctatus), cottonmouths (Agkistrodon piscivorus), two-toed amphiumas, southern leopard frogs (Rana sphenocephala), and bronze frogs (R. clamitans; Means, 2001a) (in AmphibiaWeb 2009).

Populations:

NatureServe (2008) reports that there are from 21-80 populations of One-Toed Amphiuma. Because of the difficulty of sampling and the cryptic nature of this species, total population size is unknown. Means (2005) reports that at most sites, only one to two individuals are detected in several person hours of rigorous searching.

Population Trends:

Current information on One-Toed Amphiuma population trend is inadequate. The species is thought to be declining to stable in the short term and moderately declining to relatively stable in the long term (NatureServe 2008).

Status:

The One-Toed Amphiuma is critically imperiled (S1) in Alabama, Georgia, and Mississippi, and vulnerable (S3) in Florida (NatureServe 2008). It is classified as Near Threatened by the IUCN. It is a Tier 1 species of greatest conservation need in Mississippi. It is a Priority 2 species of greatest conservation need in Alabama. It is a designated Rare species in Georgia.

Habitat destruction:

NatureServe (2008) reports that the habitat of the One-toed Amphiuma is subject to several potential threats including stream pollution, ground water disturbance, logging, mining, power plant sludge, and runoff, and emphasizes that this amphibian is very habitat-dependent and the maintenance of nonpolluted muck is essential for its conservation. Enge (2005) cites logging, groundwater use, siltation from dirt roads and cleared lands, impoundment, and poor management of adjacent upland habitat as threats to amphibian species in ravine habitats in the Florida Panhandle, including A. pholeter. The State of Georgia reports that the one-toed amphiuma is threatened by agricultural activity and associated herbicides, pesticides, and fertilizers, by habitat loss due to alteration of stream hydrology for both drainage and impoundment, and by siltation from various types of development (http://georgiawildlife.dnr.state.ga.us/assets/documents/gnhp/amphiuma_pholeter.pdf). The State of Mississippi reports that the amphiuma's habitat is highly threatened by altered fire regime, withdrawal of surface and groundwaters, logging, and development (http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%208.pdf).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Vast acreages of wetlands have been destroyed or altered in the Southeast (Dodd 1997). Aquatic amphibian habitats in the Mobile River Basin have been severely degraded by impoundment, channelization, dredging, mining for coal, sand, and gravel, discharge from industrial and municipal sources, and nonpoint discharge and run-off (LaClaire 1997, p. 329). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states:

“Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park” (p. 180).

Overutilization:

Because of its rarity, overcollection by herpetological enthusiasts is a potential threat to the One-toed Amphiuma. Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: “Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available” (p. 183).

Disease or predation:

The State of Georgia reports that the one-toed amphiuma is threatened by predation and indirect mortality from feral hogs (http://georgiawildlife.dnr.state.ga.us/assets/documents/gnhp/amphiuma_pholeter.pdf)

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, see http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009). In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002). Enge (2005) cites feral hogs as a threat to amphibians in the Florida Panhandle including the one-toed amphiuma.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect this species. It is a Tier 1 species of greatest conservation need in Mississippi, meaning it is classified as being in need of immediate conservation action and/or research because of extreme rarity, restricted distribution, unknown or decreasing population trends, specialized habitat needs and/or habitat vulnerability. It is a Priority 2 species of greatest conservation need in Alabama. It is a designated Rare species in Georgia. These state designations do not afford the Amphiuma any regulatory protection.

NatureServe (2008) reports that the Amphiuma occurs on several managed state and federal areas, and that the westernmost occurrence in Mississippi is on protected land. NatureServe (2008) provides the following management recommendations: "Entire drainage basins (including uplands) need to be preserved. Protect occurrences in at least 10 different drainages, preferably including at least one occurrence each in Georgia and Alabama. Establish state limits on collecting if exploitation is extensive."

Other factors:

Other factors which may threaten the amphiuma include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats. Enge (2005) cites water pollution, recreation, and trash dumping as threats to the one-toed amphiuma and other amphibians in the Florida Panhandle.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations” (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians. Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: "Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Anodonta heardi
Common Name:
Apalachicola Floater

G Rank:
G1

Range:
NatureServe (2008) reports the range of the Apalachicola Floater to be 250-1000 square km (about 100-400 square miles) in Alabama, Florida, and Georgia, but Williams et al. (2008) report that this species does not actually occur in Alabama, describing its range as the Coastal Plain reaches of the Apalachicola Basin in Florida and Georgia. This mussel is known from the Chattahoochee River near the junction with the Flint River, approximately 32 km downstream of the Alabama-Florida state line. The Brim Box and Williams (2000) report of this species from Alabama was a misidentification (Williams et al. 2008). This species may have occurred in Alabama historically (Williams et al. 2008).

Habitat:
The Apalachicola Floater inhabits floodplain lakes and rivers in mud where there is slow to no current (Deyrup and Franz 1994). One known site for this species is a backwater area with relatively deep water and a substrate made up of mud and packed-sand (Gordon and Hoeh 1993). Wisniewski (2008) describes this species' habitat as mud, sand, or detritus substrates in lakes, oxbows, sloughs, and backwaters.

Ecology:
Wisniewski (2008) states that the brooding period for this species is presumed to parallel that of the barrel floater (Anodonta couperiana), which exchanges gametes during late summer and broods until mid-November. The host fish for the Apalachicola floater is unknown.

Populations:
There are approximately four populations of Apalachicola Floater. There are three locations in Florida-- the Apalachicola River in Gadson County and in Calhoun County, and Tanvat Pond in Jackson County (Gordon and Hoeh 1993). This mussel also occurs in a tributary of the Flint River in Georgia (Brim Box and Williams 2000). Total population size for this mussel is low and is crudely estimated at 50 - 2500 individuals (NatureServe 2008). This mussel is known from very few individuals or shells at any one site.

Population Trends:
Available data indicate that this species, which was described in 1995, is declining (Brim Box and Williams 2000).

Status:
NatureServe (2008) ranks the Apalachicola Floater as critically imperiled in Alabama, Florida, and Georgia. This species is known from only a handful of occurrences in three adjoining river systems, with all occurrences represented by few individuals. It is "probably the most fragile of the Anodonta species in North America in terms of intrinsic vulnerability" and faces "imminent threats" (NatureServe 2008). It is listed as rare by the state of Georgia. This newly described species is being ranked as vulnerable by the American Fisheries Society (2010 draft, in review).

Habitat destruction:

The Georgia Museum of Natural History describes the Apalachicola Floater as being "very susceptible to changes within its habitat." Habitat degradation and loss have contributed to the decline of this species, including the construction of impoundments, dredging of the Apalachicola River to maintain a barge channel, and water withdrawals (NatureServe 2008). NatureServe (2008) states that this mussel appears to have experienced some decline in overall habitat quality due to imminent threats and may experience more as development impacts its native range.

Wisniewski (2008) lists the following threats to this species: "Habitat fragmentation may isolate populations and prevent fish movement, limiting the distribution of host fishes carrying glochidia. Additionally, construction of impoundments could further fragment populations and inundate suitable habitat. Excessive water withdrawals in the lower Flint River basin coupled with severe drought could cause this species to become extirpated from Georgia. Excess sedimentation due to inadequate riparian buffer zones and incompatible agricultural practices may also cover suitable habitat and could potentially suffocate individuals."

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Apalachicola Floater, and no occurrences are appropriately protected and managed (NatureServe 2008). It is listed as rare by the state of Georgia, but this designation does not provide any regulatory protection. It has no state status in Alabama or Florida.

NatureServe (2008) provides the following management recommendations for this mussel: "End channel dredging of Apalachicola River. Monitor and attempt to control Asian clam. Protect Apalachicola and Chipola rivers from pollution, siltation, impoundment, and other disturbance; this must include headwaters in Alabama and Georgia. Limit withdrawal of surface and subterranean waters as necessary to maintain normal stream flows, especially during drought. Protect floodplain forests and at least 150 ft. (ca. 50 m) of adjoining upland from timber harvest, livestock, and development. Situate roads at least 0.25 mi. (0.4 km) from heads of all tributaries, and even more on steep slopes. Use silt fencing and vegetation to control runoff and siltation at all stream crossings, especially during construction and maintenance. Prohibit dredging and damming of streams and river. Avoid introduction of non-native invertebrates, especially zebra mussel (Dreissena polymorpha). Use and maintain sewer systems rather than septic tanks and stream-dumping for management of waste water. Ban use of agricultural pesticides on porous soils near streams. Identify and maintain fish populations that serve as mussel larval hosts."

Other factors:

Other factors which threaten the Apalachicola Floater include pollution, invasive species, and small population size. Pollution is believed to have contributed to the decline of this mussel, particularly agricultural runoff (NatureServe 2008). The spread of exotic species, including the Asiatic Clam (Corbicula fluminea) and Zebra Mussel (Dreissena polymorpha), threaten the Apalachicola Floater. In addition, because this species exists in very low numbers at only five or so sites, it is inherently vulnerable to extinction due to stochastic genetic or environmental events.

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Scientific Name:
Anodontoides radiatus
Common Name:
Rayed Creekshell

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The Rayed Creekshell occurs in Alabama, Florida, Georgia, Louisiana, and Mississippi. This mussel occurs from the Tickfaw River system in Louisiana (Vidrine 1985) to the Apalachicola, Chattahoochee and Flint (ACF) rivers. It is apparently absent from the Yellow, Choctawhatchee, and Chipola rivers (Deyrup and Franz 1994), but was recently detected in the Pea River. It occurs in the Tombigbee-Alabama River system in Alabama and Mississippi, and the Conecuh-Escambia system in Alabama (Heard 1975), although there are no known records of its occurrence from the latter drainage in Florida. Johnson (1967) reported it as absent from the intervening Choctawhatchee River system and the Chipola River of the Apalachicola River system. Blalock-Herod et al. (2005) confirmed the distribution gap in the Choctawhatchee River drainage based on historical literature, but found 12 new sites (11 in Alabama, 1 in Florida) there during recent survey efforts, mostly in small tributaries (NatureServe 2008).

Habitat:
Although the rayed creekshell is known from large rivers, most collections are from small to medium-sized creeks where it occurs in mud, sand, or gravel substrates in slow to medium currents (Clench and Turner 1956, Jenkinson 1973, Heard 1979, NatureServe 2008). Mirarchi et al. (2004) provide the following description of this species' habitat: "most commonly in small to medium sized coastal plain streams, but historical records exist from larger rivers as well (Brim Box and Williams 2000). Typically occurs in sand or silt substrata in areas of low to moderate current (Brim Box and Williams 2000, Haag et al. 2002, Blalock-Herod et al. 2005)."

Ecology:
Mirarchi et al. (2004) state that the ecology of this species is poorly known, but that gravid females have been detected in September and December (Brim Box and Williams 2000), suggesting that it is a long-term brooder. Glochidial hosts are unknown, but because closely related species are generalists, it may be able to use a variety of host fishes.

Populations:
The Rayed Creekshell is sporadically distributed in five southeastern states-- Alabama, Florida, Georgia, Louisiana, and Mississippi (NatureServe 2008). This mussel was historically known from 21 occurrences in the ACF Basin, but in a recent survey it was detected at only four of 324 surveyed sites (Brim Box and Williams 2000). Johnson (1967) cites historical cites in the Alabama-Coosa River System including the Tombigbee River drainage in Mississippi and Alabama, the Coosa River drainage in Alabama, and the Alabama River drainage in Alabama. In the Escambia River System, Johnson (1967) cites the Conecuh River drainage in Alabama, the Chattahoochee and Flint River drainages in Georgia, and the Apalachicola River drainage in Florida. In the Escambia River drainage this mussel was collected historically at 10 occurrences from tributaries and the main stem of the Conecuh River. Recently in a survey of the Escambia and Yellow rivers, it was detected at six sites, but was absent at all of the resurveyed historical locations, and appears to now be restricted to small, isolated tributaries in Alabama (Williams et al. 2000). In the Pea River system (Choctawhatchee River system), this mussels was recently detected at only one of approximately 50 surveyed sites (Blalock et al. 1998). Blalock-

Herod et al. (2005) confirm the distribution gap in the Choctawhatchee River drainage based on historical literature, and report a new site in Florida and 11 new sites in Alabama, mostly in small tributaries. Pilarczyk et al. (2006) surveyed 24 sites in the Choctawhatchee River drainage but did not detect this species. In the Coosa River basin in Georgia, this mussel was historically known from the Etowah and Oostanaula River drainages, but there have been no recent live detections there (Williams and Hughes 2001). Vidrine (1993) reported Louisiana distribution as western Louisiana, the Taucipano River in eastern Louisiana, and other scattered locations. Brown and Banks (2001) report this species from eastern Louisiana in the Amite and Tangipahoa Rivers.

Little is known about the rayed creekshell's historical abundance, but it was likely rare. NatureServe (2008) states: "Museum records suggest that historically it was seldom collected in large numbers, and today it is unusual to find more than a few individuals at a site. Clench and Turner (1956) noted that Anodontoides radiatus was "exceedingly rare" in the ACF Basin. Heard (1975) listed A. radiatus among species he considered to have a reduced range or abundance (i.e., are now very rare or extinct in part of their present or past range, respectively). One of the largest collections of A. radiatus was made by H. H. Smith on 25 June 1915 in Uchee Creek (Russell County, Alabama). The collection totaled 24 individuals (Brim Box and Williams, 2000). In a recent survey of the Escambia River drainage 15 live individuals were collected from six sites in upper tributaries (Williams et al., 2000), while a single live individual was found in the Pea River watershed (Blalock et al., 1998)."

Population Trends:

The Rayed Creekshell is declining in the short term (decline of 10-30 percent) and moderately declining to relatively stable in the long term (NatureServe 2008). This species appears to have been rare and sporadically distributed historically, and is currently experiencing a reduction in both distribution and abundance. NatureServe states: "Clench and Turner (1956) noted that it was "exceedingly rare" in the ACF Basin. Heard (1975) listed this species among species he considered to have a reduced range or abundance (i.e., are now very rare or extinct in part of their present or past range, respectively). Williams et al. (1993) considered the rayed creekshell to be of special concern throughout its range, indicating that it should be carefully monitored. It may be nearly extirpated in Florida (formerly in Mosquito Creek, Apalachicola River basin, see Clench and Turner, 1956). Based on the results of a recent survey, it was assigned a conservation status of endangered in the ACF Basin (Brim Box and Williams, 2000). Williams et al. (2000) considered the rayed creekshell to be threatened in the Escambia River drainage. Pilarczyk et al. (2006) did not find any specimens in a survey of 24 sites of the Choctawhatchee, Yellow, and Conecuh-Escambia River drainages of Alabama in 2004."

Status:

NatureServe (2008) ranks the Rayed Creekshell as critically imperiled in Alabama, imperiled in Georgia, Louisiana, and Mississippi, and state historical in Florida. The IUCN ranks it as Near Threatened. Though this species has a wide range, there have been recent reductions in both number of sites and abundance per site. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

The Rayed Creekshell is threatened by stream modification, sedimentation resulting from bank destabilization, runoff from agricultural areas, and pollutants from point and non-point sources (NatureServe 2008). Any land-use activity that degrades water quality threatens this species' habitat. Blalock-Herod et al. (2000) report that this mussel is threatened by proposed impoundments in the

Choctawhatchee River drainage. Wisniewski (2008) provides the following account of threats to this species: "Habitat fragmentation may isolate populations and prevent fish movement, limiting the distribution of host fishes carrying glochidia. Additionally, construction of impoundments could further fragment populations and inundate suitable habitat. Excessive water withdrawals in the Lower Flint River Basin coupled with severe drought could cause this species to become extirpated from Georgia. Excess sedimentation due to inadequate riparian buffer zones and incompatible agricultural practices may also cover suitable habitat and could potentially suffocate individuals. Rapid development of the northern extent of the Flint River Basin could severely impact the remaining populations of this species." The Mississippi Dept. of Wildlife, Fisheries, and Parks (2010) reports that mussels in the Tombigbee Drainage are highly threatened by channel modification, agriculture, forestry, resource extraction, industrial development, dams, and headcutting. Gillies et al. (2003) report that urbanization threatens this species in the Atlanta area.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect this species, and no occurrences are appropriately protected and managed (NatureServe 2008). It is listed as Threatened in the state of Georgia and is a Species of Greatest Conservation Need in Alabama and Mississippi, but these designations do not provide the mussel or its habitat with substantial regulatory protection. It has no state status in Florida or Louisiana.

Other factors:

The Rayed Creekshell is threatened by any factor which degrades water quality. Wisniewski (2008) lists drought as a threat to this species.

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Scientific Name:
Antrorbis breweri
Common Name:
Manitou Cavesnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Manitou Cavesnail consists of less than 100 square km in Alabama (NatureServe 2008). This species is known only from its type locality, a cave in Fort Payne, DeKalb County, Alabama (Hershler and Thompson 1990, Mirarchi 2004).

Habitat:
This snail lives in the uppermost portion of a small (less than 1 m) cool stream that emerges amongst limestone rubble. The stream cascades through several narrow openings into a shallow (1-2 cm) pool in a small, rectangular, cement-lined structure (Hershler and Thompson 1990).

Populations:
There is only one population of Manitou Cavesnail, and total population size is crudely estimated at 50-2500 individuals (NatureServe 2008). Hershler and Thompson (1990) report that snails were extremely scarce at the time of collection.

Population Trends:
This species was recently identified, and no population trend data are available.

Status:
NatureServe (2008) ranks the Manitou Cavesnail as critically imperiled, and the IUCN ranks this species as vulnerable.

Habitat destruction:
Because the Manitou Cavesnail occurs at only a single location, it is extremely vulnerable to habitat degradation. Hershler and Thompson (1990) report that the cave where this species occurs was somewhat disturbed at the time of species' collection. The cave was formerly a commercial cave, but has been gated since 1980. Because a single habitat disturbing event could eradicate this species, even though the cave is now gated, this species' habitat is still vulnerable to illegal entry or potential future re-opening of the cave. Cave environments are very sensitive to perturbations, and can be degraded by activities that occur outside of the cave environment (Scott 2004). Scott (2004) states: "Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers . . . Degradation of surface habitats may also threaten cave fauna" (p. 77).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Manitou Cavesnail. The single cave where this species occurs is currently gated. This species needs Endangered Species Act protection to ensure that its habitat is protected in perpetuity.

Other factors:

The Manitou Cavesnail is threatened by any factor which degrades the water quality or alters the environmental conditions to which it is adapted. Activities inside or outside the cave environment that alter the quality, temperature, or availability of water threaten this snail, including pollution, groundwater development, drought, or global climate change. The water that supplies the cave was once part of the municipal water supply for Fort Payne. As freshwater resources become more scarce, future diversion of this water supply could jeopardize the existence of this snail.

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Scientific Name:
Aphaostracon asthenes
Common Name:
Blue Spring Hydrobe Snail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Blue Spring Hydrobe Snail consists of less than 100 square km in Volusia County, Florida (NatureServe 2008). This snail occurs only at its type locality, Blue Spring, in Blue Springs State Park, west of Orange City (Burgess and Franz 1978, Franz 1982, Johnson 1973, Thompson 1968, 1999).

Habitat:
This snail occurs in the upper portion of a spring run where plants and bottom debris are sparse (Thompson 1968, Franz 1982).

Populations:
There is only one population of this species, and population abundance is unknown (NatureServe 2008).

Population Trends:
Bleasdale et al. (2009) and Jnbaptiste et al. (2009) report that this snail is declining and is now present in lower densities than in 1992-1993.

Status:
The Blue Spring Hydrobe is critically imperiled (G1S1) (NatureServe 2008). It is categorized as Vulnerable by the IUCN. It is a C2 federal listing candidate (F.R. 84-05-22) in need of full ESA protection.

Habitat destruction:
NatureServe (2008) reports that deteriorating water quality due to erosion and runoff potentially threaten the single occurrence of this species. The Florida Wildlife Conservation Commission (2009) reports that spring habitats in the state are very highly threatened by nutrient loading from agricultural and urban runoff, and by invasive plants and animals. Bleasdale et al. (2009) report that "there is evidence suggesting chemical changes to the waters of Blue Spring and the St. John's River from direct spilling or dumping, runoff and flow rate changes from land use in the recharge basin, and/or seepage of chemicals into the groundwater source for Blue Spring." They also report that this species' habitat is threatened by the introduction of exotic species such as the Vermiculated Sailfin Catfish (Pterygoplichthys disjunctivus), which uses the long algal filaments that are a habitat component for the snail as a food source. Jnbaptiste et al. (2009) also report recent declines in water quality and outflow at the spring.

This snail is threatened by recreation, as there is a developed swimming area in part of the spring (Moss et al. 2009). The park management plan states that the spring has suffered from erosion due to people climbing on the spring banks (Florida Division of Recreation and Parks 1999). The Hydrobe is also threatened by logging, as the park management plan allows for timbering operations within park boundaries (Florida Division of Recreation and Parks 1999). Invasive tilapia (Tilapia aurea) are causing habitat degradation at Blue Spring. Tilapia make deep spawning beds in the sand bottom which can undermine bank stability (Florida Division of Recreation and Parks 1999).

Inadequacy of existing regulatory mechanisms:

This snail occurs in a state park, but the primary purpose of the park is outdoor recreation (Florida Division of Recreation and Parks 1999). It has no state status.

Other factors:

The lone population of this snail is threatened by any factor which causes water quality deterioration. Melhop and Vaughn (1994) report that due to relative immobility and dependence on highly oxygenated waters, endemic springsnails such as the Blue Spring Hydrobe are threatened by groundwater depletion, surface water diversion, and changes in water quality. Because this species occurs at only one site, spring alteration could result in species extirpation. Bleasdale et al. (2009) and Jnbaptiste et al. (2009) report deteriorating water quality at the spring. This snail is inherently vulnerable to extinction because of its occurrence in a single population, which could be extirpated by stochastic genetic or environmental events. This snail is also threatened by invasive species which prey on filamentous algae such as sailfin catfish (Bleasdale et al. 2009) and tilapia (Florida Division of Recreation and Parks 1999).

References:

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Scientific Name:
Aphaostracon chalarogyrus
Common Name:
Freemouth Hydrobe Snail

G Rank:
G1

Range:
The total range of this snail is less than 100 square km as it occupies a single spring in Alachua County, Florida (Burgess and Franz 1978, Johnson 1973, Thompson 1999).

Habitat:
This snail occurs on floating mats of filamentous algae in a spring pool that is approximately 10 ft deep. The spring is a water source for a swimming pool and has been impounded by a large circular concrete wall. The pool has a fine calcareous silty sand bottom and supports thick patches and mats of filamentous algae. There is a rectangular cement outflow pool adjacent to the spring that is 6 ft wide, 10 ft long, and a few inches deep with a "bottom of fine calcareous ooze overlying the cement and large mats of Spirogyra floating on the surface." Remaining water drains into a flatwood swamp bordered by a small creek with sand substrate. Thompson (1968) reported that the snail was abundant in the drainage pool by the spring, less common in the spring pool, but generally distributed over the cement wall, bottom silt, and vegetation. Snails were not detected in the spring run, flatwood swamp, or creek (NatureServe 2008).

Populations:
There is only one population of this snail and population size is unknown.

Population Trends:
Population trend is unknown for this species.

Status:
This snail is critically imperiled in Florida (G1S1) (NatureServe 2008).

Habitat destruction:
Because this snail occurs at only a single spring, disturbance to the spring could cause extinction of this species (NatureServe 2008). Magnesia Springs has been modified and flows into a swimming pool at a private recreation area. Alachua County (2006) reports that the spring is in fair condition and that the site is "endangered by residential development."

Inadequacy of existing regulatory mechanisms:
The lone population of this snail is in a private recreation area and is not appropriately protected and managed (NatureServe 2008). There are no existing regulatory mechanisms to ensure its survival.

References:

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Scientific Name:
Aphaostracon monas
Common Name:
Wekiwa Hydrobe Snail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Wekiwa Hydrobe Snail is less than 100 square km in the St. John's River System in Orange County, Florida, where it is restricted to Wekiwa Springs and spring run (Franz 1982, Johnson 1973, Thompson 1968, 1999).

Habitat:
This snail occurs on submerged gravel, rocks, and plants in and adjacent to springs and spring runs with high mineral content and steady annual temperatures (Thompson 1968).

Populations:
There is one population of this snail and population size is unknown (NatureServe 2008).

Population Trends:
Trend information is not available for this species (NatureServe 2008).

Status:
NatureServe (2008) ranks this snail as critically imperiled (G1S1). It is categorized as vulnerable by the IUCN.

Habitat destruction:
The Wekiwa Hydrobe Snail is exceptionally vulnerable to habitat loss and degradation because the lone population of this species occurs in a heavily used state park recreation area. Recreational impacts could cause water pollution, increased siltation, decreased aquatic vegetation, and direct crushing and displacement of snails (NatureServe 2008, Reiter 1992). Decreasing water quality or quantity threaten this species, as do external sources of pollution and groundwater decline resulting from increasing urbanization (Walsh 2001).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechansims to protect this species.

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Scientific Name:
Aphaostracon pycnus
Common Name:
Dense Hydrobe Snail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
This snail is restricted to Alexander Springs Run in the Ocala National Forest in Lake County, Florida, St. Johns River system. It has a total global range of less than 100 square km (Burgess and Franz 1978, Franz 1982, Johnson 1973, Thompson 1968, 1999).

Habitat:
This snail occurs on aquatic vegetation such as water lettuce and hyacinths in shallow, quiet, clear pools with soft bottom substrate along a spring run (Thompson 1968).

Populations:
There is only one occurrence of this species and total population size is unknown.

Population Trends:
Population trend information is not available for this snail.

Status:
NatureServe (2008) ranks the Dense Hydrobe as critically imperiled (G1S1). It is categorized as Vulnerable by the IUCN. It is a Forest Service Southern Region Sensitive Species.

Habitat destruction:
Because there is only one known population of this snail, it is highly vulnerable to habitat loss and degradation. This snail occurs in a spring that is crossed by state Highway 445, making road runoff and degraded water quality a threat to its survival (Thompson 1968). Because this snail's entire habitat is in a National Forest, it is threatened by sedimentation from logging and recreational impacts (NatureServe 2008). Melhop and Vaughn (1994) report that due to relative immobility and dependence on highly oxygenated waters, endemic springsnails such as the Dense Hydrobe are threatened by groundwater depletion, surface water diversion, and changes in water quality. Because this species occurs at only one site, spring alteration could result in species extirpation. The Florida Wildlife Conservation Commission (2009) reports that spring habitats in the state are very highly threatened by nutrient loading from agricultural and urban runoff, and by invasive plants and animals.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this species. NatureServe (2008) reports that is unknown whether the lone population of this snail is appropriately protected and managed. This snail occurs on the Ocala National Forest where it is a Forest Service sensitive species, but protection extended to sensitive species is discretionary. This snail has no state status in Florida.

Other factors:
Any factor which results in water quality degradation at the lone spring where this species occurs is a threat to its survival.

References:

Burgess, G.H. and R. Franz. 1978. Zoogeography of the aquatic fauna of the St. Johns River system with comments on adjacent peninsular faunas. The American Midland Naturalist, 100(1): 160-170.

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Thompson, F.G. 1999. An identification manual for the freshwater snails of Florida. Walkerana 10(23): 1-96.

Scientific Name:
Aphaostracon theiocrenetum
Common Name:
Clifton Spring Hydrobe Snail

G Rank:
G1

Range:
The total range of the Clifton Spring Hydrobe is less than 100 square km in Seminole County, Florida (NatureServe 2008). This species is known only from Clifton Springs Run, which flows into Lake Jessup in the St. Johns River system (Burgess and Franz 1978, Thompson 1968, 1999).

Habitat:
This snail occurs in mats of Chara and other vegetation in flowing, shallow water over a clean, hard, sand substrate. The spring run where it occurs is 10-25 feet wide, 200 yards long, and ranges from a few inches to about 2 feet in depth. The spring is bound on both sides by high sand banks and has high hydrogen sulfide content (Thompson 1968).

Populations:
There is only one population of this snail. Within this population, snails are abundant (Thompson 1968).

Population Trends:
Population trend is unknown for this species.

Status:
NatureServe (2008) ranks the hydrobe as critically imperiled in Florida (G1S1). It is a Florida Species of Greatest Conservation Need.

Habitat destruction:
The lone population of this snail occurs in a private recreational facility, making it highly vulnerable to habitat loss and degradation. NatureServe (2008) reports that there are boat docks in the facility, and that this snail is potentially threatened by hydrocarbon pollution from boats. NatureServe (2008) also reports that this species is potentially threatened by a rumored dredging application. The Florida Natural Areas Inventory (2009) reports that there are 42 total habitat acres for this snail, only 3 acres of which are protected. The Florida Wildlife Conservation Commission (2009) reports that spring habitats in the state are very highly threatened by nutrient loading from agricultural and urban runoff, and by invasive plants and animals. The land use in the watershed planning unit where this snail occurs is 45 percent urbanized, and there are many sources of point and non-point source pollution (Florida Dept. of Environmental Protection 2003). Because hydrobes are sensitive to water quality, pollution of its habitat is a threat to this species' survival. Lake Jessup is polluted by excessive phosphorus, nitrogen, and organic “muck” deposits, and has become a hypereutrophic lake that is deficient of submerged aquatic vegetation and has declining fish numbers. The watershed planning unit where this snail occurs has 21 permitted point source dischargers, including 11 domestic wastewater facilities, 7 industrial wastewater facilities, 2 concrete batch plants, and a groundwater treatment system at a petroleum contamination site. There is also a Class I solid waste landfill and two delineated groundwater areas that are contaminated by ethylene dibromide (EDB) (Florida Dept. of Environmental Protection 2003).

Walsh (2001) reports that Florida's spring organisms are threatened by habitat loss, spring modification, ground-water contamination, aquifer withdrawals, saltwater intrusion, and recreational activities, stating: "Springs are frequently modified for consumptive or recreational purposes, with concomitant impacts on aquatic organisms. Many of Florida's karst species are threatened by habitat modifications due to their very localized distributions . . . Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped . . . In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources. Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

Inadequacy of existing regulatory mechanisms:
There is only one population of this snail, and it is not appropriately protected and managed (NatureServe 2008). The spring where this snail occurs is in a private recreational facility. This snail is a Species of Greatest Conservation Need in Florida (http://www.masgc.org/gmrp/plans/FL%20FWCII.pdf) but this designation does not confer any regulatory protection.

Other factors:
This snail is threatened by water pollution.

References:

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Scientific Name:
Arnoglossum diversifolium
Common Name:
Variable-leaved Indian-plantain

G Rank:
G2

Range:
This plant is found in the Florida panhandle and adjacent portions of Georgia and Alabama. Records exist for Early, Baker, and Miller Counties, Georgia (Duncan et al. 1981, Jones and Coile 1988), Walton, Washington, Holmes, Jackson, Calhoun, Leon, disjunctly in Levy and Putnam Counties, Florida (Wunderlin and Hansen 2002), and Houston County, Alabama (ALNHP 1990).

Habitat:
The plantain inhabits floodplain forests over limestone formations, and is often found along the banks of woodland streams or in seasonally wet places in woody hammocks or calcareous swamps (Godfrey and Wooten 1981, Chafin 2007, Weakley 2008).

Ecology:
This plant is perennial.

Populations:
Roughly 30 occurrences of this species were reported as of 2007; locations and population sizes are not reported (NatureServe 2008).

Population Trends:
This plant is currently considered to be stable, but its habitat is widely threatened (NatureServe 2008).

Status:
NatureServe (2008) ranks the variable leaf Indian plantain as critically imperiled in Alabama, and imperiled in Florida and Georgia. It is state listed as threatened in both Florida and Georgia.

Habitat destruction:
Impoundments or other hydrological alterations destroy this plant's habitat, which is also degraded by urbanization, agriculture, and other human activities (NatureServe 2008). Recreation also threatens this species. Trampling destroys individuals, especially at popular fishing sites (Wunderlin 1980).

Inadequacy of existing regulatory mechanisms:
This species occurs in Marianna Caverns State Park (Florida) but is not adequately protected; no other populations are known to be appropriately protected or managed (Chagin 2007). Though it is listed as threatened in Florida and Georgia, this designation offers the variable leaf Indian plantain no substantive regulatory protections; no existing regulatory mechanisms adequately protect this species.

Other factors:
Invasive exotics, particularly Chinese privet (Ligustrem sinense) may outcompete and destroy colonies of A. diversifolium.

References:

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Wunderlin, R.P., et al. 1980. Endangered and Threatened Plant Status Surveys: Status Report on Arnoglossum diversi- folium. U.S. Fish and Wildlife Service.

Scientific Name:
Automeris louisiana
Common Name:
Louisiana Eyed Silkmoth

G Rank:
G2

Range:
Automeris louisiana is found on the coast of Louisiana and adjacent Mississippi (NatureServe 2008). It may occur in adjacent coastal Texas. Its coastal marsh habitat is continuous, and is estimated at 5600 sq. km.

Habitat:
The Louisiana Eyed silkmoth is coastal and is found in "Southern cordgrass prairie" also known as salt or brackish marsh.

Populations:
NatureServe (2008), crudely estimates that there are from 21-300 populations within the continous coastal marsh habitat of this moth. It is fairly common where found.

Population Trends:
NatureServe (2008) reports that this species is declining, perhaps severely, due primarily to recent hurricane activity (decline of 10 - greater than 70 percent). Data are needed after Hurricane Katrina which completely washed away significant habitat and affected most or all of the range severely. There can be no question the 2005 hurricanes killed huge numbers of all stages, probably most individuals, and permanently eliminated some habitat. It is not known how severe this damage was or how quickly the species might recover.

Status:
Automeris lousiana has a limited overall range, and coastal wetland loss in Louisiana is a constant and continuing threat (NatureServe 2008). The limited range and specialized habitat are sufficient to consider this moth globally uncommon, and in addition, virtually the entire known range was devastated by hurricances in 2005. Probably all habitat rangewide was under water during at least one of the major storms that year. On this basis even G1 cannot now be ruled out, assuming some stages survived the hurricanes in some places. This species is currently ranked as G1G3 (critically imperiled to vulnerable), and as SNR (under review) in all states of occurrence.

Habitat destruction:
Hurricanes are a primary threat to this species, and much of the habitat was lost to Hurricane Katrina (NatureServe 2008). Coastal wetlands in Louisiana are also declining due to submergence related to channelization of the Mississippi River and to fossil fuel extraction (Gosselink et al. in Mac et al. 1998). It is also threatened by habitat fragmentation (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. NatureServe (2008) reports that it is unknown if any occurrences are protected.

Other factors:
This moth is threatened by spraying for mosquito control (NatureServe 2008). It is also threatened by global climate change, as climate change is expected to increase the frequency and intensity of

hurricanes (globalchange.gov), a primary threat to this species habitat.

References:

Gosselink, J. G., J. M. Coleman, and R. E. Stewart, Jr. 1998. Coastal Loisiana. Pages 385-436 in: Mac, M., Opler, P., Puckett Haecker, C. and P. Doran. Status and Trends of our Nation's Biological Resources. 2 Volumes. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

Peigler, R.S. and Paul Opler. 1993. Moths of Western North America, 1. Distribution of Saturniidae of North America. Contributions of the C.P. Gillette Insect Biodiversity Museum Department of Entomology, Colorado State University.

Struttman, J. 1997. April 25, 2000-last update. Moths of North America. Saturniidae. U.S. Geological Survey, Biological Resources Division, Northern Prairie Wildlife Research Center, Jamestown, North Dakota. Online. Available: http://www.npwrc.usgs.gov/resource/distr/lepid/moths/usa/.

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Scientific Name:
Balduina atropurpurea
Common Name:
Purple Balduina

G Rank:
G2

Range:
Also known as the purpledisk honeycombhead, B. atropurpurea is endemic to the southeastern Coastal Plain. Known occurrences are geographically scattered and the species is thought to be extirpated from several historical locations, possibly from some entire states (Patrick et al. 1995). The range of this species is disjunct; populations are known in southern Georgia, northeastern Florida, and adjacent parts of Alabama, and separately in North and South Carolina, though these have not been recently confirmed (Weakley 2007). The species may now be found only in Georgia and Florida, but more extensive surveys are needed.

Habitat:
The purple balduina is found in wet pine flatwoods (longleaf, Pinus palustris, or slash pine, P. elliottii), wet savannahs, hilly seepage bogs, and pitcherplant bogs (Chafin 2000).

Ecology:
This perennial flower blooms in fall (Chafin 2000).

Populations:
Approximately 45 populations of this species are known in Georgia, seven in Florida, and reports are not available for other states in which this species may or may not occur (Chafin 2007, 2000). This plant might be extirpated in Alabama and the Carolinas. Total population size is unknown. Population size at Fort Stewart, Georgia, which is thought to be the largest site for B. atropurpurea, was estimated at between 10,000 and 44,000 in 1996 (Lincicome 1998).

Population Trends:
NatureServe (2008) determined that B. atropurpurea has experienced large declines in the long term, and that the species continues to decline rapidly.

Status:
Occurrences of this flower are widely separated and declining in number; the species is now known only from historical locations in the Carolinas and Alabama. Its habitat is naturally rare and has been widely destroyed by conversion to timber plantations or agriculture. NatureServe (2008) ranks B. atropurpurea as critically imperiled in Florida and South Carolina, imperiled in Georgia, and reports that it is likely extirpated from Alabama and North Carolina. It is state-listed as endangered in Florida and rare in Georgia.

Habitat destruction:
Habitat loss and degradation is the primary threat to this species. Wetland loss is widespread in this species range. Wet savannahs are regularly drained and converted to timber plantations or agricultural uses (NatureServe 2008). Fire suppression also threatens this species as it facilitates the incursion of woody vegetation, excluding B. atropurpurea (Patrick et al. 1995). Vehicle traffic related to military activities may also threaten some populations (Lincicome 1998).

Inadequacy of existing regulatory mechanisms:

Several populations in Georgia reportedly occur on preserved lands but it is not known what degree of protection this affords (Chafin 2007). Though it is listed as endangered in Florida, this designation confers no substantial regulatory protection to B. atropurpurea; no existing regulatory mechanisms adequately protect this species.

References:

Chafin, L. G. 2000. Field guide to the rare plants of Florida. Florida Natural Areas Inventory, Tallahassee.

Chafin, L.G. 2007. Field guide to the rare plants of Georgia. State Botanical Garden of Georgia, Athens, Georgia.

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Scientific Name:
Baptisia megacarpa
Common Name:
Apalachicola Wild Indigo

G Rank:
G2

Range:
This species is limited to a small range in Florida, Alabama, and Georgia; natural heritage records indicate that it is present in Alabama's Bibb, Bullock, Crenshaw, Henry, Lee, Macon, Montgomery, Pike, and Talledega Counties, in Florida's Gadsden, Holmes, and Liberty Counties, and in Georgia's Clay, Decatur, and Muscogee Counties (NatureServe 2008).

Habitat:
This plant is found in mixed hardwood and hardwood-pine forests, most often upslope from floodplains or streams or in ravines. It is usually associated with a canopy gap or other opening (NatureServe 2008).

Ecology:
The Apalachicola wild indigo is a perennial herb that may reach 4 ft. in height. It flowers in spring and fruits in early summer (April – June) (NatureServe 2008).

Populations:
Since 1982, only 20 occurrences of this species have been verified, and few contain more than 50 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this species is declining in both numbers and range, largely because habitat destruction has been accelerating in the past decade.

Status:
NatureServe (2008) ranks the Apalachicola wild indigo as critically imperiled in Georgia, and imperiled in Alabama and Florida. The species is listed as endangered by the state of Florida.

Habitat destruction:
Several factors threaten known occurrences of the Apalachicola wild indigo: land-use change and resultant habitat loss and fragmentation, unsustainable forest management practices, and anthropogenic alterations to regional hydrology (inundation of potential habitat and destruction of existing populations) are among the most widely cited causes of this species' decline (Southern Appalachian Species Viability Project 2002, NatureServe 2008).

Overutilization:
This plant may be threatened by collection in some locations (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Apalachicola wild indigo – though it is listed as endangered in Florida, this designation offers the species no substantial regulatory protections.

Other factors:
Invasive species such as Japanese honeysuckle, Lonicera japonica, outcompete native species and have a profound negative effect on the persistence of habitat specialists such as the Apalachicola wild indigo (NatureServe 2008).

References:

Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.

Kral, R. Baptisia megacarpa Chapm. ex Torr. Streamside wild indigo. Paper 229.

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Scientific Name:
Bartonia texana
Common Name:
Texas Screwstem

G Rank:
G2

Range:
This plant is known from a very small range in east Texas: natural heritage records exist for Hardin, Jasper, Nacagdoches, Newton, Polk, San Augustine, San Jacinto, and Tyler Counties, though not all occurrences have been recently confirmed (NatureServe 2008).

Habitat:
This plant occurs along the margins of woodland streams, bogs, and creek bottoms in swamp tupelo (Nyssa aquatica) forest or baygall (Ilex coriacea) thickets, and often establishes on clumps of sphagnum moss or other hospitable substrate (NatureServe 2008).

Ecology:
This annual plant flowers in September and October (NatureServe 2008).

Populations:
Approximately 15 occurrences of this species are known, all of which are small and widely scattered. It is estimated that there are fewer than 1,000 individual plants growing annually (NatureServe 2008).

Population Trends:
Trend information is not available for this rare species.

Status:
Texas screwstem is endemic to a small range within which few populations are known, all of which are very small, and its habitat is threatened by several anthropogenic factors. NatureServe (2008) ranks this species as imperiled.

Habitat destruction:
Habitat loss is the gravest threat to this species, and is primarily driven by timber harvesting, urbanization and suburban sprawl, agricultural development, and grazing (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Populations are found on Big Thicket National Preserve and Sandylands Preserve, but may not be appropriately protected. No existing regulatory mechanisms adequately protect this species or its habitat.

References:

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: February 1, 2010)

Scientific Name:
Blarina carolinensis shermani
Common Name:
Sherman's Short-tailed Shrew

G Rank:
T1

Range:
Sherman's short-tailed shrew has a very limited range in southern Florida from just north of Ft. Myers south to the vicinity of Royal Palm (Benedict et al. 2006). It has not been detected at the Ft. Myers type locality since 1955. It could occur at undiscovered sites in southwestern Florida or it could be extinct (NatureServe 2008).

Habitat:
The Florida Natural Areas Inventory (2001) provides the following description of this species' habitat: "Generally found where there are abundant grasses at the edges of basin and depression marshes and mesic flatwoods; may use other mesic communities or ruderal areas with at least a moderate cover of grasses or forbs." Layne (1978) reports that this shrew occurs in drainage ditches with dense grass cover and in mole runs.

Populations:
There are only one or two known occurrences of this subspecies (Benedict et al. 2006).

Population Trends:
No population information is available for this subspecies, which hasn't been detected since 1955.

Status:
Sherman's short-tailed shrew is critically imperiled (T1S1) (NatureServe 2008), and is a species of greatest conservation need in Florida.

Habitat destruction:
Churchfield (1990) states that development threatens the existence of this shrew. Habitat destruction may already have extirpated this subspecies (NatureServe 2008).

Disease or predation:
Layne (1992) states that predation by cats may have played a significant role in the reduction or possible extinction of this shrew.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this shrew.

References:

Benedict, R. A., H. H. Genoways, and J. R. Choate. 2006. Taxonomy of short-tailed shrews (genus Blarina) in Florida. Occasional Papers, Museum of Texas Tech University (251):1-19.

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Layne, J. N. 1992. Sherman's short-tailed shrew BLARINA CAROLINENSIS SHERMANI. Pages 328-334 in S. R. Humphrey, editor. Rare and endangered biota of Florida. Vol. I. Mammals. Univ. Press of Florida, Gainesville. xxviii + 392 pp.

Layne, J. N., editor. 1978. Rare and endangered biota of Florida. Vol. 1. Mammals. State of Florida Game and Freshwater Fish Commission. xx + 52 pp.

Scientific Name:
Boltonia montana
Common Name:
Doll's-daisy

G Rank:
G1

Range:
The doll’s daisy is native to wetland habitat in New Jersey, Pennsylvania, and Virginia (NatureServe 2008). It is known in Sussex and Warren Counties in New Jersey, Dauphin County in Pennsylvania, and Augusta County in Virginia (Digital Atlas of the Virginia Flora 2009). Because this species was recently determined (2008) to be distinct from Boltonia asteroides, historical records and population data are scarce.

Habitat:
The doll's daisy is found in sinkhole pond (vernal pool) habitats and along stream- and riverbanks (NatureServe 2009, Minutes of the Rare Plant Forum French Creek State Park 2007).

Populations:
There are 6 to 7 extant occurrences throughout this species' range, and total population size is unknown (NatureServe 2008).

Population Trends:
Population trends are unknown, but NatureServe (2008) reports that this species' habitat is constantly under threat.

Status:
NatureServe (2008) reports that the doll's daisy is possibly extirpated from Pennsylvania, critically imperiled in Virginia, and under review in New Jersey.

Habitat destruction:
The sinkhole habitat that Boltonia montana prefers is threatened by several factors, most notably habitat loss or degradation caused by agricultural and residential development (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the doll’s daisy.

References:

Digital Atlas of the Virginia Flora: Boltonia montana. Accessed online August 4, 2009 << http://www.biol.vt.edu/digital_atlas/index.php?do=plant&plant=690>>

Minutes of the Rare Plant Forum at French Creek State Park. 2007. Accessed online August 4, 2009 <www.paconserve.org/assets/07rpf.doc>

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NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: August 4, 2009).

Scientific Name:
Bouchardina robisoni
Common Name:
Bayou Bodcau Crayfish

G Rank:	**AFS Status:**
G1	Special Concern

Range:
This species is found in southwestern Arkansas, in Lafayette, Hempstead, Nevada and Columbia counties, in Bodcau and Dorcheat Bayou basins (Robinson and Allen, 1995). The total range for the Bayou Bodcau crayfish is less than 100-250 square km (less than about 40 to 100 square miles)(NatureServe 2008).

Habitat:
According to NatureServe (2008), this species inhabits shallow, detritus-rich, sluggish, sandy-bottomed backwaters and small intermittent streams, or overflow ditches with aquatic vegetation. It is apparently associated with aquatic vegetation, including Ludwiga sp., Utricularia sp. and grasses as the dominants plants. It has been collected from burrows that are over three meters deep (Robison and Allen, 1995). Hobbs (1977) reports that the species was found in a borrow ditch along roadside with sitting water no more than 0.5 m deep. The ditch bottom was made up of sandy clay covered by decaying leaves, and dominant adjacent trees were pines, oaks, and hawthorns.

Ecology:
Hobbs (1977) says that B. robisoni exhibits strong sexual dimorphism.

Populations:
This species has extremely limited numbers, with between 1 and 5 populatoins and less than 1000 individuals (NatureServe 2008). Four very experienced collectors secured only 40 individuals in 2.5 hours, indicating that this species is quite rare even in its prime habitat.

Population Trends:
The population trend for this species in unknown (NatureServe 2008).

Status:
This crayfish is listed as vulnerable by the American Fisheries Society (Taylor et al. 2007). It is ranked as critically imperiled by NatureServe (2008).

Habitat destruction:
NatureServe (2008) states that this extremely rare species exists only in a tenuous habitat. The Arkansas Wildlife Action Plan (2008) identifies habitat disturbance due to road construction, hydrological alteration due to forestry activities, and toxins and contaminants due to road construction as threats to this species' habitat.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

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Robison, H.W. and R.T. Allen. 1995. Only in Arkansas: A Study of the Endemic Plants and Animals of the State. University of Arkansas Press: Fayetteville, Arkansas.

Taylor, Christopher A., Schuster, Guenter A., Cooper, John E., DiStefano, Robert J., Eversole, Arnold G., Hamr, Premek, Hobbs, Horton H., III., Robison, Henry W., Skelton, Christopher E., Thoma, Roger F.. 2007. A reassessment of the Conservation Status of Crayfishes of the United States and Canada after 10+ Years of increased awareness. Fisheries 32(8):372-389

Scientific Name:
Caecidotea cannula
Common Name:
A Cave Obligate Isopod
G Rank:
G2
Range:
NatureServe (2008) reports that C. cannula has a range less than about 40 square miles. It is known only from Alpena Cave No. 1, Glady Cave and Bowden Cave in Randolph Co. and Cave Hollow Cave, Mill Run Cave and Harper Cave in Tucker Co. in West Virginia. Additional caves containing the species may be found as more are surveyed.

Habitat:
C. cannula inhabits subterranean streams and pools under flat rocks (NatureServe 2008).

Populations:
This cave obligate isopod is known from only 6 caves in 2 West Virginia Counties. The number of individuals was estimated to be between 1,000 and 3,000 by the West Virginia Natural Heritage Program in January 1991 (NatureServe 2008).

Population Trends:
Trend information is not available, but populations are assumed stable (Culver pers. comm. 1992 cited in NatureServe 2008).

Status:
According to NatureServe (2008), Caecidotea cannula is endemic to 6 caves in West Virginia and is potentially vulnerable to changes in water flow and quality. Its status in West Virgnia is critically imperiled. The State of West Virginia classifies it as a species of greatest conservation need.

Habitat destruction:
The main threats to this species are any land use practices that negatively impact groundwater quality and/or quantity. Alterations of water flow and both point and nonpoint-source pollution can severely impact this community (Culver pers. comm. cited in NatureServe 2008). Caves also may be threatened by increased recreational use. Alpena Cave No. 1 is near a proposed route for a highway, which could increase pollution and threaten this species (NatureServe 2008). This species occurs on National Forest land, making it vulnerable to pollution impacts from logging, oil and gas drilling, and other approved projects on public lands.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which adequately protect this species. It is currently receiving temporary protection from recreation because Cave Hollow Cave and other caves in the Monongahela National Forest are subject to an emergency, one-year public closure to protect populations of endangered bats (USFS 2009). Cave Hollow Cave is in Monongahela National Forest and is protected by an eight-foot, chain-link fence at the entrance. C. cannula is a Regional Forester Sensitive Species for Region 9 of the U.S. Forest Service. Pollution is the primary threat to this species, and cave closure is not adequate to protect the water in the cave from impacts from logging, development, etc.

Gating may be necessary if human visits are destructive. Both the surface and subsurface need to be protected. It is crucial to protect the watershed. Food enters the cave from surface streams and

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Scientific Name:
Calamovilfa arcuata
Common Name:
Rivergrass

G Rank:
G2

Range:
This plant is known from Arkansas, Alabama, Oklahoma, and Tennessee; natural heritage records exist for Blount County, Alabama, Howard, Perry, and Scott Counties, Arkansas, Atoka, McCurtain, and Pushmataha Counties, Oklahoma, and Cumberland, Morgan, and Scott Counties, Tennessee, though it is now likely that the Alabama occurrence is extirpated (NatureServe 2008, CPC 2009).

Habitat:
This plant grows in full sun along open gravel or cobble bars maintained by periodic flood scouring where it roots in sandy substrate between rocks (Kral 1983, Keener 1999). Its habitat is dominated by herbaceous perennials but if scouring is infrequent, it may be encroached upon by woody shrubs such as hazel alder, Alnus serrulata, Henry's garnet, Itea virginica, and silky dogwood, Cornus amomum (NatureServe 2008).

Ecology:
This species is a perennial grass.

Populations:
There are approximately 44 known occurrences of this plant. Its distribution among states is not reported, nor is population size (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that C. arcuata is experiencing moderate decline; some populations appear to be stable, but others are threatened or have already been extirpated (Oklahoma Biological Survey 1999).

Status:
This species may be extirpated iin Alabama, and though there are numerous remaining occurrences, a majority are located along just a few river systems, and any major hydrological changes would have an enormous impact on this species. NatureServe (2008) ranks C. arcuata as critically imperiled in Arkansas, Alabama, Oklahoma, and Tennessee. It is state listed as endangered in Tennessee, and was formerly a federal candidate species.

Habitat destruction:
Changes in water level, flow regime, or other factors what would interfere with the flood-scour maintenance of C. arcuata's habitat are the greatest threats to this species' persistence. Sediment-generating activities may also be problematic, but are secondary to the importance of maintaining natural flood and flow regimes (NatureServe 2008)

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Cambarellus blacki
Common Name:
Cypress Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
Cambarellus blacki has a range of less than 100 square km (less than about 40 square miles). It is probably restricted to the northern two thirds of Escambia County, Florida, with possible shallow penetration into Alabama (NatureServe 2008).

Habitat:
This species is found in Cypress ponds among submergent and emergent vegetation (NatureServe 2008).

Populations:
This species is currently known from only one locality- a creek in Escambia Co. (Franz and Franz, 1990). The total count of this species is estimated at approximately 1000 - 2500 individuals. Attempts at finding other populations have thus far been unsuccessful, but suitable habitat is still relatively inaccessible.

Status:
The Cypress crayfish is known from only one locality and is ranked as critically imperiled by NatureServe (2008). It is rated as Endangered by AFS and IUCN due to extremely few populations and very limited range.

Habitat destruction:
According to NatureServe (2008) the Cypress crayfish is currently probably secure, but expansion of nearby oil production activities could severely threaten the species, which is known from a single location.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Cambarellus diminutus
Common Name:
Least Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
Cambarellus diminutus is apparently confined to Mobile County, Alabama, and George and Jackson counties, Mississippi (Hobbs 1989).

Habitat:
The Least crayfish is found among vegetation in small to moderate blackwater streams, usually in pine woods (NatureServe 2008). This species also invades ditches near sluggish streams. It is tolerant of warm water, but prefers shaded areas (Hobbs 1989). It seems to prefer very sluggish flow with submerged, at least in part, vegetation, and it will burrow during dry conditions.

Populations:
There are 11 known sites for this species, eight in Alabama and three in Mississippi. Abundance is high in appropriate habitat.

Population Trends:
NatureServe (2008) reports that this species has declined by up to 30 percent in the short-term, stating: "It has a small extent of occurrence (<8000 sq. km) and has a continuing decline in habitat extent and quality due to dockland usage, agricultural intensification and urbanization."

Status:
NatureServe (2008) ranks this species as vulnerable in Alabama and imperiled in Mississippi. The State of Mississippi lists it as a Tier 2 Species of Greatest Conservation Need. In Alabama it is a Priority 2/High Conservation Concern species. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
NatureServe (2008) reports that this species is threatened by a "continuing decline in habitat extent and quality due to dockland usage, agricultural intensification and urbanization. Even though this species can be considered a generalist, its preference for temporary habitats consisting of thick vegetation, leaves it sensitive to any habitat alterations. Further, with the continued pollution associated with docklands and agriculture, it is not known when this will start to severely impact populations. Due to the intensification of agriculture, the likelihood of oxbow side ponds remaining long enough to be utilized by this species is uncertain. . . Mobile county is the third most populated city in the southern USA, consisting of a large dockland areas which is intensively used. This will be creating a substantial water pollution in this area of Mobile county, whilst also polluting surrounding streams and ponds. Further, C. diminutus' use of oxbow side ponds is useful for protection against predation, but these are only temporary habitats and therefore there must be other similar habitats avaliable for this species to utilize once the oxbow side ponds have silted up (Peterson et al., 1996). However, this species is somewhat tolerant of differing water and habitat qualities to exist in these habitats (Hobbs, 1945). But, with the continued expansion of the Mobile docklands usage and intensive agriculture, it is unknown how long it will be able to use these habitats."

This species is also threatened by channelization. NatureServe (2008) reports that the Corps of

Engineers is trying to iniate a project to channelize the lower Escatawpa River.

Other factors:

This species is threatened by water pollution (NatureServe 2008). There is also evidence that another Cambarellus species may be expanding its range at the expense of this species (NatureServe 2008).

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Scientific Name:
Cambarellus lesliei
Common Name:
Angular Dwarf Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	VU - Vulnerable

Range:
NatureServe (2008) states that this species is found in southwest Alabama (Baldwin, Mobile, and Washington Cos.) and southeast Mississippi (George Co.) (Hobbs, 1989).

Habitat:
Cambarellus lesliei prefers slow to moderate current, as well as shady still water (NatureServe 2008). It will hide among submergent vegetation in streams and pools (Hobbs, 1989).

Populations:
Seventeen records of this species are known from Alabama near Mobile Bay (Alabama, Mobile, Tombigbee drainages) (Mirarchi et al., 2004; appendix 1-2 pub. separately; Schuster and Taylor, 2004; Schuster et al., 2008). It is also known from George Co., Mississippi (NatureServe 2008). It is believed that about two dozen total populations are extant.

Population Trends:
Trend is unknown.

Status:
This species us only known from four counties near Mobile Bay, AL, with about two dozen records. IUCN lists this species as Vulnerable. The American Fisheries Society considers this species to be Threatened. It is ranked as imperiled in Alabama and vulnerable in Mississippi by NatureServe (2008). In Alabama it is considered to be a species of high conservation concern.

Habitat destruction:
According to the World Wildlife Federation (2009), this species may be threatened by hydropower operations. The Mississippi Dept. of Wildlife, Fisheries, and Parks (2010a) reports that the ephemeral ponds which support this species are highly threatened by agricultural conversion, channel modification, impoundments, forestry, and invasive species. In the Pascagoula drainage, aquatic species are highly threatened by forestry and invasive species, and are moderately threatened by development, recreation, and feedlots (MDWFP 2010b).

Inadequacy of existing regulatory mechanisms:
No regulatory mechanisms protect this species, and no occurrences are protected.

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Scientific Name:
Cambarus bouchardi
Common Name:
Big South Fork Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
The Big South Fork crayfish is endemic and restricted to the Roaring Paunch Creek drainage within the Big South Fork of the Cumberland drainage in Tennessee and Kentucky (Taylor and Schuster, 2004). O'Bara (1988) reported it in Roaring Paunch Creek, Scotty County, TN. The total range is less than 100-250 square km (less than about 40 to 100 square miles). The species' range in Tennesee is restricted to two streams (Knoxville News-Sentinel, April 14, 2002).

Habitat:
Cambarus bouchardi is found in streams with rubble and moderate current (NatureServe 2008).

Populations:
NatureServe (2008) reports between 6 and 20 total occurrences of this species. There are probably several populations, with around 22 localities recorded. A few occurrences could possibly be lumped into populations (O'Bara, 1988). In Kentucky, Cambarus bouchardi is restricted to Roaring Paunch Creek proper in McCreary Co. (Taylor and Schuster, 2004). A recent Tennessee suvery by Williams et al. (2002), found the species in Perkins Creek proper (type locality), a headwater tributary to Perkins Creek, and Roaring Paunch Creek, as well as from 3 new stream localities-Isham Creek, Jones Branch, and Otter Creek.

Status:
The Big South Fork crayfish is critically imperiled in Kentucky and Tennessee (NatureServe 2008). The State of Tennessee lists this species as Endangered and a Species of Greatest Conservation Need. It was formerly listed as a Candidate 2 species by U.S. Fish and Wildlife Service. The American Fisheries Society lists this species as Endangered due to its restricted range. The U.S. Forest Service (2002) has designated Cambarus bouchardi as a Sensitive Species. It is ranked as vulnerable by the IUCN.

Habitat destruction:
Williams et. al (2002) report that habitat loss is a major concern. Siltation and polluted runoff from logging and mining and habitat destruction from residential development are all indicated as threats to this species.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species. It is state-listed in Tennessee, but this confers no habitat protection. It is being considered for inclusion in a proposed Cumberland Habitat Conservation Plan (Cumberland HCP 2006). This species is found on the Daniel Boone National Forest, where it is a Forest Service Sensitive Species (USFS 2005).

Other factors:
Williams et al (2002) report that competition from nonnative crayfish is a potential problem.

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Scientific Name:
Cambarus catagius
Common Name:
Greensboro Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	VU - Vulnerable

Range:
Cambarus catagius is known from the PeeDee and Cape Fear river drainages in Guilford, Randolph, Montgomery, and Davidson counties, North Carolina (NatureServe 2008).

Habitat:
Cambarus catagius is a primary burrower which spends most it its life cycle in gallery systems in the subsurface water table (NatureServe 2008). McGrath (1994) indicates that this species was discovered on East Whittington Street in Greensboro, NC in people's yards. It was first collected from sandy clay soils with water table 5-60 cm deep.

Populations:
The Greensboro burrowing crayfish is known from 16 localities (McGrath 1994). More localities are likely to be found. LeGrand et al. (2006) cite this species as occurring in the Greensboro area to Uwharries in Davidson, Guilford, Montgomery, and Randolph Cos., North Carolina. NatureServe (2008) estimates 6-20 populations with a total of 1000 - 2500 individuals.

Population Trends:
In the short term, NatureServe (2008) believes this species has a stable population.

Status:
NatureServe (2008) ranks this species as imperiled. The State of North Carolina considers C. catagius to be a Species of Special Concern. It was a Federal C-2 Candidtate Species until that list was abolished. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
Cambarus catagius occurs in in Abbotts Creek and Pounders Fork which flow into High Rock Reservoir. Both streams are part of the Yadkin-Pee Dee River Drainage that is impounded by dams of Alcoa Power Generating Inc. The on-going effects of these impoundments is unknown.

McGrath (1994) reports that this species' known range is restricted and impacted by urban development.

Inadequacy of existing regulatory mechanisms:
C. catagius occurs in the Uwharrie National Forest in North Carolina, but this does not confer regulatory protection to the species or its habitat. No existing mechanisms adequately protect this species.

Other factors:
The Greensboro burrowing crayfish is potentially threatened by an invasive species, Procambarus clarkii, which was observed in upper High Rock Reservoir near the mouth of South Potts Creek and north in the Yadkin River (Alcoa 2006).

According to the North Carolina Wildlife Resources Commission (2000): "Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species. In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species."

According to the South Carolina Department of Natural Resources (2006): "The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from a native catfish have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the coastal plain and eastern piedmont plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b) and the risk to our native species is great if further introductions or extensive spread on non-indigenous crayfish occurs."

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Scientific Name:
Cambarus chasmodactylus
Common Name:
New River Crayfish

G Rank:	**AFS Status:**
G4	Currently Stable

Range:
The New River crayfish is endemic to the New River drainage system, from the upper reaches of the Greenbrier River in Pocahontas and Monroe counties, West Virginia, south through Virginia to Alleghany, Ashe and Watauga counties, North Carolina.

Habitat:
Preferred habitat for C. chasmodaytylus is under and between rocks in unsilted, cool, swiftly moving streams with rocky riffle areas away from the shore, often in larger, turbulent streams.

Ecology:
In general crayfish occupy a small home range, as reported by NatureServe (2008). They are subject to predation by mammals, birds and herptiles. Helms and Creed (2005) found no influence of Cambarus chasmodactylus and coexisting Orconectes cristavarius (and associated differences in diet) on sediment accumulation and benthic invertebrate populations in a large river in North Carolina. Fortino and Creed (2006) found that in the headwaters of the South Fork of the New River (Watauga Co., North Carolina), “C. chasmodactylus, is the dominant crayfish species in third-order streams although C. bartonii is still present and occasionally co-dominant.”

Populations:
Jezerinac et al. (1995) recorded this species from 33 localities. Total population is thought to number at least 2500 individuals.

Population Trends:
NatureServe (2008) states that this species is declining in the short term (decline of 10-30 percent). Prior to the 1930's the species was apparently common in the New River, but now specimens can only be found in the Greenbriar River and other tributaries. There is developmental pressure on these tributaries and with increasing levels of siltation appear to be adding to the species decline.

Status:
Cambarus chasmodactylus is apparently vulnerable to degradation of habitat, and appears to be declining as watersheds are developed. The status of C. chasmodactylus in WV, VA, and NC is vulnerable (NatureServe 2010). It was also a Class 2 Federal Candidate species until that list was abolished.

Habitat destruction:
The New River crayfish is threatened by habitat loss and degradation from several sources. Because it requires lotic waters of considerable size, impoundments eliminate its required riffle habitat (Cooper and Cooper 1977). Its apparent preference for large streams could prevent its establishment in smaller headwaters if displaced from larger waters by impoundment. Appropriate habitat for this species is already limited in the Virginia and West Virginia portions of its range, and there are "other apparent encroachments on the few known populations in those states" (Cooper and Cooper 1977).

NatureServe (2010) states that the species is no longer common in the Green River, and concerning the tributaries where it still occurs, states: "there is developmental pressure on these tributaries and with increasing levels of siltation appear to be adding to the species decline."

Concerning the fragility of this species, NatureServe (2010) states: "New River riffle crayfish populations appear to be seriously impacted by siltation and structures that disrupt water flow. The populations are geographically isolated and vulnerable to localized destructive events which may cause local extinction with little chance of later natural recolonization."

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that no occurrences of this declining species are appropriately protected.

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Scientific Name:
Cambarus chaugaensis
Common Name:
Chauga Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
The Chauga crayfish is Endemic to tributaries of the Savannah River in a two county area: Oconee Co., South Carolina, and Rabun County, Georgia (Eversole and Foltz, 1993). LeGrand et al. (2006) also cite streams within the Savannah drainage in Jackson, Macon, and Transylvania Co., North Carolina.

Habitat:
The Georgia Museum of Natural History (2008) states that this species lives within fast-moving streams with rocky substrates.

Populations:
According to NatureServe, there are between 6 and 20 total populations of Cambarus chaugensis. It was recorded from one location in Rabun County, Georgia, and 18 localities in Oconee County, South Carolina. LeGrand et al. (2006) also cite streams in Savannah drainage in Jackson, Macon, and Transylvania Co., North Carolina. Eversole and Jones (2004) include tributaries of the Savannah River in Oconee Co., South Carolina, and Rabun Co., Georgia; but most abundant in South Carolina in the Chauga River drainage. The total population is between 1000 and 2500 individuals.

Status:
NatureServe (2008) ranks this species as critically imperiled in Georgia, and imperiled in North and South Carolina. North Carolina has classified this species as Special Concern.
The State of South Carolina list it as a Highest Conservation Priority species (SCDNR 2005).
AFS now considers this species as threatened (Taylor et al 2007). The U.S. Forest Service (2002) has designated Cambarus chaugensis as a Sensitive Species.

Habitat destruction:
This species is threatened by habitat degradation primarily from development. According to the North Carolina Wildlife Resources Commission (2001), concerning Cambarus chaugensis: "Until recently, the North Carolina portion of the Savannah River Basin has remained relatively undeveloped and pristine. Currently, the area seems to be developing at a higher rate than in the past, with tourist attractions such as the towns of Highlands, Cashiers, and Sapphire, the newly established Gorges State Park, and Lake Toxaway. Some timber cutting in the region may also affect habitat and stream quality."

The Georgia Museum of Natural History (2008) states that "Water quality degradation, pollution and habitat destruction pose serious threats to this and all species of crayfish in the Southeast."

According to SCDNR (2005): "Physical alteration of habitat also represents a challenge to the survival of crayfish. Some aquatic crayfishes are quite adaptable and can live in ponds, impoundments and roadside ditches, while others are more sensitive to habitat alteration. Some crayfishes are oxygen regulators and are able to increase ventilation rates in response to reduced oxygen conditions, while others, the oxygen conformers, are unable to do this (Hobbs 1991). Therefore, some species are better equipped to survive when the flow of water slows and oxygen levels decline. Some species… have been eliminated from parts of their range as a result of damming activities associated with reservoir construction. Channelization and dredging can also be very detrimental to aquatic crayfish that require rocks, crevices or tree roots along undercut banks as hiding places (Hobbs and Hall 1974). In general, crayfish are not as sensitive to siltation as some aquatic invertebrates such as mussels, but severe siltation has caused declines in or the extirpation of many populations of crayfish (Hobbs and Hall 1974).

Pollution has been known to eliminate crayfish from streams. Ortmann (1909) noted the extirpation of crayfish from some sections of streams and rivers due to mining and oil refineries.

Inadequacy of existing regulatory mechanisms:
According to USFS (2005) and NatureServe (2008), most of range of this species falls within the Chattahoochee National Forest in Georgia, the Sumter National Forest in South Carolina, and the Nantahala National Forest in North Carolina. It is a Forest Service Sensitive Species (USFS 2005), but this designation confers only discretionary protection and does not ensure habitat protection for this species. For example, the U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis (U.S. Forest Service 2008).

Other factors:
This species may be threatened by invasive crayfish species. According to the North Carolina Wildlife Resources Commission (2009): "Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species. In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species."

Similarly, SCDNR (2005) reports that: "The arrival of introduced species is probably the greatest challenge to crayfish (Lodge et al. 2000 a,b). The ranges and abundances of many native crayfish may have been reduced by invasive crayfish, both in the United States and in Europe (Lodge et al. 2000a; Hobbs et al. 1989).

Prevention of future introductions is most likely the only effective way to deal with the challenges caused by nonnative crayfish. No methods for eliminating invasive species without also harming native species are currently available. Even if effective biological control methods are developed, preventing introductions will still be much easier than eradicating an established species. Lodge et al. (2000b) proposed federal legislation that, if enacted and enforced, would drastically reduce the risk of future introductions. They include banning the use of live crayfishes as bait, and adopting a 'white list' approach for the sale of all crayfish in the aquarium, garden pond and educational trade."

Crayfish are harmed by a variety of insecticides, herbicides and industrial chemicals (Eversole et al. 1996). Juvenile crayfish are generally about four times as sensitive to water borne pollution than adults; early instars are about three times as sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were actually more abundant downstream of areas with large amounts of garbage or animal remains. Enrichment may be harmful to crayfish, however, when it results in oxygen depletion (Hobbs and Hall 1974). Pollution of groundwater may impact terrestrial burrowers, because they inhabit water trapped in their burrows."

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Scientific Name:
Cambarus coosawattae
Common Name:
Coosawattae Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	VU - Vulnerable

Range:
Skelton (2008) states that the species "is known only from the Coosawattee River system in Gilmer County, Georgia. Records are from streams and rivers upstream of Carter’s Lake and are within the Blue Ridge physiographic province."

Habitat:
Cambarus coosawattae is found in moderately flowing streams with rubble bottoms; it appears mostly in riffle areas, as described by NatureServe (2008). Skelton (2008) states that "[a]dults are typically found under rocks in relatively fast currents within streams. Juveniles may be found in leaves or woody debris in slower moving water."

Populations:
NatureServe (2008) estimates fewer than 5 occurrences of this species, stating: "Hobbs (1981) listed 11 localities and Schuster (2001) found it at the 18 sites (6 of them Hobbs' original sites) in Gilmer and Pickens Cos. all within a limited range and restricted to the Elljay and Cartecay Rivers and their tributaries although Hobbs (1981) also reported from the Coosawattee River proper but this site has not been resurveyed."

Population Trends:
Skelton (2008) reports that "populations at collection locations were apparently secure during a survey conducted in 2001."

Status:
NatureServe (2008) ranks this species as critically imperiled. It is listed as Endangered by the state of Georgia and by the American Fisheries Society. Its habitat is being rapidly developed.

Habitat destruction:
NatureServe (2008) reports that this species' range has been severely fragmented by reservoir construction (Carters Lake). The Coosawattee watershed has also experienced a large increase in residential development in recent years, and over 100,000 acres of forest have been allocated for residential building to be completed by 2030 (White 2009). The watershed also contains many confined animal feed operations scattered in the headwaters above Carter's Lake that can potentially impact habitat.

According to Skelton (2008) "[t]he small range of this species and the high development rates within that range are significant threats to the Coosawattee crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation. . . [c]onserving populations of the Coosawattee crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) states that several populations of Cambarus coosawattae occur in the Chattahoochee National Forest, but this does not protect the species from habitat degradation. It is listed as endangered in Georgia, but this designation provides no protection for the species' habitat which is being rapidly developed.

Other factors:

Skelton (2008) states that the introduction of non-native crayfishes is a threat to all native crayfishes.

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Scientific Name:
Cambarus cracens
Common Name:
Slenderclaw Crayfish

G Rank:	**AFS Status:**
G1	Endangered

Range:
NatureServe (2008) reports that the range of the Slenderclaw crayfish is 250-1000 square km (about 100-400 square miles). In Alabama, it is known questionably from the Black Warrior, Coosa and Tallapoosa River systems and described from the Tennessee River system (Hobbs, 1989; Mirarchi et al., 2004; in appendix 1-2 published separately). Schuster et al. (2008) cite only the Tennessee River system for Alabama.

Habitat:
C. cracens is found in clear, sluggish streams flowing over bedrock and sand (NatureServe 2008). The water is generally shallow (less than two feet). According to NatureServe (2008), this species was not collected outside rock-littered areas of streams. According to Bouchard and Hobbs (1976), C. cracens was first found in a "clear stream, some 35 to 40 feet wide and mostly less than one foot deep, flows rather sluggishly over a bed-rock and sandy bottom littered with large rocks. Shading the shore line are Platanus occidentalis, Liriodendron tulipifera, Quercus sp., and Pinus sp."

Populations:
This species was known from seven historical sites, but has been recently detected at only one of them (NatureServe 2010).

Population Trends:
NatureServe (2010) reports a very rapid short term decline of 50-70 percent for this species. It was only found recently at one historical sites of all historical known sites (7 total) (G. Schuster, C. Taylor, pers. comm., 2009 cited in NatureServe 2010). NatureServe (2010) states: "repeated survey efforts have only uncovered extant populations in one or two sites (decline greater than 80 percent and ongoing)."

Status:
The State of Alabama lists this species as a Priority 2 Species of Greatest Conservation Need. It is ranked by NatureServe (2008) as critically imperiled and by the American Fisheries Society as endangered.

Habitat destruction:
NatureServe (2010) reports that this species is highly, substantially, and imminently threatened, stating: "Historical and current stresses are the same: impoundment of the Tennessee River. Reasons for decline (based on current versus historic records) are not known but the species is absent from nearly all historical sites where it was formerly known (G. Schuster, C. Taylor, 2009)."

According to the World Wildlife Federation (2009), C. cracens is an Alabama Species of Greatest Conservation Need in the Tallapoosa drainage, and the species or its habitat may be impacted by hydropower operations.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms protect this declining and highly threatened species.

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Scientific Name:
Cambarus cryptodytes
Common Name:
Dougherty Plain Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
NatureServe (2008) reports that the Dougherty Plain cave crayfish occurs in the aquifer of the Dougherty Plain (Marianna Lowlands), from Decatur County, Georgia, to Jackson County, Florida, USA. All known sites can be enclosed by 50 km circle, and all lie within the Apalachicola River basin. Skelton (2008) states that "The species is currently known from Dougherty and Decatur counties in southwestern Georgia and Jackson and Washington counties, in the Panhandle of Florida. It almost certainly occurs in Mitchell and Baker counties, Georgia, as these counties lie between Dougherty and Decatur Counties, in southwest Georgia."

Habitat:
Cambarus cryptodytes lives in subterranean fresh waters, specifically low energy caves in carbonate rocks. It has been taken from wells, sinks, shallow caves, and spring caves (NatureServe 2008).

Ecology:
According to Purvis and Opsahl (2005), C. cryptodytes has a lower metabolic rate than surface crayfish, so is more able to survive in low oxygen habitats. They found that troglobytic crayfish can live as long as 16 years, much longer than surface crayfish. However, they reproduce infrequently and so the population of this species is not resilient.

Populations:
NatureServe (2008) states that there are between 6 and 20 populations with less than 1000 individuals in total. There are approximately 15-20 EOs, but these all are relatively close and may even be interconnected.

Status:
According to NatureServe (2008), Cambarus cryptodytes is narrowly endemic. While there are a moderate number of occurences, they all lie within a small, county-sized area. In Florida this species has a status of imperiled, and in Georgia it is critically imperiled (NatureServe 2008). The State of Georgia lists the Dougherty Plains cave crayfish as Threatened (Skelton 2008). Florida lists it as a Species of Greatest Conservation Need. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
NatureServe (2008) reports that there are multiple threats to water quality throughout this species' range, which is largely an agricultural region. The aquifer may be contaminated with EDB and other chemicals. Unregulated spelunking and sewage leaks pose additional potential threats. The habitat of Cambarus cryptodytes is unable to support large numbers of macrocrustacea.

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

Skelton (2008) states that "Small range size makes this species vulnerable to extirpation. Excessive water withdrawals from the Floridian Aquifer reduce the amount of habitat for the Dougherty Plain cave crayfish. Runoff of pesticides and nutrients from agricultural areas is also a threat."

According to Walsh (2001):

"Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation. These threats could be avoided by state acquisition of the springs, or through comprehensive land use planning.

Inadequacy of existing regulatory mechanisms:

According to NatureServe (2008) one site containing the Dougherty Plain cave crayfish is gated, at Florida Caverns State Park. Also,the Marianna Bat Cave (also known as Judges Cave) was purchased by state of Florida and The Nature Conservancy. This cave is now fenced.This crayfish is listed as threatened by the state of Georgia, but this designation does not provide habitat protection.

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Scientific Name:
Cambarus cymatilis
Common Name:
Conasauga Blue Burrower

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
According to NatureServe (2008) the range of Cambarus cymatilis is less than 100 square km (less than about 40 square miles). It is known only from Murray County, Georgia, and a seepage area along Mill Creek in Bradley County, Tennessee (Hobbs, 1981). These locations are within 15 miles of each other. Skelton (2008) reports that this species is found in "the Conasauga and Hiwassee river systems in the Ridge and Valley physiographic province in northwestern Georgia and southeastern Tennessee. In Georgia, it is has been collected from only about 5 locations, most around Chatsworth in Murray County."

Habitat:
The Conasauga Blue burrower is found in elaborate burrows in open grassy areas with a high water table, commonly burrowing around houses and flower gardens (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are 1-5 populations with between 1000 - 2000 total individuals. The first collection of this species produced 6 specimens in 1 hour; apparently it is not rare where it occurs.

Status:
The Conasauga Blue burrower has a status of critically imperiled in both Georgia and Tennessee (NatureServe 2008). Small populations are known from only two nearby places (NatureServe 2008). Tennessee and Georgia both classify this species as Endangered. The AFS status of Endangered is based on the species' extremely limited range. The U.S. Forest Service (2002) has designated Cambarus cymatilis as a Sensitive Species. It is ranked as vulnerable by the IUCN.

Habitat destruction:
Current threats to Cambarus cymatilis include loss of habitat due to development for home sites, according to NatureServe (2008). Skelton (2008) reports that for this species, the "small range size makes this species vulnerable to extirpation. About one-half of the known populations of this species occur within the Chatsworth city limits. One location is in a neighborhood, and the other was along a street that has now been paved over." Cambarus cymatilis occurs in the project area for a new powerline in Gordon and Whitfield Counties, Georgia, proposed by the Tennessee Valley Authority. Construction and maintenance of this powerline has the potential to disrupt aquatic ecosystems occupied by C. cymatilis (TVA 2007). The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis (U.S. Forest Service 2008).

Inadequacy of existing regulatory mechanisms:
Skelton (2008) states that there is a single population of Cambarys cymatilis on state-owned property, the Conasauga River Natural Area. C. cymatilis is found on the Chattahoochee National

Forest, where it is a USFS Sensitive Species (USFS 2005). This species is listed as endangered in both Tennessee and Georgia. None of these designations provide significant regulatory protection for the species or its habitat.

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Scientific Name:
Cambarus eeseeohensis
Common Name:
Grandfather Mountain Crayfish

G Rank:
G1

Range:
The Grandfather Mountain crayfish is found only in the Linville River of North Carolina and presently known to exist only above the falls of the Linville River; a distance of about 5-10 miles (Thoma 2005).

Habitat:
Cambarus eeseechensis has been observed under rocks in riffle areas of a small river in North Carolina (Thoma 2005).

Populations:
NatureServe (2008) reports that there are fewer than five occurrences with an unknown total population size.

Population Trends:
This species is newly described so no population or trend information is available (NatureServe 2008).

Status:
The Grandfather Mountain crayfish has a very limited distribution, occupying only mainstem portions of the Linville River. It is potentially imperiled due to invasive species (NatureServe 2008). AFS lists this species as Threatened and NatureServe (2008) ranks it as critically imperiled.

Habitat destruction:
The only locality of this species, Linville River, has numerous impoundments on its mainstem (Thoma 2005).

Inadequacy of existing regulatory mechanisms:
No regulatory mechanisms protect this recently described species.

Other factors:
NatureServe (2008) reports that this species is potentially imperiled due to invasive crayfish species likely introduced by fishermen who frequent the single area from which this species is known. Thoma (2005) reports that impoundments on the Linville River create the possibility of bait bucket introductions of non-native crayfish species, and that due to the placid nature of this species, the introduction of any mainstream dwelling species could result in extinction of the Grandfather Mountain crayfish.

According to the North Carolina Wildlife Resources Commission (2000): "Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species.

In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species."

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Scientific Name:
Cambarus elkensis
Common Name:
Elk River Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008) the Elk River Crayfish has only been recorded from the Elk River above Sutton Lake, and in the Holly and Birch rivers in Webster, Nicholas, and Pocahontas counties, West Virginia. Its total range is about 100-250 square km (about 40-100 square miles).

Habitat:
Cambarus elkensis is found under loose rocks in riffles or pools that have current (Jezerinac et al. 1995). Is absent from headwater streams. Jezerinac and Stocker (1993) report that riverbed habitat for this species consists of sandstone boulders, cobble, gravel, and sand. It is found in an area with significant current, under cobble, on top of sand and gravel, or under loose rocks in riffles, or pools with currents. Vegetation in area consists of hemlocks, birches, alders, and rhododendrons.

Populations:
NatureServe (2008) estimates that Cambarus elkensis has between 6 - 20 populations with a total of 1000 - 2500 individuals. Eleven element occurrances have been recorded, one of which is historic and probably extirpated. To date a total of 95 specimens have been recorded (Jezerinac and Stocker, 1993), although little is known about actual population size.

Population Trends:
NatureServe (2008) reports that this crayfish is declining in the short-term by up to 30 percent.

Status:
NatureServe (2008) ranks this species as critically imperiled. AFS lists it as Threatened due to limited range and habitat loss. It is one of two crayfish species endemic to West Virginia (Jezerinac et al. 1995).

Habitat destruction:
NatureServe (2008) states, "It is currently known that coal mining, siltation, logging and other impacts to water quality are affecting Cambarus elkensis (Forests for Watersheds and Wildlife 2005). The Elk River Watershed is dominated by agricultural lands, and coal mining, and oil and gas extraction are common. This is causing acidic discharge into the river and having a severe negative impact on the river system (United States Environmental Protection Agency 2001)." The Upper Elk River is threatened by a sewage treatment plant, according to Ruediger (2005). Jezerinac and Stocker (1994) state that C. elkensis is found in Elk River above Sutton Lake and Birch River below Sutton Lake, but suitable habitat was destroyed between when the lake was constructed.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

Other factors:

This crayfish may be threatened by exotic crayfish. As a coldwater stream with a reservoir at one end, the opportunity for introduction of the exotic competitor, Orconectes virilis, is high. This crayfish is threatened by pollution from coal mining, agriculture, and development.

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Scientific Name:
Cambarus extraneus
Common Name:
Chickamauga Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
NatureServe (2008) reports that Cambarus extraneus is restricted to South Chickamauga Creek basin in Catoosa, Walker and Whitfield counties in Georgia and Hamilton County in Tennessee. The total range is about 250-1000 square km (about 100-400 square miles). Skelton (2008) reports 15 collection sites in Georgia.

Habitat:
The Chickamauga crayfish is found in moderately flowing, small, shallow, rock-littered streams, according to NatureServe (2008). It can also be found among trapped leaf litter.

Populations:
Hobbs (1981) found 12 populations in Georgia, based on thorough collecting; Tennessee is less well collected, but could add a few more locations. NatureServe (2008) reports between 6 and 20 populations with a total population of at least 2,500 individuals.

Population Trends:
Skelton (2008) believes that Tennessee populations are thought to be declining, while limited collecting in Georgia indicates the at least some populations are doing well.

Status:
NatureServe (2008) ranks this species as imperiled in Georgia and critically imperiled in Tennessee. The States of Georgia and Tennessee have both classified this species as Threatened. This species was a C2 Candidate Species under the Federal ESA before that list was abolished. The U.S. Forest Service (2002) has designated Cambarus extraneus as a Sensitive Species. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
The species is threatened by the always strong possibility for stream impoundment in the region (NatureServe 2008). There are several populations in or near the Chattanooga metropolitan area that could be impacted by development pressure. Skelton (2008) reports: "Small range size makes this species vulnerable to extirpation. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation. . . . [c]onserving populations of the Chickamauga crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis (U.S. Forest Service 2008).

Inadequacy of existing regulatory mechanisms:

According to the USFS (2005) this species occurs on National Forests in Alabama, where it is a

Other factors:

Skelton (2008) reports: "The introduction of non-native crayfishes is a threat to all native crayfishes."

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Chattahoochee-Oconee National Forest: Banks, Habersham, Rabun, Stephens, Towns, Union and White Counties. 62 pp.

Scientific Name:
Cambarus fasciatus
Common Name:
Etowah Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
NatureServe (2008) states that Cambarus fasciatus is restricted to the Etowah River drainage in northwest Georgia (a six county area) (Hobbs 1981). Skelton (2008) reports that "the Etowah crayfish is known only from the Etowah River system, primarily above Allatoona Dam. All of the records of this species are from the Piedmont physiographic province. Only three collections have been made downstream of Allatoona Dam and it is possible that this form represents an undescribed species."

Habitat:
The Etowah crayfish is found in swift parts of small streams (Nature Serve 2008). Skelton (2008) reports that "[t]he Etowah crayfish is usually found beneath rocks in moderately to swiftly flowing areas of streams. It is occasionally found in association with woody debris or aggregations of leaves."

Populations:
NatureServe (2008) estimates from 20-80 populations of this species, with no detailed information on population size or trend available.

Status:
NatureServe (2008) ranks this species as imperiled, and the State of Georgia lists it as Threatened, as does the American Fisheries Society.

Habitat destruction:
According to NatureServe (2008), most populations of this species are located near the rapidly expanding Atlanta metropolitan area. The range has already been fragmented by the Allatoona Lake reservoir, and more development could result in more habitat loss. Mining, agriculture and other human activities have also caused the degradation of water quality in the Etowah River basin in recent years (Walters et al. 2003)

Skelton (2008) indicates that "The small range of this species and the high development rates within that range are significant threats to the Etowah crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation. . . Conserving populations of the Etowah crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis. (U.S. Forest Service 2008).

Inadequacy of existing regulatory mechanisms:
According to Skelton (2008) "[s]ome populations occur on publicly owned conservation lands in

headwater tributaries to the Etowah River." This crayfish is listed as threatened by the state of Georgia, but this designation does not protect the species' habitat.

Other factors:
Skelton (2008) states that "The introduction of non-native crayfishes is a threat to all native crayfishes."

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Scientific Name:
Cambarus georgiae
Common Name:
Little Tennessee Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
NatureServe (2008) reports the Little Tennessee crayfish is known from Rabun County, Georgia and Macon County, North Carolina (50 stream miles of the Little Tennessee River drainage). It is also found in the upper Little Tennessee River basin of North Carolina and Georgia. LeGrand et al. (2006) cite the Little Tennessee drainage in Jackson and Macon Cos., North Carolina. NatureServe esitmates a total range of 100-250 square km (about 40-100 square miles).

Habitat:
C. georgiae is associated with debris in slower parts of swift streams and areas lacking other crayfish competitors (NatureServe 2008).

Ecology:
NatureServe (2008) reports that this species seems unable to compete with Cambarus Bartonii in riffle areas, and hides in trapped leaf debris.

Populations:
NatureServe (2008) states that species is known from fewer than 10 localities and that it has been collected from 37 sites. Global abundance is estimated at 1000-2500 individuals: "An intensive survey for the species collected 302 individuals from 37 sites. Hobbs (1981) cites 51 specimens from a single site on the Little Tennessee River in Rabun Co., Georgia and Macon Co., North Carolina. It was collected at one of 13 sites surveyed recently (but not sites known to have historical occurrences) (Simon and Fraley, 2008)."

Population Trends:
NatureServe (2008) reports that this crayfish has declined in the short-term by up to 30 percent. Hobbs (1981) notes some decline, especially at the type locality, based upon competition with Cambarus bartonii.

Status:
The State of Georgia lists this species as Endangered. In North Carolina it is a species of Special Concern. AFS now lists it as Vulnerable (Taylor et al. 2007). It was a Federal C2 Candidate Species until that list was abolished. The U.S. Forest Service (2002) has designated Cambarus georgiae as a Sensitive Species. NatureServe (2008) ranks it as critically imperiled in Georgia and imperiled in North Carolina.

Habitat destruction:
The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis. U.S. Forest Service (2008).

According to Skelton (2008), "[t]he small range of this species and the high development rates within that range are significant threats to the Little Tennessee crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation." Furthermore, "[t]he upper

Little Tennessee River in Georgia is surrounded by intensive agriculture and urban development and is in very poor condition." And, "Conserving populations of the Little Tennessee crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

Inadequacy of existing regulatory mechanisms:

Though this crayfish is state-listed in Georgia, this designation provides no regulatory protection for the species' habitat. The species occurs in the Nantahala and Chattahoochee National Forests in NC and GA, where it is a U.S. Forest Service Sensitive Species (USFS 2002) but this protection is discretionary. According to Skelton (2008), "[a] large tributary to the Little Tennessee River, Betty's Creek, has high habitat quality and has a conservation easement in place in its headwaters" which may confer some protection to the species in that location.

Other factors:

NatureServe (2008) reports that this species can tolerate some sedimentation, but is intolerant to point source pollution and is absent from the most polluted areas in its range (McLarney 1993).

This species is apparently unable to compete with the sympatric C.(C.) bartonii, and has declined at some localities due to competition (NatureServe 2008).

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Scientific Name:
Cambarus harti
Common Name:
Piedmont Blue Burrower

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
Despite intensive collection by a very experienced collector, this species is known from only two sites in the piedmont of Flint and Chattahoochee river systems, in Meriwether County, Georgia. Skelton (2008) “found bluish crayfish specimens that may represent the Piedmont blue burrower at six additional locations in Meriwether County, but none were males and thus the identifications are considered tentative. A recent collection of blue burrowing crayfishes from the Whites Creek system (Flint tributary) may also be the Piedmont blue burrower.”

Habitat:
The Piedmont Blue burrowing crayfish burrows in the seepage area of stream floodplains with water level near the surface, according to NatureServe (2008). Skelton (2008) reports that C. harti occupies “complex burrows adjacent to streams and seepage areas, or in low areas where the water table is near the surface of the ground.”

Ecology:
C. harti digs complex burrows in sandy, organically rich, water saturated soil with many roots (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are less than 5 populations with a total of fewer than 1000 individuals of C. harti extant. There are only two confirmed sites.

Status:
NatureServe (2008) indicates that Cambarus harti is made up of small populations with a restricted range and ranks it as critically imperiled. The State of Georgia lists it as Endangered, as do the IUCN and the American Fisheries Society.

Habitat destruction:
According to Fiegel (2009), “There is concern for C. harti vulnerability to extirpation due to habitat changes, destruction or degradation. For example, the site where Hart and Hart (1974) captured individuals has been altered due to logging operations and the species may be gone from that location."

According to Skelton (2008), “[s]mall range size makes this species vulnerable to extinction. The small size of individual populations makes them vulnerable to land disturbing activities. Any expansion of the Warm Springs National Fish Hatchery or the Warm Springs water works would threaten this species.”

Inadequacy of existing regulatory mechanisms:
One population is on property owned by the city of Warm Springs and is somewhat protected (Skelton 2008). This species is listed as endangered by the state of Georgia, but this designation provides no habitat protection.

Other factors:

According to Fiegel (2009), "This species is an obligate burrowing crayfish and may be susceptible to climate changes related to drought."

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Scientific Name:
Cambarus jezerinaci
Common Name:
Spiny Scale Crayfish
G Rank:
G2
Range:
NatureServe (2008) reports that the range of C. jezerinaci is 100-250 square km (about 40-100 square miles). This species is confined to small tributaries of the Powell River in Lee County, Virginia and Clairborne County, Tennessee (Thoma 2000).

Thoma (2009) reports that this species "is found in Kentucky, Tennessee, and Virginia. The Virginia and Tennessee populations are found in the Powell River basin and the Kentucky populations is found throughout the Cumberland River basin upstream of Pine Mountain."
Habitat:
The Spiny Scale crayfish prefers first and second order, spring fed streams of higher altitude and high gradient. It is a secondary burrower (Thoma 2000).
Populations:
NatureServe (2010) states: "In Tennessee it occurs in the Ridge and Valley province in the Powell River, on a tributary of Mill Hollow, east of Bacchus, Claiborne Co. (Williams and Bivens, 2001). In Virginia it is in two counties (including Lee Co.) in the Powell River basin in streams abutting Cumberland and Stone Mountain only. A third Virginia population in the South Fork Powell River of Wise Co., Virginia, is morphologically similar somewhat to C. parvoculus but is far separated from nominal C. parvoculus populations but has not been analyzed genetically; therefore it is currently placed tentatively in C. jezerinaci (Thoma and Fetzner, 2008). Kentucky populations are found in the upper Cumberland River above Pine Mountain and Kentucky River headwaters (R. Thoma, pers. comm., 2009)."
Population Trends:
NatureServe (2010) reports that this species is declining in the short-term by up to 30 percent due to forestry and mining.
Status:
NatureServe (2010) ranks this species as critically imperiled in Virginia and not ranked in Tennessee and Kentucky. AFS lists it as Stable. Virginia classifies it as a Tier II Species of Greatest Conservation Need.
Habitat destruction:
According to Thoma (2009), C. jerzerinaci is "impacted by human activities such as urbanization, agriculture, and enrichment (especially from sewage). In small streams with adjacent roads C. jezerinaci populations were either suppressed or completely absent. Roads resulted in increased nutrient loads from adjacent lawns and septic systems associated with houses. Bed load sediments also tended to be higher in such streams. The best populations were found in streams such as White Branch that drained directly from Cumberland Mountain in a west to east direction. These streams have steep narrow valleys and afford little opportunity for human habitation or road building. They are also heavily wooded. The greatest threat to the species is thought to be timbering activities, especially clear cutting and associated road building that would result in

increased bedload sediments. Unregulated grazing on steep terrain also has negative effects on instream sediment and consequently C. jezerinaci populations."

NatureServe (2010) reports that there are some declines in Virginia populations due to forestry activities as well as decline on the Tennessee/Virginia line due to coal mining. Coal mining also occurs in this species range in Kentucky, and could pose a threat there as well. NatureServe (2010) states: "It is likely to be undergoing localized declines due to climate change, water pollution and alterations to the hydrological regime."

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

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Scientific Name:
Cambarus jonesi
Common Name:
Alabama Cave Crayfish

G Rank:	**AFS Status:**
G2	Currently Stable

Range:
NatureServe (2008) states that the species is found in Tennessee River caves between Florence and Guntersville, AL (Hobbs, 1989; Buhay et al., 2007). On Federal land, it is found in Key Cave National Wildlife Refuge. A new study by Buhay and Crandall (2009) found that "a single population of C. jonesi along with some newly discovered neighboring populations all in Marshall County, Alabama actually represented a distinct cryptic evolutionary lineage … herein described as Cambarus speleocoopi."

Habitat:
This species lives in cave pools (NatureServe 2008). Its population falls in the middle of three co-extensive troglobitic crawfishes without any reported habitat partitioning. The species is found alongside Cambarus tenebrosus (facultative cave dweller) and Orconectes australis (obligate cave dweller) in Madison Co., Orconectes sheltae (obligate cave dweller) and Cambarus veitchorum (obligate cave dweller) in Limestone Co., and Procambarus pecki (obligate cave dweller) in Colbert, Lauderdale, and Morgan Cos., Alabama (Buhay et al., 2007).

Ecology:
Buhay et al (2007) report that "[u]nlike C. hamulatus, C. jonesi is known to co-occur with other obligate cave-dwelling crayfish species."

Populations:
There are between 6 and 20 populations with 1000-10000 total individuals, according to NatureServe (2008).

The species is currently found in 12 caves in Alabama (Buhay et al. 2007). Similar crayfish identified in caves in Marshall Co. are a distinct species currently being described. Thus the species occurs in Colbert, Limestone, Lauderdale, Madison, and Morgan Cos., Alabama. Information (Hobbs 1981) indicating the species occurs in the Chattahoochee River in Georgia to Halawakee Creek in Alabama is now belived to be incorrect (see also Mirarchi et al., 2004; in appendix 1-2 published separately; Schuster and Taylor, 2004; Schuster et al., 2008).

All occurrances have very low populations with low fecundity (Buhay et al., 2007).

Population Trends:
In the short-term, this species is declining rapidly, by 30-50 percent, as reported by NatureServe (2008). Long term, the decline is 25-50 percent. The species was previously found in 14 sites in the Highland Rim region of northern Alabama (6 counties on both sides of the Tennessee River); this has now fallen to 12 sites. A decline in cave habitat quality has been noted (Buhay et al., 2007).

Status:
This species has a low area of occupancy, low number of occurrences, and each population has

Habitat destruction:

The entire range of the species is subject to intensive stream impoundment and modification, as reported by NatureServe (2008). Development associated with rapid expansion of cities within the range continues to degrade habitat (Decatur and Huntsville, Alabama urban areas).

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

As a cave obligate, its habitat requirements are very narrow, and the species is a specialist with key requirements scarce. Recreation is a potential threat to this species.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms protect this species. Some occurrences are on Key Cave National Wildlife Refuge (USFWS Undated), but even these may not adequately be protected from pollution impacts. It is an Alabama species of greatest conservation need, but this designation conveys no regulatory protection.

Other factors:

NatureServe (2008) reports that the species is subject to low fecundity and a long immature period.

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Web Page for Key Cave National Wildlife Refuge: http://www.fws.gov/keycave/. Last accessed March 26, 2009.

Scientific Name:
Cambarus nerterius
Common Name:
Greenbrier Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
Cambarus nerterius is known from a single cave in Pocahontos County and 15 caves or springs in Greenbrier County, West Virginia (NatureServe 2008). The range is thus less than 100-250 square km (less than about 40 to 100 square miles).

Habitat:
NatureServe (2008) reports that the Greenbrier cave crayfish is generally found in subterranean streams, usually in the upper portions of the cave, but small specimens have also been collected from dry stream beds that were nearly saturated by humidity.

Populations:
Cambarus nerterius is known from 16 caves or springs. Total population is estimated to number at least 2,500. The density was observed to be about one crayfish per 2.4 square meters of habitat (Jezerinac et al. 1995).

Population Trends:
NatureServe (2008) indicates that the short-term trend for this species is stable, and long-term trend is unknown.

Status:
NatureServe (2008) ranks this species as critically imperiled, the IUCN ranks it as vulnerable, and AFS lists it as Endangered, due to limited range.

Habitat destruction:
NatureServe (2008) reports that this species is most likely intolerant of perturbations. According to the U.S. Forest Service (2001), cave crayfish including C. nerterius face numerous threats. These include contamination from sewage, pesticides and herbicides, hazardous materials from industrial accidents, habitat destruction from logging, mining and road construction, farming, and other groundcover disturbances. Impoundments also harm cave species by interrupting streamflow and modifying habitat, while smoke and quarrying have been noted as reducing water quality in caves. Oil, gas and water extraction can also damage cave habitats, and invasive species can devastate cave-obligate endemic species. Finally, human intrusion and vandalism have also reduced crayfish viability at times. Road and trail construction near caves encourages human use and associated impacts. Despite these pervasive effects, the Forest Service is not currently monitoring C. nerterius.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species. C. nerterius is a USFS Regional Forester Sensitive Species that occurs in caves on the Monongahela National Forest in West Virginia, but protection for sensitive species is discretionary. This species also occurs in General Davis Cave, which is owned and gated by The Nature Conservancy.

Other factors:

Water pollution from a variety of sources threatens this crayfish.

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Scientific Name:
Cambarus obeyensis
Common Name:
Obey Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Obey crayfish is confined to headwaters and tributaries of the East Fork Obey River in Cumberland, Fentress, Putnam, and Overton counties, Tennessee (Williams et al. 2006).

Habitat:
Cambarus obeyensis occurs in small to large streams where they are found beneath large rocks in moderate to slow current (NatureServe 2008). However, the known range distribution suggest that it is restricted to the upper reaches of streams that remain on the table rock portion of the Cumberland Plateau upstream of where the streams have began to cut through the Pennsylvanian Sandstone caps (Williams et al. 2006).

Populations:
There are 8 known occurrences of this species. In the original description, Hobbs and Shoup (1947) reported only three known localities, all occurring within Hurricane Creek and its tributaries. Since then, this species has been collected from only one other locality outside the Hurricane Creek watershed (a single record collected from Dripping Springs Creek, a tributary to Meadow Creek, a northerly flowing tributary just southwest of Hurricane Creek). Recent survey efforts (Williams et al., 2006) found populations at all historic sites except Dripping Springs Creek plus one new stream locality record within a tributary of Hurricane Creek.

Population Trends:
NatureServe (2010) reports that this species has experienced short-term decline of up to 30 percent, stating: "Although one population may have been lost in Dripping Springs Creek (more surveys are needed to confirm this), all historical occurrences have been confirmed to be extant and viable recently (Williams et al., 2006). However, in 2008, most of the streams dried completely so decline is imminent. These streams dry periodically causing fluctuations in population numbers (T. Jones, R. Thoma, pers. comm., 2009)."

Status:
C. obeyensis is only known from the headwaters of one river system in Tennessee. Its status in Tennessee is imperiled, and it is critically imperiled globally (G1S2) (NatureServe 2008). The American Fisheries Society re-ranked this species from Threatened to Endangered (Taylor et al. 2007). The State of Tennessee classifies C. obeyensis as Threatened. Williams et al. (2006) suggest that its state status be elevated to endangered. NatureServe (2010) states: "This species is only known from the headwaters of one river system at the junction of three counties in Tennessee in a very small area and populations fluctuate up and down due to periodic drought. Also poor water quality is contributing to declining habitat for this species. It is extremely rare and localized."

Habitat destruction:
Concerning threats to this species, NatureServe (2010) states: "Habitat loss and poor water quality issues from point and non-point source pollution have plagued aquatic organisms within these streams for many decades. While efforts are currently underway to improve water quality in a few streams, much of

the watershed continues to suffer from historical surface coal mining practices. Although much of the East Fork Obey River system remains forested, increasing residential development and poor logging and agricultural practices pose continuing threats. Note there is the potential (not realized) threat of a large sand mine being considered for construction in heart of range (per R. Thoma to C. Taylor, pers. comm., 2008)."

C. obeyensis may occur near the Mine Lick Creek Interchange on Interstate 40 in Putnam County, and could be impacted by construction (TDOT 2006). No surveys were performed and no analysis of impacts was undertaken in the Environmental Assessment.

The Obey crayfish also occurs in the vicinity of the Algood 161KV Transmission line, which is due to be upgraded. (TVA 2008.) While this project has the potential to degrade the aquatic habitat of this species, again no surveys were performed and no analysis of impacts was undertaken by the action agency.

Inadequacy of existing regulatory mechanisms:
C. obeynsis and C. bouchardi are being considered for inclusion in a proposed Cumberland Habitat Conservation Plan (Cumberland HCP 2006). This species is state listed in Tennessee, but this designation conveys no habitat protection.

Other factors:
According to Williams et al. (2006) "the potential for nonindgenous crayfish species introductions merit reason for additional concern, although none were found during our surveys."

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Scientific Name:
Cambarus parrishi
Common Name:
Hiwassee Headwater Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
NatureServe (2008) reports that a very experienced collector was able to produce only five localities of Hiwassee headwater crayfish in Towns County, Georgia, and two in adjacent Clay County, North Carolina in ten years of intensive collecting; all localities are in the headwaters of the Hiwasee River. Recent efforts have discovered four additional localities in Clay County, North Carolina and one in Cherokee Co.. The total range is estimated at 100-250 square km (about 40-100 square miles).

Habitat:
According to NatureServe (2008), Cambarus parishi inhabits very swift, clear water flowing over a bed of sand and rocks.

Ecology:
Although occurring in riffle areas, Hiwassee Headwater crayfish is most common in the rocky areas between riffles, under rocks & in debris trapped by the rocks (NatureServe 2008); this apparently allows it to partition the habitat with the sympatric C. bartoni.

Populations:
This species is known from a total of 11 locations, and it is estimated that there are less than 1000 total indivuals (NatureServe 2008). A total of 143 specimens have been collected, and this species is apparently never abundant.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as critically imperiled in Georgia and imperiled in North Carolina. The U.S. Forest Service (2002) has designated Cambarus parrishi as a Sensitive Species. In North Carolina it is designated a Special Concern species. The State of Georgia lists it as Endangered. It was also a Federal C-2 Candidate species before that list was abolished. It is ranked as vulnerable by the IUCN and as endangered by the American Fisheries Society.

Habitat destruction:
According to Skelton (2008), "The small range of this species and the high development rates within that range are significant threats to the Hiwassee headwater crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding place on which crayfishes rely to avoid predation . . . Conserving populations of the Hiwassee headwater crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis. U.S. Forest Service (2008).

Inadequacy of existing regulatory mechanisms:

The USFS (2005) reports that this species is found on the Chattahoochee and Nantahala National Forests, where it is a USFS Sensitive Species, but this designation conveys no regulatory protection for the species' habitat. This crayfish is listed by the state of Georgia, which provides protection from collection, but not habitat protection.

Other factors:

Skelton (2008) states that the introduction of non-native crayfishes is a threat to all native crayfishes. According to the North Carolina Wildlife Resources Commission (2000): "Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species. In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species."

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Scientific Name:
Cambarus pristinus
Common Name:
Pristine Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
According to NatureServe (2008) the range of C. pristinus is 100-250 square km (about 40-100 square miles). This species maintains a spotty distribution within the upper tributaries of the Caney Fork River drainage, Cumberland Co. (possibly White and Van Buren Cos.), Tennessee.

Habitat:
This species is restricted to sandstone-derived streams of the Upper Caney Fork drainage of the Cumberland Plateau. It is found in small to large streams under slabrock resting on bedrock, with interspersed small rocks, cobble and sand occupying areas of 0-100 percent canopy cover. It is associated strongly with streams in or near headwaters (Rohrbach and Withers 2006).

Populations:
C. pristinus has recently been discovered in several additional localities (approximately 15 newly discovered since 2004) and is now known from 19 streams in Cumberland, Van Buren, White and Bledsoe Cos., Tennessee (Rohrbach and Withers 2006).

Population Trends:
According to NatureServe (2008) this species is increasing in the short term and relatively stable in the long term. Recently several new localities of C. pristinus were discovered, but the Fall Creek Falls State Park record is now considered historical (Rohrbach and Withers 2006).

Status:
The pristine crayfish is critically imperiled (NatureServe 2008). It is a Federal Species of Management Concern, and the State of Tennesee lists it as Endangered. It is ranked as vulnerable by the IUCN, and as endangered by the American Fisheries Society.

Habitat destruction:
Rohrbach and Withers (2006) report that the primary threat to this species is siltation associated with silvicultural and agricultural practices. Many sites where this species occurs are significantly influenced or surrounded by large tracts of corporate timberland.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that few (1-3) occurrences of C. pristinus are appropriately protected. One small segment of Oldfield Branch within Bledsoe State Forest was inhabited by this species, and other streams on the forest are expected to contain the species. Blade Creek, also on the state forest, once had a population but it is now considered historical (Rohrbach and Withers 2006). Occurrence on a state forest does not necessarily protect this species from logging impacts, a primary threat. This species is state-listed in Tennessee, but this designation conveys no habitat protection.

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Scientific Name:
Cambarus scotti
Common Name:
Chattooga River Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008) this species occupies less than 100-250 square km (less than about 40 to 100 square miles). It is restricted to the Chattooga River basin in Chattooga and Walker counties in Georgia and Cherokee County, Alabama. The Alabama specimens are tentatively assigned to this species, but do not share all characters (Hobbs 1981), although it is listed as occurring in Alabama in Taylor et al. (2007). Mirarchi et al. (2004; appendix 1.2 pub. separately) lists this species in Alabama from 9 records in the upper Coosa River system (Chattooga River).

Habitat:
Cambarus scotti is most abundant in areas with swift water and rocks (Hobbs, 1981).

Populations:
The Chatooga River crayfish was collected at 14 sites in Georgia and five sites in Alabama (Hobbs 1981). Mirarchi et al. (2004; appendix 1.2 pub. separately) and Schuster and Taylor (2004) list this species in Alabama from 9 records in the upper Coosa River system (Chattooga River) (Schuster et al. 2008). This species can be locally abundant.

Status:
This species is ranked as imperiled in Georgia and it is not ranked in Alabama (NatureServe 2008). AFS classifies this species as Threatened due to restricted range. Georgia lists this species as Threatened.

Habitat destruction:
According to Skelton (2008), "[t]he small range of this species and poor land use practices within that range are potential threats to the Chattooga River crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation. . . "[c]onserving populations of the Chattooga River crayfish will require general watershed level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

Inadequacy of existing regulatory mechanisms:
The Chattooga River was designated as a Wild and Scenic River in 1974 by The Wild and Scenic Rivers Act. This species is listed as threatened in Georgia, but this designation conveys no habitat protection.

Other factors:
According to Skelton (2008), "The introduction of non-native crayfishes is a threat to all native crayfishes."

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Scientific Name:
Cambarus speciosus
Common Name:
Beautiful Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Endangered	VU - Vulnerable

Range:
According to NatureServe (2008), this species is confined to a short stretch of the Coosawattee River in Gilmer, Murray and Pickens counties, Georgia (Hobbs, 1989). The area is less than 100 sq. km (less than 40 sq. miles).

Skelton (2008) reports that "The Beautiful crayfish is endemic to the Coosawattee River system (Upper Coosa River system) in northwest Georgia. Records are known from Talking Rock Creek and several other streams and rivers upstream of Carter's Lake Reservoir."

Habitat:
Cambarus speciousus occurs in clear to slightly cloudy water flowing swiftly over rocky bottom, generally in a sandy and rocky substrate (NatureServe 2008).

Ecology:
NatureServe (2008) states that the Beautiful crayfish has not been found in small headwaters streams. Most specimens were taken from under rocks or in beds of Podostemum.

Populations:
NatureServe (2008) states that a very experienced collector produced only 9 sites with 76 Beautiful crayfish in more than a decade of study. Less than 1000 individuals are believed to exist.

Population Trends:
This species is declining in the short term by 10-30 percent, according to NatureServe (2008).

Status:
AFS considers this species endangered due to its small range and small population. IUCN lists it as vulnerable, and NatureServe (2008) considers it to be imperiled. The Beautiful crayfish is listed as Endangered by the State of Georgia. The U.S. Forest Service (2002) has designated Cambarus speciosus as a Sensitive Species. Schuster (2001) reports this species as stable.

Habitat destruction:
NatureServe (2008) indicates that Carter's Dam & other impoundment dams are destroying its habitat.

The U.S. Forest Service states that "management activities most likely to create adverse effects to this aquatic species are those that disturb soil and cause excessive siltation. Dams that restrict water flow and change stream also create problems for this crayfish."

Skelton (2008) relates the following: "The small range of this species and the high development rates within that range are significant threats to the beautiful crayfish. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation."

The U.S. Forest Service is conducting herbicide-based vegetation management in the range of this species without surveys or species-level analysis (U.S. Forest Service 2008).

Skelton (2008) warns that "conserving populations of the beautiful crayfish will require general watershed-level protection measures, including the protection of riparian zones, control of sediment and nutrient runoff from farms and construction sites, and limiting the amount of impervious cover (e.g., pavement) within occupied watersheds."

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

This species is found in the Chattahoochee National Forest, where it is a USFS Sensitive Species, but this designation does not effectively protect this species because the management of sensitive species is discretionary, and the Forest Service is conducting potentially harmful activities in the range of this species without surveys or species-level analysis (U.S. Forest Service 2008).

It is listed as endangered by the state of Georgia, but this designation provides no protection for the species habitat.

Other factors:
Skelton (2008) states that "The introduction of non-native crayfishes is a threat to all native crayfishes." Non-native crayfish are being spread by fishermen who use them as bait.

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Scientific Name:
Cambarus spicatus
Common Name:
Broad River Spiney Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
The Broad River Spiney Crayfish is restricted to the Little and Broad River drainages in Fairfield, Richland, and Spartanburg counties, South Carolina (Eversole, 1995). Cooper and Braswell (1995) report a new record from Cleveland County, North Carolina. LeGrand et al. (2006) cite streams in the Broad River drainage in Cleveland and Polk Cos., North Carolina.

Habitat:
NatureServe (2008) reports that this species is found in streams of small to medium size with trapped leaf litter. Clamp (1999) states that Cambarus spicatus is found in "debris along the margins of the stream."

Populations:
NatureServe (2008) estimates that there are at least 21 occurrences of this species, with at least 2,500 individuals. It is not uncommon within its limited range.

Status:
NatureServe (2008) ranks this species as imperiled in North Carolina and vulnerable in South Carolina. IUCN classifies this species as Vulnerable based on its restricted range.
In North Carolina, Cambarus spicatus is a Species of Special Concern. In South Carolina, it is a Species of High Conservation Concern. It is ranked as threatened by the American Fisheries Society (Taylor 1996).

Habitat destruction:
Where Cambarus spicatus is found near urban areas, its habitat is flanked by major impoundments (NatureServe 2008). There is also an unquantified threat from recreational development and further impoundments.

SCDNR (2005) states that:

"Physical alteration of habitat also represents a challenge to the survival of crayfish. Some aquatic crayfishes are quite adaptable and can live in ponds, impoundments and roadside ditches, while others are more sensitive to habitat alteration. Some crayfishes are oxygen regulators and are able to increase ventilation rates in response to reduced oxygen conditions, while others, the oxygen conformers, are unable to do this (Hobbs 1991). Therefore, some species are better equipped to survive when the flow of water slows and oxygen levels decline. Some species… have been eliminated from parts of their range as a result of damming activities associated with reservoir construction. Channelization and dredging can also be very detrimental to aquatic crayfish that require rocks, crevices or tree roots along undercut banks as hiding places (Hobbs and Hall 1974). In general, crayfish are not as sensitive to siltation as some aquatic invertebrates such as mussels, but severe siltation has caused declines in or the extirpation of many populations of crayfish (Hobbs and Hall 1974).

Pollution has been known to eliminate crayfish from streams. Ortmann (1909) noted the extirpation of crayfish from some sections of streams and rivers due to mining and oil refineries. Crayfish are harmed by a variety of insecticides, herbicides and industrial chemicals (Eversole et al. 1996). Juvenile crayfish are generally about four times as sensitive to water borne pollution than adults; early instars are about three times as sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were actually more abundant downstream of areas with large amounts of garbage or animal remains. Enrichment may be harmful to crayfish, however, when it results in oxygen depletion (Hobbs and Hall 1974). Pollution of groundwater may impact terrestrial burrowers, because they inhabit water trapped in their burrows."

Other factors:

Fullerton and Watson (2001) believe that Cambarus spicatus may be threatened by the appearance of the non-native crayfish Orconectes rusticus, which has caused problems for native crayfish in other places.

According to the NC Wildlife Resources Commission (2000): “Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species. In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species.”

According to SCDNR (2005): "The arrival of introduced species is probably the greatest challenge to crayfish (Lodge et al. 2000 a,b). The ranges and abundances of many native crayfish may have been reduced by invasive crayfish, both in the United States and in Europe (Lodge et al. 2000a; Hobbs et al. 1989).

Prevention of future introductions is most likely the only effective way to deal with the challenges caused by nonnative crayfish. No methods for eliminating invasive species without also harming native species are currently available. Even if effective biological control methods are developed, preventing introductions will still be much easier than eradicating an established species. Lodge et al. (2000b) proposed federal legislation that, if enacted and enforced, would drastically reduce the risk of future introductions. They include banning the use of live crayfishes as bait, and adopting a 'white list' approach for the sale of all crayfish in the aquarium, garden pond and educational trade."

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Scientific Name:
Cambarus strigosus
Common Name:
Lean Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	EN - Endangered

Range:
Cambarus strigosus is found in the Broad and Little River basins in Elbert, Oglethorpe and Wilkens counties, Georgia; Hobbs (1981) thinks it is probably more widespread in these basins in the Piedmont Province.

Habitat:
The Lean crayfish forms elaborate burrows in sandy clay substrates, in densely matted roots, and in high organic matter soils. NatureServe (2008) reports that this species digs complex burrows and is usually found beneath water level.

Populations:
According to NatureServe (2008), C. strigosus is currently known from only 5 localities, with an estimated total population of 1000 - 2500 individuals. This is a crude estimate and available data is very limited.

Status:
NatureServe (2008) ranks this species as imperiled. The State of Georgia has classified it as Threatened. It is ranked as threatened by the American Fisheries Society and as endangered by the IUCN.

Habitat destruction:
Skelton (2008) reports that "[t]he small range of this species makes it vulnerable to land disturbing activities around streams and wetlands."

Inadequacy of existing regulatory mechanisms:
Skelton (2008) indicates that "[a] large population is known from Nancy Hart State Park." NatureServe (2008) reports that it is unknown if any occurrences of this species are appropriately protected.

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Scientific Name:
Cambarus unestami
Common Name:
Blackbarred Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
This crayfish is confined to streams on Lookout and Sand Mountains (Tennessee River system) in extreme northwestern Georgia and northeastern Alabama. Hobbs Jr. (1981) reports that this species is found at altitudes of approximately 333 to 500 meters. Georgia DNR (2008) reports that the range of this species is "the Cumberland Plateau and the Ridge and Valley physiographic provinces in tributaries of Chattanooga, Cole City, and Lookout Creeks in northwestern Georgia and extreme northeastern Alabama. These streams are in the Tennessee River drainage. It has also been taken from tributaries to the Little River, which is part of the Coosa River system."

Habitat:
The Blackbarred crayfish lives in streams under rocks (Schuster and Taylor 2004). According to Georgia DNR (2008), "[t]he blackbarred crayfish is usually collected in medium-sized streams from beneath rocks or within leaf litter in moderate to swift current."

Populations:
NatureServe (2008) estimates that there are between 21 and 80 populations of this species with a total of 2500-10,000 individuals. In Alabama, Cambarus unestami is known only from two database records from the Tennessee River system in Jackson County (Mirarchi et al., 2004, appendix 1.2 pub. separately; Schuster and Taylor, 2004; Schuster et al., 2008).

Population Trends:
The population trend for this species is not known.

Status:
In Alabama and Georgia this species has a status of imperiled due to restricted range and proximity to a large metropolitan area (NatureServe 2008). The State of Georgia lists this species as Threatened (Georgia DNR 2008), as does the American Fisheries Society (2008).

Habitat destruction:
According to NatureServe (2008), this species' range is located adjacent to the expanding Chattanooga, Tennessee metropolitan area. Development pressures from road construction, human residence and commercial enterprises will likely reduce water quality and degrade or destroy habitat.

Georgia DNR (2008) states that "[t]he small range size of this species makes it vulnerable to extirpation. Heavy sedimentation resulting from poor development and land management practices may cover substrates and other daytime hiding places on which crayfishes rely to avoid predation."

The U.S. Forest Service (2008) reports that in the range of Cambarus unestami, "the viability of many of the rare crustaceans is most threatened because of their small ranges. Impacts to habitats that would reduce or extirpate local populations of other taxonomic groups might result in extinction of some crustaceans. Crayfish are somewhat tolerant of desiccation, but permanent conversion of wetlands to pasture or urban uses could eliminate populations and lead to extinctions."

Inadequacy of existing regulatory mechanisms:

This species likely occurs in streams in Cloudland Canyon State Park (Georgia DNR 2008). No information on any additional protection is available for this population. This crayfish is listed as threatened in Georgia, which protects it from collection but not from habitat degradation.

Other factors:

According to Georgia DNR (2008), "the introduction of non-native crayfishes is a threat to all native crayfishes."

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Scientific Name:
Cambarus veteranus
Common Name:
Big Sandy Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
NatureServe (2008) reports that the Big Sandy crayfish is found in the upper Guyandotte River and Bluestone River drainage of West Virginia, and the upper Big Sandy drainage in Virginia (Buchanan and Dickerson counties) and Kentucky (Floyd and Pike counties). Recent fieldwork in Kentucky found the species to occur in both Tug Fork (Pike County) and Levisa Fork (Floyd County) of the Big Sandy drainage. There are now seven confirmed sites in Kentucky. More fieldwork will probably identify additional populations. Jezerinac and Stocker (1989) failed to find the Big Sandy crayfish in the Guyandotte river.

Habitat:
Cambarus veteranus inhabits moderately sized streams (10-20 meters wide) with bedrock, cobble, boulder, and sand substrate and permanent, fast-flowing water.

Populations:
According to NatureServe (2008), this species occurs in three river drainages in small areas in KY, VA, and WV. There are 7 occurrences in KY, 8 in VA and 16 in WV. The 16 WV occurrences includes 8 pre-1971 occurrences, 7 from 1988-89 and 1 update in 2000. Despite the historic occurences, the species has been sought every year since 2000 in WV without success.

In Kentucky, it is known only from the upper portions of the Big Sandy River drainage in Floyd and Pike Cos. and a single collection from the Red River in Estill Co. (Kentucky River drainage). The Big Sandy Crayfish exists in the Eastern Kentucky University Crayfish Collection, but

Population Trends:
NatureServe (2008) reports this species is very rapidly declining in the short-term, by 50-70 percent, stating: "Special efforts have been made to collect this species from adjacent streams in neighboring counties but to no avail (Jezerinac et al. 1995). The species has lost half of its distribution in Virginia, is near extirpation in West Virginia, and still occupies a small portion of the Russell Fork mainstem in Kentucky (R. Thoma, pers. comm., 2009). he species has been searched for every year since 2000 in WV without success including intensive survey effort based on habitat suitability modeling (Channell, 2004)." This crayfish has suffered long-term decline of up to 75 percent.

Status:
The Big Sandy crayfish is critically imperiled in Kentucky, Virginia, and West Virginia (NatureServe 2008). Kentucky lists the Big Sandy Crayfish as a species of Special Concern, and Tennessee considers this species to be of Greatest Conservation Need. Virginia lists this species as State Endangered. U.S. Fish and Wildlife Service classified this species as a Candidate 2 for listing under the Endangered Species Act, before that status was discontinued. It is ranked as threatened by the American Fisheries Society and as vulnerable by the IUCN. This rapidly declining species is severely threatened by coal mining activities.

subsequent surveys have not found the species in the state (Taylor and Schuster, 2004).

Habitat destruction:

Continued coal mining presernts a significant threat to Cambarus veteranus (NatureServe 2008). This crayfish is threatened by surface coal mining and by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, disrupting the food web (Wood 2009). In West Virginia, there are major mining threats in the area and plans for interstate construction as well (Jennifer Wykle, WV DNR, pers. comm., January 2005 cited in NatureServe 2008). Jezerinac et al. 1995 report that the species is absent from streams polluted with human-generated organic material from septic tanks and coal dust.

Thoma (2009) reports that "Recent collection efforts by the author and others (Channell, 2004) have failed to find the species in its West Virginia range. Mr. Zac Loughman, of West Liberty University, has reported finding the species in very low numbers in Pinnacle Creek of Wyoming County, WV (personal communication, June, 2009). It now appears nearly extirpated from West Virginia. The Kentucky population appears, based on Taylor and Schuster (2004), to be primarily derived from upstream populations in Virginia. The Virginia populations in the Russell Fork basin and Dismal Creek of the Levisa Fork basin are the only known healthy, self sustaining populations. Channell (2004) reported a collection from the mainstem Levisa Fork downstream of the Dismal Creek confluence but followup sampling in spring 2009 failed to find the species in that area. It seems likely that any individuals in Levisa Fork downstream Dismal Creek would likely be derived from the Dismal Creek population and not represent a permanent, viable population. Garden Creek, also in the Levisa Fork basin, was historically known to harbor C. veteranus but efforts to find the species there failed. The stream is heavily impacted by bedload sediments derived from coal mining activities."

Furthermore, "Much of its former range in Virginia is subject to dense, stream side urbanization (Levisa Fork). These areas have been subjected to elevated non-point run off, especially from roads, and, in unsewered areas, elevated nutrient loads from septic systems. Many streams no longer impacted by septic input have been channelized during installation of instream sewer lines. These stream reaches now have degraded habitat quality not suitable to supporting the species. In Virginia, unlike West Virginia, coal mining impacts are limited. Few sampled sites had significant loads of coal in the stream bed though some, like Garden Creek, were impacted by heavy bedload sediments derived from coal mining. Only a few sites were found that lacked C. veteranus as a consequence of coal mining impacts. The presence of a coking facility at the mouth of Dismal Creek with Levisa Fork may, in part, explain the absence of the species in Levisa Fork. Also, considerable coal transportation by truck occurs adjacent Dismal Creek and spills (coal & diesel fuel) resulting from wrecks could negatively impact C. veteranus in its only habitat in the Levisa Fork basin. Since the Dismal Creek population is the last viable population in the Levisa Fork basin (along with numerous 17 fish species) special attention should be accorded to protecting of this stream system."

Also, "Below the town of Pound, sewage is negatively impacting Pound River for at least six miles. A site 5.5 miles downstream of the town was noticeably suffering the effects of excess sewage and only two C. veteranus could be found after an extended search period. Sludge and excess algal growth was abundantly evident and the substrate was heavily imbedded with fine sediment. In McClure River, downstream of McClure, heavy bed load sediments, primarily of sand, have eliminated much of the favorable habitat and substrates are heavily imbedded."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that no occurrences of this species are appropriately protected. Its state designations provide no habitat protection. This species is rapidly declining due to coal mining, and urgent protection is needed for its habitat.

Thoma (2009) suggests that "if possible, West Virginia, Guyandotte River basin material should be brought into captivity and efforts made to maintain the population. Its genetic status should be determined as the two known populations may represent unique genetic units of the species."

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Scientific Name:
Cambarus williami
Common Name:
Brawleys Fork Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Endangered	EN - Endangered

Range:
This species has a limited range of the upper East Fork Stones River drainage in Cannon Co., Tennessee (Rohrbach and Withers, 2006; Bouchard and Bouchard 1995). The area covered by the Brawleys Fork crayfish is less than 100 square km (less than about 40 square miles) according to NatureServe (2008). Huggins (2002) reports that "[t]he species is apparently restricted to small, spring-fed, gravel and chert-bottomed streams, where it inhabits burrows constructed in the substrate. It was reported only from Brawley's Fork until the Division of Natural Heritage initiated surveys in 2000. Currently, Cambarus williami is reported from 13 sites in 10 streams, all within the escarpment of the Eastern Highland Rim in the East Fork Stones drainage."

Habitat:
Cambarus williami burrows primarily into gravel substrates in fast to moderately rapidly flowing water. It has also been found under rocks at the shoreline and in the water (Bouchard and Bouchard, 1995). It may be found in small burrows at or near the surface of cobble substrates, both in areas of uniform cobble distribution and in more isolated pockets of such material in streams with more pervalent bedrock (Rohrbach and Withers 2006).

Populations:
NatureServe (2008) reports that there are between 6 and 20 populations with up to 1000 total individuals. Although originally known only from the type locality at Brawley's Fork (East Fork of Stones River), Cannon Co., Tennessee, it has been discovered since 2004 in several new localities (including the East Fork Stones River proper) bringing the total distribution to 18 streams in Cannon Co. (Rohrbach and Withers, 2006).

Status:
The State status of this species in TN is imperiled (NatureServe 2008). The Tennessee Wildlife Resources Agency listed this species as Endangered in 2001. AFS and IUCN list this species as Endangered based on its very limited range.

Habitat destruction:
During 2004-2005, installation of a gas pipeline along the East Fork Stones River occurred, with poor erosion control and several stream crossings causing a significant amount of unconsolidated material to enter the uppermost part of the watershed. The overall impacts to the watershed or this species have not yet been determined. Outside Woodbury, the large rural agricultural areas often provided cattle access to creeks, which were subsequently devoid of crayfish. Rohrbach and Withers (2006) noted the primary threat to this species appears to be habitat desruction through sedimentation, which is increasing due to residential growth particularly in the Woodbury area.

Inadequacy of existing regulatory mechanisms:
This crayfish is listed as endangered by the state of Tennessee, but this designation provides no regulatory protection for the species' habitat. Currently, no public lands exist in the East Fork Stones

River watershed of Cannon County.

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Scientific Name:
Carex brysonii
Common Name:
Bryson's Sedge
G Rank:
G1
Range:
Bryson's sedge is endemic to Alabama's Cumberland Plateau where it occurs in several gorges in the upper Sipsey Fork drainage, and part of the Black Warrior River drainage (NatureServe 2008). There are only 5 known occurrences of this species, and natural heritage records indicate it is present in Tuscaloosa, Walker, and Winston Counties.
Habitat:
This species occurs in shaded forest slopes above streams or riparian areas. Dominant species in C. brysonii's preferred habitat include sugar maple (Acer saccharum), American hornbeam (Carpinus caroliniana), American beech (Fagus grandifolia), tulip tree (Liriodendron tulipifera), eastern hemlock (Tsuga canadensis), and numerous pine species (Naczi 1993). The richwoods sedge (Carex oligocarpa), and Boott's sedge (Carex picta) are also closely associated with C. brysonii. Soil type within this species' preferred habitat is moist, sandy loam. While this species has specific ecological requirements, the habitat it prefers is not naturally rare within its range.
Ecology:
This perennial sedge fruits in the spring (Flora of North America 2002).
Populations:
Only five occurrences of this species are known, and total population size is low (NatureServe 2008).
Population Trends:
NatureServe (2008) reports that while populations are currently considered stable, given the imminent threats of habitat loss and invasive species and the very small global population size of C. brysonii, the long-term viability of all occurrences is in jeopardy.
Status:
Small population size and restricted range make this species highly vulnerable to the loss or degradation of habitat or population losses to other threats. NatureServe (2008) ranks the Bryson's sedge as critically imperiled in Alabama.
Habitat destruction:
This species is imminently threatened by habitat-fragmenting agricultural and residential development, and also by timber harvesting operations (Southern Appalachian Species Viability Project 2002). Most populations of this species occur on public lands, and timber management is extensive throughout much of Alabama (NatureServe 2008). Three of the five known occurrences of Carex brysonii are also threatened by invasive species, particularly privet (Ligustrum sinense). Recreational development and a proposed campground development also apparently threatens one occurrence of this species on land adminstered by the Army Corps of Engineers (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Two of the five known populations occur in the Sipsey Wilderness Area of the Bankhead National Forest, where no evidence of disturbance was present as of 2004 (pers. comm. as cited in

NatureServe 2008); these are the only protected occurrences of this species. No existing regulatory mechanisms adequately protect other occurrences of the Bryson's sedge, nor are any recovery or management programs being developed or implemented, though the species is demonstrably in need of protection.

Other factors:

Because occurrences are small and sparsely distributed, they are vulnerable to stochastic extinction events and other perils faced by small, isolated populations (NatureServe 2008). Invasive privet also threatens this sedge (NatureServe 2008).

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Scientific Name:
Carex impressinervia
Common Name:
Impressed-nerved Sedge

G Rank:
G2

Range:
Also known as the ravine sedge, C. impressinervia is currently known from sites in Alabama, Mississippi, and North and South Carolina. Natural heritage records place C. impressinervia in Autauga, Bibb, Bulter, Chilton, Monroe, Russell, and Wilcox Counties, Alabama, Forrest, George, Marion, and Winston Counties, Mississippi, and Anson, Harnett, Montgomery, and Stanly Counties, North Carolina (NatureServe 2008). It may be present in Georgia, but no occurrences are confirmed. Known occurrences are widely scattered.

Habitat:
This sedge is found in moist to wet deciduous forests (Southern Piedmont) on slopes above small streams or within ravines (FNA 2002).

Ecology:
The impressed-nerved sedge is a perennial species that forms dense clumps. It flowers March-April, and fruits April-May in the southern portion of its range (NatureServe 2008).

Populations:
This plant is currently known from between 20 and 25 sites, all widely disjunct. Most populations are found in Alabama and Mississippi, fewer in North and South Carolina. Total population size is not known, though occurrences may contain thousands of individuals (NatureServe 2008).

Population Trends:
Trend information is not available for this species.

Status:
This species is currently known from relatively few disjunct sites, and most of these are not considered to be of good viability. It is threatened across its range by various causes of habitat loss. NatureServe (2008) ranks C. impressinervia as critically imperiled in Alabama, Mississippi, and North and South Carolina.

Habitat destruction:
This plant is threatened primarily by conversion of habitat to agricultural, residential, or silvicultural uses and unsustainable forest management practices (Southern Appalachian Species Viability Project 2002). Carex impressinervia prefers mature forests, which are destroyed or excluded by most current forestry practices. Hydrologic changes wrought by anthropogenic activities also threaten this species and its habitat (USFS 2006).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect C. impressinervia; though it is listed as threatened in North Carolina, this designation offers the species no substantial regulatory protections.

Other factors:
This sedge may be threatened by invasive exotics like the Japanese honeysuckle (Lonicera

japonica) (USFS 2006).

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Scientific Name:
Cicindela marginipennis
Common Name:
Cobblestone Tiger Beetle

G Rank:
G2

IUCN Status:
NT - Near threatened

Range:
The cobblestone tiger beetle may have historically occurred in Alabama, Indiana, Massachusetts, Mississippi, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Vermont, and West Virginia (NatureServe 2008). Current populations are found on the Coosa River in Alabama, Whitewater River in Indiana, Sciota River in Ohio, Connecticut River in New Hampshire and Vermont, and Delaware River in New Jersey and Pennsylvania. Historic collection sites in Mississippi and West Virginia, and perhaps in Ohio and Pennsylvania, were flooded by dams. Alabama populations may be tenuous. There is uncertainty about the original range of this species (NatureServe 2008).

Habitat:
The cobblestone tiger beetle inhabits sandy cobble beaches on the banks or upstream side of islands in free-flowing rivers (Pyzikiewicz 2006). These areas are characterized by sparse vegetation due to seasonal flooding and/or scouring by ice in winter, which maintains the beetle's preferred cobblestone habitat (Pyzikiewicz 2006).

Ecology:
C. marginipennis is active during the summer months, generally from early July to early September, though emergence and disappearance times vary annually. Full development from larval stage to adult stage takes two years; larvae burrow into subterranean habitat in September and remain there through the winter. Both larval and adult stages are predatory invertivores, sit-and-wait foragers that feed on smaller insects, particularly ants and flies (NatureServe 2008). Adults are volant and are capable of dispersing substantial distances, but the flow of individuals and/or genes among populations has not been well studied.

Populations:
In 1995 there were only 25 populations of C. marginipennis throughout its range, and populations of C. marginipennis are generally small (comprised of fewer than 100 adults) (NatureServe 2008). This beetle was likely extirpated from Pennsylvania, Mississippi, West Virginia, and Alabama by dam-related flooding (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the cobblestone tiger beetle has experienced long-term declines of up to 90 percent in parts of its range, and populations continue to decline.

Status:
NatureServe (2008) lists this species as critically imperiled in Alabama, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, and West Virginia, and imperiled in Indiana and Ohio. It is not ranked or under review in Maryland and South Carolina, and reportedly extirpated from Mississippi. The cobblestone tiger beetle is listed as threatened in Ohio, Vermont, and West Virginia, and as endangered in New Hampshire. It has been a candidate for federal listing since 1997 (McCollough 1997).

Habitat destruction:

Habitat loss caused by dam construction and operation is considered the greatest threat to C. marginipennis (Kinsley and Schultz 1997, New York State Dept. of Environmental Conservation 2005, NatureServe 2008). Dams and other impoundments destroy cobblestone tiger beetle habitat by prolonging seasonal inundation or permanently submerging formerly terrestrial habitat, killing both larvae and adults in their subterranean burrows. Parts of this species' historical range in Pennsylvania and West Virginia have been flooded by dams, causing their local extirpation, and the single known occurrence in Mississippi was destroyed by the Tenn-Tom Waterway (NatureServe 2008). Dams have been proposed in Pennsylvania, New Jersey, Vermont, and New Hampshire, but are not actively being considered at present (NatureServe 2008). Impoundment and disruption of natural flooding regimes can also cause cobble bars to become overgrown with dense herbaceous and shrub vegetation, rendering them unsuitable for this beetle (New York State Dept. of Environmental Conservation 2005).

Canoeists, campers, and all-terrain vehicle riders can also destroy beetle habitat by crushing stones and compacting soil habitat, and may simultaneously kill larvae (Pyzikiewicz 2006). In studies of other rare tiger beetle species, populations were small to nonexistent in areas of heavy recreation and larger in areas where recreation was limited and vehicles were prohibited (USFWS 1990).

The New York State Dept. of Environmental Conservation (2005) reports that this beetle is threatened by gravel mining, ATV use, dams, and channelization, stating: "There are a number of existing (gravel mining) permits on both the Genesee River (Taft 2002) and Cattaraugus Creek that have the potential to negatively impact populations of Cicindela marginipennis. Off road vehicle use of cobble bars can destroy larval habitat and has been noted as a threat both in the literature and during on site surveys in western New York . . . Population declines would be expected to occur should gravel mining of cobble bar habitat and ATV use of cobble bar habitat continue and/or if additional dams, and channelization projects take place on rivers and creeks that support these species. Cicindela marginipennis, if truly present on just two rivers in the state, could especially face extirpation if gravel mining and other threats are widespread on the two rivers."

Overutilization:

Intensive collecting by private collectors has been noted as a threat to some species of tiger beetle and is a potential threat to Cicindela marginipennis (New York State Dept. of Environmental Protection 2005).

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the Cobblestone Tiger Beetle: though it is listed as state-endangered or state-threatened in several states, these designations do not afford any significant regulatory protection.

While invertebrates like the Cobblestone Tiger Beetle certainly benefit from broader-scale conservation efforts designed to protect vertebrates and other more wide-ranging taxa, many invertebrates are fine-scale habitat specialists, and as such, require more precise, fine-tuned protections (McCollough 1997).

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Scientific Name:
Clonophis kirtlandii
Common Name:
Kirtland's Snake

G Rank:
G2

Range:
The Kirtland's Snake is a small, nonpoisonous snake species found in the Midwestern and Southeastern United States. It is currently known in Illinois, Indiana, Michigan, Missouri, Ohio, and Pennsylvania, though its historical range was significantly larger (NatureServe 2008). Wilsmann and Sellers (1988) reported that Kirtland's snake was once known from more than 100 counties in eight states, but that since 1980, it has been observed in only one quarter of those counties.

Habitat:
The Kirtland's snake occupies wet, relict prairie areas, including prairie fens, meadow wetlands, open and wooded wetlands, seasonal marshes, open swamps, and other water-associated habitat (NatureServe 2008). However, because these habitats are increasingly rare, the snake is currently found most often in urban areas: vacant lots near to streams or wetlands provide the closest approximation of their preferred habitat in most regions. These urban populations are likely remnants of larger populations that have been mostly extirpated by urbanization, although they can be quite abundant (Minton et al. 1983, Minton 2001). A secretive species, C. kirtlandii is most often found beneath debris or underground, often using burrows excavated by other species (Harding 1993). Fossorial habitat is more thermally moderate (fewer temperature extremes), more humid, and provides food resources for this snake, which feeds on earthworms, slugs, and leeches (Wilsmann and Sellers 1988, Conant 1943, Minton 1972).

Ecology:
This species feeds on earthworms, slugs, and leeches (Wilsman and Sellers 1988, Conant 1943, Minton 1972). While the Kirtland's snake regularly consumes native slug species (Deroceras spp.), it will not feed on non-native, introduced European slugs, Limax maximus (Tucker 1994).

Both adults and juveniles aestivate or hibernate during periods of extreme heat or cold, though active individuals have been observed aboveground in all months (pers. comm. as cited in NatureServe 2008). Mating occurs in early summer, and parturition in late summer or early fall; clutch size reportedly ranges from 4 to 15 young (USDA FS 2004, Conant 1943, Tucker 1976).

Populations:
Total population size is unknown but estimated to be at least a few thousand (NatureServe 2008). Dense populations are found in several locations, though the species has declined across its entire range in recent decades (Harding 1997, Barbour 1971). Kirtland's snake was once known in more than 100 counties in eight states, but since 1980 it has been observed in just a quarter of that historical range. Ohio, Illinois, and Indiana contain a significant proportion of the remaining populations (Wilsmann and Sellers 1988). No studies have been conducted on the population biology of this species, which makes determining population viability challenging (USDA FS 2004).

Population Trends:

NatureServe (2008) determined that the Kirtland's snake has experienced major declines (up to 90%) in recent decades, and that popluations continue to decline rapidly.

Status:

NatureServe (2008) reports that the Kirtland's Snake is critically imperiled in Michigan and Missouri (a single record from 1964), imperiled in Illinois, Indiana, Kentucky, and Ohio, and extirpated from Pennsylvania.

It is state-listed as endangered in Indiana, Pennsylvania (last recorded in 1965), and threatened in lllinois, Ohio, and Kentucky.

Habitat destruction:

Development, both residential and agricultural, and all associated habitat loss, fragmentation, and degradation are the primary threats to the Kirtland's snake (NatureServe 2008). Historically, most of the snake's habitat has been lost to agricultural land use (Wilsmann and Sellers 1988), but as urban and suburban sprawl continue to encroach on formerly undeveloped lands, residential development has become a substantial driver of C. kirtlandii's decline. Remnant populations occupy patchy remaining habitat in these developed areas, but are small, isolated, and therefore highly vulnerable to extirpation by further development.

Overutilization:

Collection for the pet trade poses a threat to many populations, and should be prohibited to curtail further losses from this practice (Harding 1997).

Disease or predation:

Natural predators include other snakes, birds, carnivorous mammals, and some fish species (Wilsmann and Sellers 1988). While it is not thought that natural levels of predation exert a significant detrimental force on populations of C. kirtlandii, additive mortality perpetrated by domestic pets present in developed areas may be unsustainable. No data has been collected on diseases that may affect the Kirtland's snake (USDA FS 2004).

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that few occurrences are appropriately protected or managed. A range-wide survey conducted in 1985 indicates that two populations of this snake were located on designated natural areas, and two in wildlife sanctuaries (NatureServe 2008). Though the Kirtland's snake is listed as state endangered, protected, or as a species of special conservation concern in several states, this designation affords no significant regulatory protections to the species. The Kirtland's snake occurs in the Hoosier National Forest (Indiana) and the Huron-Manistee National Forest (Michigan), and is listed as a Regional Forester's Sensitive Species, but management plans are not specifically tailored to this species in any locations (USDA FS 2004).

It can thus be concluded that existing regulatory mechanisms do not adequately protect this rare and declining snake species.

Other factors:

Other factors widely cited in the decline of the Kirtland's snake include:

•Agricultural pesticides that permeate watersheds and soil: Wilsmann and Sellers (1988) report an absence of the Kirtland's snake from habitat contaminated by chemical pollutants. The replacement of natural fire regimes by herbicides as a means of controlling ecological succession also poses a threat to the Kirtland's snake and all other species with which it co-occurs (USDA FS 2004).

•Collection of individuals for the pet trade: Kirtland's snake has been shown to do poorly in captivity – individuals collected can thus be seen as absolute losses to the greater population (Conant 1943)

•Climate change

•Competition from invasive or non-native species (NatureServe 2008)

Additionally, because the burrows excavated by crayfish are so commonly used by C. kirtlandii, activities that harm crayfish or crayfish habitat, such as water pollution or alteration to local hydrological regimes, are also detrimental to this species (USDA FS 2004). The Kirtland snake's environmental specificity is a natural part of its life history that makes it highly vulnerable to habitat losses. In developed areas, the Kirtland's snake is also vulnerable to mortality on roads and in mowed areas, which may have a detrimental influence on population health or persistence: Minton (1972) reports 18 dead C. kirtlandii on 0.4 miles of suburban road (Bavetz 1993, Dalrymple and Reichenbach 1984). Finally, prescribed burns that occur in the summer months when C. kirtlandii is most active may result in direct disturbance or mortality (Seigel 1986).

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Scientific Name:
Cordulegaster sayi
Common Name:
Say's Spiketail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
Say's spiketail resides in the Florida Panhandle and Peninsula south to Gainesville and north to central Georgia (NatureServe 2008).

Habitat:
Eggs and larvae of this species are found in silt of seeps, while adults forage in weedy fields (NatureServe 2008). This dragonfly requires a specific combination of adjacent habitats-- seeps in or near deciduous forest with openings nearby (NatureServe 2008).

Populations:
C. sayi is known from 20 populations in Florida and southeastern Georgia (NatureServe 2008). There are an estimated 250 - 10,000 individuals in toto, with probably hundreds of larvae per site, but relatively few mature.

Population Trends:
NatureServe (2008) reports that this species is declining in the short term, based on a former large colony in Gainesville, Florida being reduced to low density by development.

Status:
Cordulegaster sayi has a very limited range and is threatened by development (NatureServe 2008). Its habitat is more specialized and vulnerable then co-existing gomphids. It also has a specific combination of adjacent habitats that is needed for larvae and adults.The known localities are few and fragmented, and certain populations (Gainesville, Florida) are declining (Abbott, 2007). Its state rankings are FL (S2), GA (S1S2), NC (SNA).

C. sayi was denied listing as Endangered under the Federal ESA "because the taxon presently is not in danger of extinction or likely to become so in the foreseeable future." 60 Fed. Reg. 36380, July 17, 1995.

A Positive 90-day finding was made on October, 26, 1994. 59 Fed.Reg. 53776. This finding was based on the potential devastation of the largest known breeding area by a proposed City of Gainesville flood-control project.

It was a Federal C-2 Candidate species until that list was abolished. The State of Georgia lists Cordulegaster sayi as Threatened. Ga. Comp. R. & Regs. r. 391-4-10-.09.

Habitat destruction:
Pesticides, tree-cutting and subsequent run-off destroy necessary habitat, according to NatureServe (2008). Fields used for feeding are also often altered for development.

Inadequacy of existing regulatory mechanisms:

According to NatureServe (2008), most known sites are publicly owned. In Florida C. sayi occurs in two state parks, a state preserve, two state forests, and a military base. In Georgia it occurs in a state park and a military reservation.

It is considered a Sensitive Species by the U.S. Forest Service (2007).

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Scientific Name:
Coreopsis integrifolia
Common Name:
Ciliate-leaf Tickseed

G Rank:
G1

Range:
The ciliate-leaf tickseed is a rare species endemic to the Southeast United States. It is known from just a few widely scattered locations in northern Florida, southern Georgia, and southeastern South Carolina (NatureServe 2008). Natural heritage records show this species is present in Florida's Calhoun, Jackson, Nassau, St. Johns, and Washington Counties, in Georgia's Calhoun, Camden, Decatur, and Glynn Counties, and in South Carolina's Berkeley, Charleston, and Horry Counties (NatureServe 2008).

Habitat:
This plant occurs on moist sandy banks and low, flat floodplains of rivers and creeks (NatureServe 2008).

Ecology:
The tickseed is a perennial herb that flowers in late summer (NatureServe 2008).

Populations:
There are few populations of this species rangewide, and global population size is not known.

Population Trends:
Trend information is not available

Status:
This species is found in a few widely scattered locations, is considered rare, and is widely threatened by habitat destruction. NatureServe (2008) ranks the ciliate-leaf tickseed as critically imperiled in Florida, Georgia, and South Carolina.

Habitat destruction:
The tickseed is threatened by dams, diversions, and alterations to natural hydrological patterns that may either inundate or dessicate its habitat, by clearcutting in bottomland habitat, and by mowing or herbicide application on roadside verges or right-of-way areas (Chafin 2000, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the ciliate-leaf tickseed - it is listed as endangered in Florida, but this designation affords it no substantive regulatory protections.

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Scientific Name:
Crangonyx grandimanus
Common Name:
Florida Cave Amphipod

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
According to NatureServe (2008) the Florida Cave Amphipod has a range of 100-250 square km (about 40-100 square miles). It is known from 12 counties in Florida, USA. Most of these are in the northern part of the peninsula and the nearby eastern panhandle, with approximately half of the occurrences lying within the Suwannee River drainage. Other sites are clustered in the Woodville Karst region south of Tallahassee, and along the Gulf coast north of Tampa Bay. It is not known west of the Ochlockonee River. The Dade County occurence in southern Florida is an odd outlier.

Habitat:
Crangonyx grandimanus is found in caves, wells, and karst springs (Zhang and Holsinger 2003).

Populations:
NatureServe (2008) grossly estimates that there are between 6 and 80 populations of this species, with 1000 - 2500 individuals. It has been collected from at least 20 sites in 12 counties (Alachua, Citrus, Dade, Gilchrist, Hernando, Leon, Levy, Madison, Marion, Pasco, Suwanne, Wakulla Cos.) in Florida, USA (Zhang and Holsinger, 2003; Walsh, 2001), so it is probable that more occurrences could exist. At least some of the known occurrences are united by a common aquifers. The exact number of individuals is unknown. Although relatively widespread, the species is not common, and population densities appear to be low.

Status:
NatureServe (2008) reports that Crangonyx grandimanus is endemic to Florida, with relatively few known occurrences, most of which are unprotected at present. Its status in Florida is imperiled. It was a Federal C-2 Candidate Species until that list was abolished. The State of Florida classifies it as a Species of Greatest Conservation Need. It is ranked as vulnerable by the IUCN.

Habitat destruction:
NatureServe (2008) states that C. grandimanus is probably sensitive to degradation of aquifers and alteration of detrital flow.

According to Walsh (2001): “Perhaps the most serious potential threat to Florida’s hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species.”

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation. These threats could be avoided by state acquisition of the springs, or through comprehensive land use planning.

Inadequacy of existing regulatory mechanisms:

Crangonyx grandimanus occurs in the caves of Edward Ball Wakulla Springs State Park, and in the springs of Peacock Springs and Manatee Springs State Parks (Florida DEP 2002, 2004, 2007) which provides habitat protection from development but not from pollution or recreation. There are no existing regulatory mechanisms which adequately protect this species.

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Scientific Name:
Crangonyx hobbsi
Common Name:
Hobb's Cave Amphipod

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
NatureServe (2008) reports that the range of Crangonyx hobbsi is less than 100-250 square km (less than about 40 to 100 square miles). It is endemic to Florida , where it occurs mostly in the northern peninsula and adjacent eastern panhandle. It is currently known from 13 counties, including Alachua, Citrus, Columbia, Dade, Gilchrist, Hernando, Leon, Levy, Madison, Marion, Pasco, Suwannee, and Wakulla. It has not been found west of the Ochlockonee River. Approximately half of known sites occur in the Suwannee River drainage. The Dade County occurrence in southern Florida is widely disjunct from others.

Habitat:
This species occurs in subterranean fresh waters in caves and wells in limestone bedrock (Zhang and Holsinger 2003). It is usually found near entrances and detritus.

Populations:
Currently more than three dozen occurrences of this species are known, all in submerged caves in Florida (Walsh 2001). Additional, undiscovered occurrences may exist. Zhang and Holsinger (2003) list Alachua, Citrus, Columbia, Dade, Gilchrist, Hernando, Leon, Levy, Madison, Marion, Pasco, Suwanne, Walkulla Cos. Population size and trend have not been reported.

Status:
Hobb's cave amphipod is endemic to Florida, and although it has a fairly wide range within the state, there are no known protected populations (NatureServe 2008). Its status in Florida is critically imperiled (NatureServe 2008). In 1985, the US Fish and Wildlife Service determined that this species warranted listing under the Endangered Species Act, but was precluded by efforts to list other species. After that, it was a Federal C-2 Candidate Species until that list was abolished. It is ranked as vulnerable by the IUCN.

Habitat destruction:
According to NatureServe (2008), C. hobbsi is potentially susceptible to changes in aquifer water quality and disruption of detrital flow, both as a result of human disturbance.

According to Walsh (2001): “Perhaps the most serious potential threat to Florida’s hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species.”

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation. These threats could be avoided by state acquisition of the springs, or through comprehensive land use planning.

Inadequacy of existing regulatory mechanisms:

Hobb's Cave amphipod may occur in caves on the Ocala National Forest, where it is a USFS Sensitive Species, but this designation provides no regulatory protection for this species. It also occurs in the springs of Peacock Springs and Manatee Springs State Parks (Florida DEP 2002, 2004). No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Croton elliottii
Common Name:
Elliott's Croton

G Rank:
G2

Range:
Elliott's croton is endemic to the coastal plains of South Carolina, Georgia, Alabama, and historically Florida, though the species is now thought to be extirpated from Florida. Natural heritage records indicate C. elliottii's presence in Barnwell, Aiken, and Clarendon Counties, South Carolina, in Barbour, Geneva, and Houston Counties, Alabama, and in Baker, Decatur, and Grady Counties, Georgia (NatureServe 2008). Suitable habitat is present in a very small part of this range.

Habitat:
This plant is found along shorelines and exposed bottomlands, limesink ponds, lakes, and pools, and Carolina bays, with occurrences sometimes extending up into flatwoods, fields, agricultural areas, and pine plantations. Preferred substrate includes sand, sandy peat, and peat. It requires annually fluctuating water levels, and abundance is highest in years with dry spring and summer conditions and flooding during winter months which reduces the abundance of competing perennial species. This plant seems to exploit disturbance to soils, as individuals have been observed flourishing on plowed pond edges (NatureServe 2008).

Ecology:
This plant has specific germination requirements; it prefers dry conditions in spring and summer, and flooding in winter which eliminates competition from co-occurring perennials.

Populations:
Three occurrences of this plant have been confirmed in Alabama, 21 in South Carolina, and approximately 51 in Georgia, though some of these could be consolidated as they are closely occurring (NatureServe 2008). Global population size is unknown, and estimation is complicated by the sporadic nature of this plant's population cycles. Because the species has such precise requirements for germination, population size fluctuates greatly from year to year (Kral 1983).

Population Trends:
NatureServe (2008) and other sources report that this species is in decline across its range, and particularly in Alabama. Several sites in Barnwell County, SC, have not reported any occurrences of this species since 2003, though it was historically present (P. McMillan pers. comm. cited in NatureServe 2008).

Status:
This plant is declining across its already-small range and its habitat is rapidly being degraded or lost to anthropogenic activities. NatureServe (2008) ranks C. elliottii as critically imperiled in Alabama, and imperiled in Georgia and South Carolina.

Habitat destruction:
Disruptions to local hydrological regime (dams, diversions, or drainage) and conversion of habitat to timber plantations, agricultural uses, or residential development are the most imminent threats

to this species (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

The majority of Georgia occurrences are located on the Ichauway Plantation/Joseph W. Jones Ecological Research Center, which is managed so as to maintain natural conditions (prescribed burns), protecting populations of C. elliottii. Beyond this reserve, no other populations of C. elliottii are appropriately protected, and many occur on private lands. No existing regulatory mechanisms adequately protect this species from the habitat loss that imperils it.

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Scientific Name:
Cryptobranchus alleganiensis
Common Name:
Hellbender

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The hellbender once occurred in many eastern states, but has been extirpated from much of its range. AmphibiaWeb (2010) provides this description of the hellbender's historic range: "Historically, hellbenders (Cryptobranchus alleganiensis) were found in the Susquehanna system (Atlantic drainage) in New York, Pennsylvania, and Maryland; tributaries of the Savannah River (Atlantic drainage) in South Carolina and Georgia; the Tenessee system in Georgia, Virginia, Alabama, Mississippi, Tennessee, North Carolina, and Kentucky; and the Ohio system in New York, Maryland, Pennsylvania, Virginia, West Virginia, Ohio, Indiana, Kentucky, and Illinois (eastern hellbenders; C. a. alleganiensis). A second cluster of populations inhabits portions of the Missouri drainage in south-central Missouri; the Meramec (Mississippi drainage) in eastern Missouri; and the White system in southern Missouri and north-central Arkansas (Ozark hellbenders; C. a. bishopi). Cope (1889) listed a specimen in the U.S. National Museum from Des Moines, Iowa, and Firschein (1951b) mentioned an unverified record from the Skunk River (Mississippi drainage) in southeastern Iowa. Others have referred to the hellbender's presence in Iowa (e.g., Hay, 1892; McMullen and Roudabush, 1936), suggesting that Iowa might be within the historical range. Firschein (1951b) convincingly discredited a specimen from Vernon County, Missouri (Arkansas drainage). Two specimens from the Neosho River (Arkansas drainage) in southeastern Kansas (Hall and Smith, 1947) have come under scrutiny. Based on the extreme hiatus between the Kansas records and the nearest verified records to the east, several authors have speculated that these specimens were either introduced (Smith and Kohler, 1977) or are otherwise invalid (Dundee, 1971). Records from the Great Lakes, Louisiana, and New Jersey are certainly invalid and represent introductions or confusion with other species (see summary in Nickerson and Mays, 1973a)."

Habitat:
This salamander occurs in rocky, clear creeks and rivers, usually where there are large shelter rocks. It generally avoids water warmer than 20 degrees C. Males prepare nests and attend eggs beneath large flat rocks or submerged logs (NatureServe 2008).

Ecology:

AmphibiaWeb (2010) provides the following information on the ecology of the hellbender:

"A. Breeding.

i. Breeding migrations. The suggestion by Alexander (1927) that male hellbenders move many km to reach their breeding grounds in the fall has not been supported by recent research. Most authorities agree that no actual breeding migration takes place, although males may move short distances within their home ranges to brooding sites.

ii. Breeding habitat. The breeding season is variable but occurs mainly in September and October, although evidence of breeding activity as late as December and January has been reported for the Spring River in Arkansas (Peterson et al., 1989). Only a few specific breeding dates are given in the literature. Smith (1907) reported egg-laying dates from 28 August–8 September in six consecutive years starting in

1906 in northwestern Pennsylvania. Swanson (1948) stated that egg-laying takes place about the 1 September in Venango County, Pennsylvania. The release of milt from captured males and the presence of gravid females was documented between 7 September–11 October during two years of study in the Blue River of Indiana (Kern, 1986b). Nests with eggs have been reported in the North Fork River, Missouri, on 13 September (Nickerson and Mays, 1973a), and 2 and 8 October (Nickerson and Tohulka, 1986). Dundee and Dundee (1965) noted a nest containing eggs in the Niangua River, Missouri, on 14 November, and Johnson (1981) noted a clump of eggs in the same river on 19 September. Bothner and Gottlieb (1991) reported nests in the Susquehanna River in New York on 10 and 11 September. Green (1934) reported the spawning season of the hellbender in the vicinity of Elkins, West Virginia, to be from the middle of August to early September. The release of milt from captured males was reported from 20 August–11 September in the West Fork of the Greenbrier River in West Virginia (Humphries, 1999). A nest with eggs has also been reported from the Williams River in Webster County, West Virginia, during September 1997 (S. Blackburn, personal communication).

B. Eggs.

i. Egg deposition sites. The beginning of the breeding season is marked by a change in behavior of hellbenders, especially males. They leave their routine hiding places and move around the stream bottom, even during daylight, exploring cavities under flat rocks and crevices or holes in the bedrock (Smith, 1907). Eventually a male occupies a suitable site and may actively prepare a nest by moving gravel to create a saucer-shaped depression (Bishop, 1941b). Peterson (1988) also reported males using a hole in a mud-gravel bank for nesting. The males lie at the opening of their nests, frequently with their heads exposed, waiting for gravid females. Females may enter nest sites voluntarily or they may be forced into the cavity by the male. As soon as the female starts to deposit eggs, the male moves alongside or slightly above the female and sprays the eggs with snowy-white seminal fluid that may take the form of a cloudy mass or ropy chunks (Smith, 1907).

ii. Clutch size. A single female may deposit from 200 to > 400 eggs (Smith, 1907, 1912a; Bishop, 1941b, Nickerson and Mays, 1973a), but this may not represent all the eggs available for oviposition, as > 20% of a female's compliment may be resorbed (Topping and Ingersol, 1981; Petranka, 1998). Males may accept several females into their nest cavity, so the total number of eggs in a single nest may be > 2,000 (Bishop, 1941b). Deposited eggs are often eaten by both males and females (Smith, 1907; Bishop, 1941b). The eggs are yellow, round, approximately 6 mm in diameter, and surrounded by two transparent envelopes. The inner envelope is attached as a solid rope from egg to egg resulting in long egg strings (Nickerson and Mays, 1973a). The eggs swell with water and eventually increase to 18 mm in diameter (Smith, 1912a). It may take > 2 d for a female to expel her eggs, at which time she either leaves the nest or is expelled by the male (Bishop, 1941b). Males usually remain in the nest cavity with the eggs, and both Smith (1907) and Bishop (1941b) witnessed episodes of active nest guarding by males. Bishop (1941b) also observed a brooding male swaying from side to side over the eggs, which may increase the oxygen supply to the eggs. The duration of this brooding period varies, but Smith (1907, 1912a,b) found males attending nests that contained embryos about 3 wk old.

Bishop (1941b) estimated the incubation period at 68–84 d for western New York and Pennsylvania. Peterson (1988) encountered hatchlings in the Niangua River, Missouri, that he believed to be no more than 45 d old. Temperature undoubtedly plays a major role in determining length of embryonic period. Smith (1912) provides the most comprehensive data on embryonic development and should be consulted for details.

C. Larvae/Metamorphosis.

i. Larval stage. Newly hatched larvae are approximately 30 mm TL and are well pigmented dorsally and on the tail. The venter is unpigmented except for the yellow of the yolk sac. The mouth and eyes are conspicuous, the gills are short and flattened, the front limbs terminate in two lobes, and the hindlimbs are paddle-shaped and unlobed (Bishop, 1941b). Development is rapid, and hatchlings double their size during the first year (Bishop, 1941b). Larvae normally lose their external gills in the second summer after hatching, at 100–130 mm TL (Smith, 1907; Bishop, 1941b; Nickerson and Mays, 1973a).

ii. Larval requirements.

a. Food. The diet of larval hellbenders has not been studied but probably includes invertebrates.

b. Cover. Nickerson and Mays (1973a) reported that larval hellbenders utilize small stones and chert for cover. They also reported an anecdotal account of a larval hellbender taken from the interstices of a gravel bed in an area of subsurface percolation. The scarcity of records for larval hellbenders compared to adults supports this suggestion (Kern, 1986c; Petranka, 1998).

iii. Larval polymorphisms. None reported.iv. Features of metamorphosis. The major morphological features of hellbender metamorphosis are the loss of the external gills and the attainment of adult color pattern.

v. Post-metamorphic migrations. None known.

vi. Neoteny. Not reported.

D. Juvenile Habitat. Same as for adults.

E. Adult Habitat. Adult hellbenders are found in fast-flowing streams containing abundant cover in the form of large flat rocks, bedrock shelves and crevices, and logs (Bishop, 1941b; Nickerson and Mays, 1973a).

F. Home Range Size. Home range has been reported in various forms for several populations of hellbenders. Using minimum area convex polygon in Missouri, average home range size was 28 m2 for females and 81 m2 for males (Peterson and Wilkinson, 1996). Coatney (1982) calculated an elliptical home range of 90 m2 for seven Ozark hellbenders radio-tracked nocturnally for 2 wk. In Pennsylvania, average inter-captured distance was 18.8 m for males and 18.7 m for females (Hillis and Bellis, 1971). The mean activity radius for this population was 10.5 m. Calculated as a circular home range, the average home range was 346.4 m2. Linear distance between captures in Tennessee ranged from 5–60 m (Casey et al., 1993). Topping and Peterson (1985) provided evidence for size-specific movement in hellbenders in Missouri. They demonstrated a tendency for upstream movements ranging from 2.3–25.7 m/d. In contrast, Peterson (1987) detected no net movement upstream or downstream in the Niangua River, Missouri. Mean linear movement of hellbenders in a West Virginia stream was 20.1 m, ranging from 0.8–70.2 m between captures at least 1 mo apart (Humphries, 1999).

G. Territories. Home ranges of hellbenders overlap (Peterson and Wilkinson, 1996), but they apparently avoid being in the area of overlap at the same time (Coatney, 1982). However, hellbenders have been observed in close proximity to each other at night without conflict between individuals (Humphries, 1999). Rarely is > 1 hellbender found beneath the same rock except during the breeding season (Smith, 1907; Hillis and Bellis, 1971; Nickerson and Mays, 1973a; Peterson, 1988), and they are known to defend shelter rocks (Peterson and Wilkinson, 1996; Hillis and Bellis, 1971). Hellbenders will utilize rocks recently vacated by other individuals (Hillis and Bellis, 1971; Peterson and Wilkinson, 1996; Humphries, 1999). Male hellbenders become extremely territorial during the breeding season and will defend nest holes or rocks (Smith, 1907; Bishop, 1941b; Peterson, 1988). Blais (1996) reported that during the breeding season in New York, male hellbender's home ranges tended to overlap more than those of females.

H. Aestivation/Avoiding Dessication. Not reported; however, Green (1934) stated that hellbenders in West Virginia moved to deeper holes in summer to find colder water.

I. Seasonal Migrations. See "Breeding migrations" above. Seasonal change in nocturnal activity has been reported in high elevation populations in West Virginia (Humphries and Pauley, in press). Hellbenders were most active during early summer (May–June), with decreased activity in later months. Nocturnal searches with flashlights were most productive in early summer in these populations; however, nocturnal activity shifts have not been reported in other parts of the hellbender's range. Noeske and Nickerson (1979) reported on seasonal changes in activity rhythms in the laboratory.

J. Torpor (Hibernation). In most streams, hellbenders likely become inactive during winter. Overwintering sites in New York included deep pools > 2 m deep, fast-flowing riffles that remained free of ice cover, and deep water pockets within riffles 1.5–2 m deep (Blais, 1996). However, hellbenders sometimes breed in Missouri and Arkansas during winter (Dundee and Dundee, 1965; Peterson et al., 1989).

K. Interspecific Associations/Exclusions. None known.

L. Age/Size at Reproductive Maturity. Sexual maturity is reached from 300–400 mm TL, with males normally maturing at a smaller size than females (Taber et al., 1975), although there is much variation reported in the literature (see Petranka, 1998, for a review). Age at sexual maturity has been estimated at 3–4 yr (Smith, 1907) and 5–6 yr (Bishop, 1941b) for eastern populations and 5–6 yr (Dundee and Dundee, 1965; Nickerson and Mays, 1973a) for Ozark populations.

M. Longevity. Hellbenders have survived as long as 29 yr in captivity (Nickerson and Mays, 1973a). Extrapolations from growth rate data suggest that some large individuals may live as long as 30 yr in nature (Taber et al., 1975; Peterson et al., 1983; Petranka, 1998).

N. Feeding Behavior. Crayfish are the most important food item for hellbenders, as indicated by their position at the top of most food lists in the literature (Smith, 1907; Green, 1935; Bishop, 1941b; Swanson, 1948). Other items that have been recorded include fish, insects, earthworms, snails, tadpoles, fish eggs, other hellbenders, and hellbender eggs (Nickerson and Mays, 1973a)."

NatureServe (2008) provides the following information on hellbender ecology and life history:

"General Description: A large (up to 74 cm) salamander with a broad flattened head, wrinkled, fleshy folds of skin along each side and a conspicuous gill slit (sometimes missing) just in front of each forelimb (Green and Pauly 1987).

Diagnostic Characteristics: Adults differ from other large salamanders by lacking external gills and by their strongly flattened head and body. Larvae have four limbs; external gills; flattened, fleshy toes; a broad, flattened snout; and loose skin along the sides of the noncylindrical body.

Reproduction Comments: Lays eggs in late summer or fall (August, September, early October; e.g., Jensen et al., 2004, Herpetol. Rev. 35:156); winter breeding has been observed in the Spring River, Arkansas (Peterson et al. 1989). Clutch size averages about 350-500; increases with female body length. Several females may oviposit in same site. Males guard developing eggs. Larvae hatch in 1.5-3 months, lose gills about 18 months after hatching. Sexually mature in 5-8 years (Minton 1972, Peterson et al. 1988). Longevity 25+ years.Ecology Comments: In Missouri, 80% of recaptures were within 30 m of tagging site. Also in Missouri, average home range size was 28 sq m in females, 81 sq m in males; there was considerable overlap in the home ranges of both males and females; number of rocks used as shelter ranged from 1 to 13 (Peterson and Wilkinson 1996). In Pennsylvania, home range averaged 346 sq m (Hillis and Bellis 1971).

Populations:

It is unknown how many populations of hellbender are still extant. There are many occurrences in at least several dozen rivers, and the lack of new distributional records since 1995 suggests that relatively few occurrences remain undiscovered (NatureServe 2008). AmphibiaWeb (2010) states: "Because of the secretive nature of hellbenders and their confusion with mudpuppies (Necturus maculosus), the present range is not known with certainty. They are no longer present in Iowa (if they ever occurred there), and they are almost certainly extirpated from the Ohio drainage in Illinois, although there is a verified 1991 record from the Wabash River in White County. Hellbenders have been eliminated from Indiana except for a small population in the Blue River and the lower portions of the South Fork of the Blue River (Kern, 1986a). In Ohio, Pfingsten (1989a) spent 2,000 person-hours searching for hellbenders from 1985–'88 and failed to find any in the Miami River or its tributaries, but did locate them in the other main drainages of the Ohio River. Populations in the remainder of the Ohio drainage are extant, as are most of those in the Tennessee drainage. Green (1934) reported hellbenders to be common in the Ohio River, but not so common in the tributaries near Huntington, West Virginia. Hellbenders were also reported from the Ohio River near Marietta, Ohio (Krecker, 1916). Records for the hellbenders in the Ohio River have not been reported since these early sightings. Humphries (1999) reported hellbenders to still be common in many high elevation streams in West Virginia. Bothner and Gottlieb (1991) studied the distribution and abundance of hellbenders in New York and found the species in both the Allegheny and Susquehanna drainages. The same is true for both systems in Pennsylvania and Maryland (Gates, 1983). No recent data are available for the Savannah drainage populations in Georgia and South Carolina. Populations are also still found throughout the species' historical range in Missouri and Arkansas (Trauth et al., 1992a,b; Trauth et al., 1993b; LaClaire, no date)" (accessed April 12, 2010 at: http://www.amphibiaweb.org).

Population Trends:
Several populations of hellbender have been extirpated, and many others are near extirpation, or dwindling. Anecdotal data indicate that the hellbender is declining across its range. Although quantitative data are not available, the data that are available indicate that this species is in decline, and that some extant populations may no longer be viable. In Indiana, although several nests have been located during the past 11 years, evidence of juveniles has not been found (Nature Conservancy 2010). Concerning the status of the species in Ohio, Lipps (2010) states, "Recent surveys in Ohio by Lipps and Pfingsten have found an 80 percent decline in Hellbender populations compared to the mid-1980's. Nearly all remaining populations are made up of very large (old) individuals, raising concerns about recruitment of new individuals into aging populations." In Georgia, a 2005 survey of all historic hellbender streams found them to be absent at 38 percent of the sites they were originally reported from. Of the historic streams that still contain hellbenders at the original reporting sites, 31 percent were considered "unhealthy," that is, they are not likely to support long-term, viable populations of this species (Jensen and Humphries 2007).

Furniss (2003) reports that due to the life-history characteristics of this species, declines may not become apparent until they are severe, stating "Hellbenders do not reproduce until approximately 7 years of age. Declines being observed presently may be the result of activities that occurred years earlier. Because juvenile hellbenders are rarely observed, it takes many years to detect population trends. The lack of recruitment in most all Ozark hellbender populations is a significant sign that little reproduction has occurred in these populations for several years. Delayed reproduction, when paired with a long life span, can disguise declines until they become fairly severe (Rogers, 2001). The present distribution and status of Ozark hellbender populations in the White and Black River systems in Arkansas and Missouri may be demonstrating the characteristics mentioned above. Genetic studies have demonstrated repeatedly very low genetic diversity in hellbender populations, which may be a factor in the decline of the species. The current combination of population fragmentation and habitat degradation may prohibit this species from recovering without the intervention of conservation measures designed to facilitate hellbender recovery (Rogers, 2001)."

NatureServe (2008) reports that the hellbender has declined by up to 30 percent in the short-term and by up to 75 percent in the long-term, stating: " Compared to historical conditions, the species has significantly declined in population size, extent of occurrence, area of occupancy, and number and condition of occurrences (subpopulations) to a moderate extent (actual degree of decline is unknown but is closer to 25% than to 75%) (Nickerson and Mays 1973, Williams et al. 1981, Minton 2001, Wheeler et al. 2003, Trauth et al. 2004, Phillips and Humphries 2005). Some populations in Illinois (Phillips et al. 1999, Phillips and Humphries 2005), Indiana (Kern 1986, Minton 2001), and Ohio (Pfingsten 1990) have been extirpated. In Indiana, most reductions occurred between 1935 and 1965 (Minton 2001). However, populations are still present in most of the historical range. For example, the species is still common in many high-elevation streams in West Virginia (Humphries 1999). Populations still remain in the Allegheny and Susquehanna drainages in New York (Bothner and Gottlieb 1991) and in those systems in Pennsylvania and Maryland (Gates 1983). The species still occurs throughout the historical range in Missouri and Arkansas (Phillips and Humphries 2005), although a population in the Spring River in Arkansas is nearing extirpation (Trauth et al. 2004). Aside from the Spring River population, good documentation of population declines is scarce (Phillips and Humphries 2005). Assessment of status throughout the range is needed."

AmphibiaWeb (2010) states: "As early as 1957, it was noted that the hellbender's range was rapidly shrinking as a result of human modification of stream habitats (Smith and Minton, 1957). Dundee (1971) listed "siltation, general pollution, and thermal pollution" as being responsible for eliminating the hellbender from "much of the Ohio River drainage, and from other industrialized regions." Bury et al. (1980) mentioned channelization and impoundment of streams and rivers as an agent of decline specifically for Alabama, Maryland, Missouri, Tennessee, and West Virginia. They also cited Nickerson and Mays (1973) when implicating industrialization, agricultural runoff, and mine wastes as contributing factors in Ohio, Pennsylvania, and West Virginia. Other authors have alluded to the range-wide decline in hellbender numbers (Williams et al., 1981; Gates et al., 1985). However, rigorous quantification of effort is lacking in most hellbender surveys, so there are few data to back up these claims. The sole exception of which we are aware, that of Trauth et al. (1992a), documented a drastic decline in hellbenders along the Spring River of Arkansas. They attributed the decline to over-collection of specimens for scientific purposes (see "Predators" above), habitat alteration related to recreational activities, elimination of riparian habitats leading to an increase in the silt burden, and water pollution associated with human occupation and development along the river. Rigorous historical abundance data exist for other streams (see "Historical versus Current Abundance" above) and these areas should be targeted for resurvey."

Historical versus Current Abundance. Historical data on abundance are available for only a few populations and even in those cases, rigorous quantification of effort is lacking. For example, Green (1935) reported catching 34 hellbenders between the hours of 8 (PM) and midnight on 21 June 1934 in the headwaters of the Shavers Fork of the Cheat River (New River drainage of West Virginia). Hellbenders were detected using an acetylene light, but the number of observers or the length of the stream surveyed was not specified. Swanson (1948) reported collecting (and permanently removing) over 650 hellbenders from a 4.8 km (3 mi) stretch of Big Sandy Creek (Allegheny drainage) in Venango County, Pennsylvania, from 1932–'48. Other vague accounts are available for Bear Creek in the Tennessee drainage of northeastern Mississippi (Ferguson, 1961b), French Creek in the Allegheny drainage of northwestern Pennsylvania (Hillis and Bellis, 1971), and the streams in the Ohio River drainage of Ohio (Pfingsten, 1989a).

More rigorously documented abundance data are available for Allegheny River drainage of New York State where Bothner and Goettlieb (1991) performed mark-recapture studies to estimate both abundance and density at eight sites along Ischua Creek, Oswayo Creek, and the Allegheny River. Abundance estimates ranged from 3–58 individuals in study areas that ranged from 424–14,003 m2 of stream bed. A series of mark-recapture studies has been conducted in Missouri starting with Nickerson and Mays (1973b), who estimated abundance at 1,142 hellbenders in a 2.67-km stretch of the North Fork River (White River drainage) in 1969 and 269 hellbenders in a single riffle (4,600 m2) in the same river in 1970. Effort, in person-hours, was recorded as 750 in 1969 and 108 in 1970. Peterson et al. (1983) conducted a mark-recapture study in the same riffle during 1977–'78, and their estimate of 231 fell within the 95% confidence interval of Nickerson and Mays, indicating no change in abundance in that riffle during a 7-yr period. Mark-recapture estimates of hellbender abundance ranging from 0.9–6.1 hellbenders/100 m2 were reported for the Spring and Eleven Point rivers (White River drainage of Missouri and Arkansas) and Big Piney and Gasconade rivers (Missouri River drainage of Missouri) during 1980–'82 (Peterson et al., 1988). Peterson (1987) captured 110 adults in a 2600-m2 study site in the Niangua River in Missouri during 1985. Humphries (1999) conducted a mark-recapture study from 1998–'99 in the West Fork of the Greenbrier River in West Virginia. An abundance estimate of 31 individuals was found within a 216 m stretch of stream. The density in this section was 0.80 individuals/100 m2.

Four streams in the White River drainage of Missouri were surveyed in 1992 (Ziehmer, 1992). Numbers encountered and effort were recorded as follows: Jack's Fork, 4 in 66 person-hours; Current, 12 in 60 person-hours; North Fork, 122 in 49 person-hours; Bryant's Creek, 0 in 22 person-hours. Trauth et al. (1992a) surveyed seven sites on the Spring River (White River drainage of Arkansas) in 1991, including two of the same sites that Peterson (1985) had studied between 1908 and 1982. Trauth et al. (1992a) did not encounter any hellbenders at a site where Peterson had marked 60 and encountered only 5 where Peterson had marked 310. This is the only evidence of decline in a hellbender population that has been documented rigorously in the literature. "

Status:

NatureServe (2008) ranks the hellbender as globally vulnerable because it has a wide range, but many populations have declined or have been eliminated by dams, sedimentation, water pollution, and overcollecting, and better information is needed on the conservation status of this species in much of its range. It is ranked as critically imperiled in Maryland, Mississippi, Illinois, and Ohio, as imperiled in Alabama, Arkansas, Georgia, New York, Virginia, and West Virginia, and as vulnerable in Kentucky, Pennsylvania, and Tennessee (NatureServe 2008). It is classified by the IUCN as near threatened.

Hellbenders are classified as Endangered in Illinois, Indiana, Maryland, and Ohio; Rare in Georgia; Of Special Concern or Species of Concern in New York, North Carolina, and Virginia; Watch List in Missouri; and Deemed in Need of Management in Tennessee (AmphibiaWeb 2010). C.a. bishopi is a federal candidate, and C.a. alleganiensis is a federal Species of Concern. Because the data which are available indicate range-wide decline and ongoing threats, the Center is petitioning for the entire C. alleganiensis species complex.

Concerning C.a. bishopi, Furniss (2003) states: "The viability of the Ozark hellbender is in question. A decline in populations numbers begin in the mid 1980's and was marked by a shift in age structure. Today's hellbender populations have fewer individuals and those left in the population are of a large size, indicating poor recruitment. The population declines of the Ozark hellbender is documented in a study over a 20 period as declining by an average of approximately 70 percent. (Wheeler et al. 2003). The cause(s) for this dramatic decline in population numbers and shift in age structure is unknown."

Habitat Destruction:
NatureServe (2008) reports that the principal threat to the hellbender's survival is degradation of habitat, "including impoundments, channelization, ore and gravel mining, silt and nutrient runoff (e.g., from timber harvest, agriculture, faulty septic and sewage treatment systems), other water pollution, and den site disturbance due to recreational uses of rivers (Nickerson and Mays 1973, Mount 1975:109, Bury et al. 1980, Williams et al. 1981, LaClaire 1993, Phillips et al. 1999, Wheeler et al. 1999, Minton 2001, Trauth et al. 2004). The species depends on cool, flowing, well-oxygenated water, and it needs a coarse (rocky) substrate. In agricultural regions, most of the former rocky habitat has been buried under silt (Phillips et al. 1999). Hellbenders appear to be intolerant of heavy recreational use of the habitat" (NatureServe 2008).

The Arkansas Game and Fish Commission (2005) reports the following threats to the hellbender's habitat: chemical alteration from municipal and industrial point sources, nutrient loading from confined animal feeding operations, grazing, urban development, and point sources, sedimentation from grazing, forestry, road construction, and urban development. The Society for the Study of Amphibians and Reptiles (2000) reports that hellbenders in Arkansas are threatened by deforestation, human alteration of cedar glades, and agriculture, and that populations of hellbenders in the Spring River are severely imperiled.

Jensen and Humphries (2007) report that the hellbender in Georgia is threatened by "the deteriorating quality of habitat resulting from stream impoundment, chemical pollution from agricultural and industrial runoff, and siltation originating from adjacent land disturbance . . . Stream impoundment and thus decreased water flow reduce the dissolved oxygen content necessary for efficient respiration of all stream fauna which do not breathe air. Because hellbenders breathe almost exclusively through their skin, toxic chemicals introduced into streams may become absorbed in their bodies. Acid rain may be another agent of chemical pollution threatening this species. In addition, sedimentation often creates unsuitable habitat by plugging the gaps beneath rocks used for shelter and breeding; suffocation of eggs may occur as a result of persistent sediment influxes." The Georgia Museum of Natural History (2008) lists habitat destruction as a primary threat to the species in Georgia, particularly from siltation, pollution, and impoundment.

The Virginia Department of Game and Inland Fisheries (2010) reports that hellbender habitat in Virginia is threatened by water pollution and impoundments, stating: "Dams eliminate free-flowing sections of rivers and produce low oxygen conditions on the river bottom. Untreated sewage, sedimentation, and chemical runoff from lawns, fields, and parking lots all contribute to a reduction in their populations. Because respiration is through the skin, any toxic substance in the water can have significant adverse health effects. Removal of streamside vegetation and soil disturbance can cause sedimentation. Sedimentation affects hellbender survival by suffocating eggs, filling in hiding places of the young and killing invertebrates, such as crayfish they feed on."

The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that hellbenders in the state are threatened by gravel and sand quarrying, dredging, impoundments, woody debris removal, logging of riparian zones for agriculture and development, channelization, coal mining, road construction, and urbanization.

The Maryland Dept. of Natural Resources (2006) reports that hellbenders in the state are threatened by sedimentation from erosion, mine run-off, dam construction, and pollution. The New York State Department of Environmental Conservation (2005) reports that hellbenders in New York are threatened by channelization, silt loading, pollutants, dams, and bridge construction and repair. Lipps (2010) reports that hellbenders in Ohio are threatened by pollution and degradation of stream habitat, removal of rocks, and stream channelization and damming, and excessive siltation, resulting from the conversion of forests to agriculture and human development. In Indiana, hellbenders are threatened by pollution, siltation, and impoundment (The Nature Conservancy 2010). The Tennesssee Amphibian Monitoring Program (2004) reports that hellbenders in Tennessee are threatened by impoundments and pollution.

Nickerson et al. (2002) report that even in Great Smoky Mountains National Park, hellbenders are threatened by habitat loss and degradation, stating: "Salamander populations have been eliminated within GSMNP streams downstream from road building and areas where road fill was utilized in projects near streams (Huckabee et al., 1975). These salamander kills were associated with lowered pH (4.5-5.9) and increased sulfate and metal concentrations, which occur naturally via leaching of pyritiferous phyllite from geological formations within GSMNP (Huckabee et al., 1975). Disturbances that expose the Anakeesta rock formations eliminate nearly all of a stream's macroinvertebrates as well as aquatic salamander populations (Kucken et al., 1994). The slightly acidic readings within Little River and Noland Creek (Table1), suggest that water quality should be routinely monitored at those and other GSMNP sites. Cryptobranchus alleganiensis have unique respiratory components, including a single hemoglobin that does not show a Bohr effect (Taketa and Nickerson, 1973a, b), therefore, a shift toward a more acidic habitat might negatively affect populations. Crayfish are the major diet of C. alleganiensis throughout their range (Nickerson and Mays, 1973a; Nickerson and Ashton, 1983). The GSMNP streams surveyed had low populations of crayfishes when compared to Ozark streams with high populations of Cryptobranchus (Nickerson, unpubl. data). Several otters (Lutra canadensis) were observed within Little River, and large populations of otters could significantly reduce crayfish populations. Some aspects of fish population management may also be hazardous to Cryptobranchus and Necturus survival. Use of chemicals to reduce "competitive and rough fish" populations are implicated in Cryptobranchus and Necturus declines (Matson, 1990; C J. McCoy, pers. comm). In the past, Pro-noxfish (liquid rotenone) has been used to eliminate fishes from Abrams and Indian Creeks and their tributaries (Lennon and Parker, 1957, 1959). Rotenone undoubtedly affected salamander and macroinvertebrate populations, the latter of which may have been part of the salamander food base. We do not know the effects of electro-shocking on gravid Cryptobranchus, their eggs or larvae" (Nickerson et al. 2002).

In a status report of the eastern hellbender, Mayasich et al. (2003) report: "As early as 1957 it was noted that the hellbender's range was rapidly shrinking as a result of human modification of stream habitats (Smith and Minton 1957). Indeed, destruction and modification of habitat is considered the main threat to hellbender population persistence (Williams et al. 1981a) and to amphibian populations worldwide (Wyman 1990). Dundee (1971) listed "siltation, general pollution, and thermal pollution"as being responsible for eliminating the hellbender from "much of the Ohio River drainage, and from other industrialized regions." Bury et al. (1980) entioned channelization and impoundment of streams and rivers as an agent of decline specifically for Alabama, Maryland, Missouri, Tennessee, and West Virginia. They also cited Nickerson and Mays (1973) when implicating industrialization, agricultural runoff, and mine wastes as contributing factors in Ohio, Pennsylvania and West Virginia. Other authors have alluded to the range-wide decline in hellbender numbers (Williams et al. 1981a, Gates et al. 1985). However, rigorous quantification of effort is lacking in most hellbender surveys so there are few data to back up these claims. Exceptions to this circumstance, that of Trauth et al. (1992) and Wheeler et al. (2003) documented drastic declines in hellbenders along rivers in Arkansas (Ozark hellbender) and Missouri (Ozark and eastern hellbender). Although no data were collected to monitor potential causal factors in theses studies the authors speculated that the declines were attributed to factors such as habitat alteration and degradation, elimination of riparian habitats leading to an increase in the silt burden, and water pollution associated with anthropogenic activities. Siltation: Evidence from studies of amphibian populations in the Pacific Northwest (Welsh and Ollivier 1998) link fine sediment accumulation to reduced densities of Pacific giant salamanders (Dicamptodon tenebrosus) which rely on coarse streambed substrates as larval habitat. Sediment deposition effectively fills interstitial spaces among coarse sediments reducing cover and foraging habitat. Although very little is known about the habitat requirements of larval hellbenders, it is reasonable to suspect that coarse bottom substrates are vital as refugia from predation and as foraging sites. Nickerson and Mays (1973) cite a personal communication from S. Minton in which sediment accumulation is suspected of destroying eggs and juvenile hellbenders (see also Jensen 1999). Prey abundance may also decline as a result of increased siltation. Siltation can also impede the movement of individuals and Routman (1993) speculates that colonization of new habitat will only occur when rivers have low silt loads. Erosion events associated with road construction, timber harvesting and other development activities in riparian habitats may therefore contribute to hellbender population declines by reducing the availability of potentially crucial microhabitat conditions. Impoundment: Because hellbenders breathe primarily through the skin (Guimond 1970) they are dependent on cool, well-oxygenated, flowing water. Construction of dams stops swift water flow and submerges riffles; thereby reducing hellbender habitat and degrading the suitability of the lotic environment through declines of dissolved oxygen concentration and increased water temperature (Jensen 1999). Impoundments also act to fragment hellbender habitat, blocking the flow of immigration and emigration between populations in addition to preventing recolonization from source populations (Dodd 1997). Small, isolated populations are more susceptible to environmental perturbation and demographic stochasticity, both of which may lead to local extinction (Lande 1988, Wyman 1990). Water Quality: Nickerson et al. (2002) cites a study by Huckabee et al. (1975) which implicated lowered pH levels and increased sulfate and metal concentrations as the likely contributor to salamander elimination from streams in the Great Smoky Mountains National Park. Salamander kills occurred downstream from road building projects (Huckabee et al. 1975). Dodd (1997) describes the environmental effects of mining which destroys and alters habitat through toxic pollution, decreased pH levels, and increased siltation. Both acid mine drainage (Humphries 1999) and streambed gravel mining are considered possible threats to hellbender populations. Since hellbenders' primary means of respiration is cutaneous (Guimond 1970), introduced toxins are readily absorbed (Jensen 1999) and can cause either direct mortality or interference with physiological processes, effectively reducing individual fitness and recruitment."

The IUCN (International Union for the Conservation of Nature) (2004) states: "The principal threat to this species is degradation of habitat, since it is a habitat specialist with little tolerance of environmental change (Williams et al. 1981). It breathes primarily (approximately 90%) through the skin (Guimond 1970) and is therefore dependent on cool, well-oxygenated, flowing water. Construction of dams stops swift water flow and submerges riffles. Logging, mining, road construction and maintenance, and other activities, can cause extensive sedimentation that covers the loose rock and gravel important as nest sites, and for shelter and food production. In Illinois, "most former rocky habitat has been buried under silt" (Phillips, Brandon and Moll 1999). Chemical pollutants and acid mine drainage are probably destructive, especially to eggs and larvae. Thermal pollution of water with a consequent oxygen loss would also be detrimental. Several streams in Alabama "have been polluted, impounded, or otherwise modified to the extent that they are, from all indications, incapable of supporting hellbender populations" (Mount 1975). Nickerson and Mays (1973b) noted additional factors they suspected might affect local populations, such as gigging (hunting of the species at night), heavy canoe traffic, dynamiting of large boulders to enhance commercial canoe traffic, and riverside cattle and pig pens. Hellbenders generally are intolerant of heavy recreational use of habitat." The IUCN lists the following threats to hellbender habitat: residential and commercial development, tourism and recreation areas, energy production and mining, quarrying, transportation and service corridors, roads and railroads, logging and wood harvesting, recreational activities, dams and water management, pollution, domestic and urban wastewater, industrial and military effluents, mine seepage, and agricultural and forestry effluents.

Overutilization:

Overutilization is a known threat to the hellbender. Hellbenders are taken accidentally during fishing, intentionally for fishing or for persecution, are collected for the pet and biological trades, and have been overcollected by scientists as well. The viability of small populations of hellbender can be reduced by removal of relatively few adults (NatureServe 2008). Furniss (2003) states, "Because the species is long lived and does not reproduce until approximately age seven, the removal of even a few individuals from a population that is experiencing declines can impact the recruitment potential of that population (Rogers 2001)." Collection is especially harmful to populations that are already declining due to habitat degradation. For example, in West Virginia, where the hellbender is threatened by mountaintop removal coal mining, there is an organized effort by sport groups to eradicate hellbenders because they are believed to be harmful to fish.

Many states list intentional take, persecution, fishing, and recreational use as threats to the hellbender, including Arkansas, Georgia, Kentucky, Maryland, New York, Ohio, Virginia, and Tennessee (Tennesssee Amphibian Monitoring Program 2004, Arkansas Game and Fish Commission 2005, Kentucky Dept. of Fish and Wildlife Resources 2005, New York State Department of Environmental Conservation 2005, Maryland Dept. of Natural Resources 2006, Lipps 2010, Virginia Dept. of Game and Inland Fisheries 2010).

Jensen and Humphries (2007) state, "Anglers who catch hellbenders while in pursuit of sport fish sometimes kill them out of spite, fear, or the erroneous belief that they impact trout populations. Ironically, trout anglers would reasonably be one of this species' best allies since stream impacts that harm the hellbender typically also harm the trout fishery. The introduction of liquid bleach into streams to collect bait salamanders ("spring lizards") is a technique that likely threatens all aquatic life in localized areas, including hellbenders and their prey."

The IUCN (2004) states: "Injuries and deaths sometimes also result when the salamanders are hooked by anglers, and some fishermen still believe that hellbenders are dangerously poisonous and also destroy game fish and their eggs (both beliefs are false), and therefore kill them at every opportunity. In the past, there were even attempts by organized sportsmen's groups in West Virginia to eradicate them. There is some collecting of hellbenders for sale as live animals or as preserved specimens. Over-collecting has been considered a serious threat in some parts; a decline was noted in the early 1990s, apparently due to collecting."

AmphibiaWeb (2010) states, "Man is an important predator, as a result of both commercial collecting and scientific research. Swanson (1948) reported taking over 650 individuals from a 4.8-km stretch of Big Sandy River, Pennsylvania. Peterson (1989) killed 108 hellbenders in the Niangua River, Missouri, in 1974 and 62 from the Spring River, Arkansas, in 1985–'86 for a study of food habits. Ingersol et al.

(1991) killed 127 from the Niangua River in 1979–'80 to document their reproductive cycle. . . Trauth et al. (1992a), documented a drastic decline in hellbenders along the Spring River of Arkansas. They attributed the decline to over-collection of specimens for scientific purposes, habitat loss, and other factors . . . In 1992, a gentleman from Alabama confessed to illegally collecting 100 or more hellbenders from the North Fork of the White River in the mid 1980's to sell to the pet trade. Also, hellbenders are susceptible to anglers, gigging for suckers. Over the years, gigged hellbenders have been found throughout the range of hellbenders in Missouri (Briggler pers. com.)."

Mayasich et al. (2003) state: "The illegal pet trade is a likely threat to eastern hellbenders. Nickerson and Mays (1973) quote live hellbenders as selling for $15 to $35 dollars each in 1972. Although collection for commercial sale is illegal in several states (e.g., Missouri, Ohio, Indiana, Illinois, New York, North Carolina, Virginia, West Virginia), once removed, hellbenders can be legally sold to pet wholesalers in states where restrictions have not been enacted. In 2001 an advertisement in a Buffalo, New York newspaper was selling hellbenders for $50 each (A. Bresich, pers. comm.). Jeff Briggler (pers. comm.) provided an anecdotal report that a single group collected over 100 Ozark hellbender individuals during the 1980s in Missouri and that as recent as the 1990s, hellbenders were still being collected in Arkansas. Traugh et al. (1992) suggested that removal of specimens for "scientific or other purposes" in addition to habitat degradation has contributed to the decline of the Ozark hellbender in Arkansas. There is some indication that extensive scientifically motivated collections may have negatively impacted hellbender populations. Mike Pinder (VA Dept. of Game and Inland Fisheries, pers. comm.) described hellbender removal by a university teacher for sale to biological supply companies. Gates et al. (1985) suggest that recreational fishing may have a negative impact on hellbender populations due to an unfounded animosity towards hellbenders which are thought to be poisonous and/or to interfere with fisheries production. The extent and impact of this threat is difficult to gauge."

The Nature Conservancy (2010) states, "As a large but apprehensive amphibian, the adult hellbender's main threat is man. An angler using live bait may accidentally hook one or may unknowingly destroy their nests while trudging along the riverbed. Then there are those who search to capture the hellbender to keep them as pets or sell them to pet stores."

Disease or predation:

Hellbenders are increasingly threatened by both disease and predation. NatureServe (2008) states: "Some recent studies found open sores, tumors, and missing limbs and eyes in hellbenders in the Spring and Eleven Point rivers in the Ozark region (see Wheeler et al. 2002, Trauth et al. 2004). The cause of the abnormalities is unknown. AmphibiaWeb (2010) reports that captive hellbenders are often infected by water mold (Saprolegnia sp.) (AmphibiaWeb 2010). Briggler et al. (2007) report that chytrid fungus now threatens wild hellbender populations, stating: "Both eastern (Cryptobranchus alleganiensis alleganiensis) and Ozark hellbenders (Cryptobranchus alleganiensis bishopi) have experienced marked population decline with an average of 77% since the 1970s. Data reveal a shift in age structure of hellbender populations, with larger, mature individuals being most prevalent and young age classes being virtually absent . . .One emerging threat that has received increased attention in the past few years is the prevalence of amphibian chytrid fungus, Batrachochytrium dendrobatidis (Bd). In March 2006, captive-reared hellbenders, which were raised from eggs collected from two rivers in Missouri in 2002, tested positive for Bd. Tests for Bd on hellbenders in the wild began and immediately yielded positive confirmation of Bd on hellbenders. With this new discovery, additional information has been collected over the past two field seasons to document the frequency and distribution of this fungus on hellbenders in Missouri. This fungus was found on hellbenders in five of the eight rivers surveyed in 2006 and 2007. Positive Bd results were found in three Ozark hellbender rivers and two eastern hellbender rivers with the majority of the infected animals occurring in Ozark hellbender rivers. Positive animals tended to be isolated to a few locations on each river, and frequency of infection was between 2% and 25% of hellbenders tested. Infected animals' total length ranged from 26.5 cm to 51.5 cm with longer hellbenders having higher average infection rates."

Hellbenders may be particularly vulnerable to disease because they exhibit low genetic diversity and are distributed as small, isolated populations (Furniss 2003). Concerning the threat of disease to hellbenders, Furniss (2003) states: "The majority of hellbenders captured in the past few years have an alarming number of abnormalities; mainly the absence of toes with exposed flesh (Trauth pers. com.). Although the causes of these abnormalities are unknown, some type of disease might be involved." Mayasich et al. (2003) state: "Nickerson and Mays (1973) describe various fungi, protozoans, nematodes, trematodes, cestodes, acanthocephalans, and annelids (leaches) as hellbender parasites. Krecker (1916) reported the worm Filaria cingula to be a skin parasite of C. alleganiensis. These factors can adversely affect individual eastern hellbenders although relative to the threatening factors associated with habitat degradation, it is doubtful that they have negatively impacted populations of eastern hellbenders, significantly. However, the cumulative effects of multiple environmental and biological stressors may increase hellbender mortality rates. For example, Kiesecker et al. (2001) describe how climate-induced changes in UV-B exposure increase susceptibility to pathogen outbreaks in western United States amphibian populations" (Mayasich et al. 2003)."

Hellbenders are also threatened by predation, especially in conjunction with other threats including habitat loss, collection, and disease. Furniss (2003) states: "Within their natural range, most aquatic plants and animals are kept in check by the powerful forces of competition, predation, and disease. If moved to new regions, however, these aquatic species may be freed from their normal biological and physical constraints, and spread unfettered. They displace native aquatic plants and animals, disrupt ecological processes, upset the stability of ecosystems, and can permanently change our natural landscapes. In the past decade, numerous publications have indicated the negative impacts that non-native trout have on native species with the majority of the work focusing on amphibian assemblages in mountain lakes Conservation Assessment for Ozark hellbender (Cryptobranchus alleganiensis bishopi) (Bradford 1989, Bradford et al. 1993, Brana 1996, Frank and Dunlap 1999, Knapp and Mathews 2000). Although there has not been any direct evident of the effects of trout on hellbenders; other species of salamanders have been impacted by trout (Tyler et al. 1998a and 1998b, Rundio and Olson 2003). Salamanders have developed the ability to respond (fright response) to chemical cues of known predators. Recent evidence by Unger (2003) indicates that hellbender larvae from Missouri do not show a fright response to chemical cues by trout. Thus, indicating that larvae hellbenders would not adjust their behavior to trout and therefore, trout could decrease the survival of hellbender larvae. Since trout and hellbender habitats overlap in Missouri and Arkansas, further investigation is warranted."

Mayasich et al. (2003) state: "Nickerson and Mays (1973) contains thorough accounts of hellbender predators and parasites. They identify northern pike and muskellunge, turtles and water snakes, and humans as hellbender predators. Over one third of the state agencies contacted, speculated that introduced game fish may have detrimental effects on hellbender populations."

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that several occurrences of hellbender are somewhat protected because they occur on public lands, but that these habitats may still be negatively impacted by water pollution emanating from upstream portions of the watershed. Occurrence on public lands also does not prevent the hellbender from being negatively affected by logging projects or other actions, for example,

hellbenders in Great Smoky Mountains National Park have been negatively affected by agency actions (Nickerson et al. 2002).

The hellbender is listed by several states, but these listings provide protection only from collection, not from habitat destruction. Although collection for commercial sale is illegal in several states (e.g., Missouri, Ohio, Indiana, Illinois, New York, North Carolina, Virginia, West Virginia), once removed, hellbenders can be legally sold to pet wholesalers in states where restrictions have not been enacted. Further, even in areas where hellbenders are collected, enforcement is inadequate to protect the species.

AmphibiaWeb (2010) states: "Hellbenders are classified as Endangered in Illinois, Indiana, Maryland, and Ohio; Rare in Georgia; Of Special Concern or Species of Concern in New York, North Carolina, and Virginia; Watch List in Missouri; and Deemed in Need of Management in Tennessee. The actual degree of protection each of these designations afford varies by state, but generally, Endangered status requires that a permit be secured before a hellbender can be captured and provides penalties for possessing hellbenders without such a permit. The other categories listed above do not afford this level of protection, but do allow for some acknowledgment that the future of the species within their boundaries is not totally secure. Other states such as Alabama, Arkansas, Kentucky, Mississippi, South Carolina, and West Virginia track hellbender distribution records in a database, but do not generally afford them protection from take. Pennsylvania apparently neither tracks hellbender records nor protects them from take."
Mayasich et al. (2003) report that existing regulatory mechanisms that could protect the hellbender are not being implemented and enforced, stating: “Existing regulatory mechanisms merit some discussion here because they are coupled with most of the anthropogenic activities that manifest themselves as threats to the eastern hellbender. The Clean Water Act has provisions to address the water quality requirements of the eastern hellbender and the National Environmental Protection Act (NEPA) addresses land-use issues that affect eastern hellbender habitat. The provisions of the Federal Insecticide Fungicide Rodenticide Act (FIFRA) minimize the risks associated with pesticide use. In and of themselves, these regulatory mechanisms appear appropriately focused and sufficiently robust to prevent or control the human activities that are potentially hazardous to eastern hellbenders. However, given the threats to eastern hellbender populations presented above, implementation and enforcement of existing regulatory mechanisms appears to be problematic. Proving that a direct “take” will occur because of a specific land use activity is often difficult, but most certainly the cumulative effects of increased development, logging, and mining has made survival more difficult for hellbenders (E.Thompson, pers. comm.). Many states have afforded the eastern hellbender some level of protective status). However, the extent to which overutilization is reported indicates that implementation and/or enforcement of these protective measures is lacking."

Similarly, Furniss (2003) states: "The states of Arkansas and Missouri prohibit the taking of Ozark hellbenders for any purpose without a state collecting permit. However, enforcement of this permit requirement is difficult. Additionally, state regulations do not protect hellbenders from other threats. Existing authorities available to protect riverine ecosystems, such as the Clean Water Act (CWA), administered by the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers, may not have been fully used to prevent instream activities and the resulting habitat degradation. This may have contributed to the general habitat degradation apparent in riverine ecosystems and loss of populations of aquatic species in the southeast. Although the Ozark hellbender coexists with other federally listed species throughout parts of its range, listing under the Endangered Species Act would provide additional protection, as the threats to hellbenders and the other endangered species are not identical. Federal permits would be required to take the species, and federal agencies would be required to consult with the Service when activities they fund, authorize, or carry out may adversely affect Ozark hellbenders (Rogers, 2001)."

Other factors:

The hellbender is threatened by several other factors. Many populations are now small and isolated, making them vulnerable to stochastic genetic and environmental events. NatureServe (2008) states: "Many populations have become reduced to the point at which the usual problems associated with small population size come into effect. Fragmentation of populations as a result of habitat loss/degradation is making it increasingly unlikely that extirpated populations can be reestablished through natural dispersal."

The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that hellbenders in the state are threatened by stochastic events such as droughts, unusual weather, pine beetle damage, and flooding. An exceptionally large flood event may have contributed to the decline in the Spring River, Arkansas (Trauth et al. 1999). This species has also experienced unexplained declines in some areas (KY Dept. of Fish and Wildlife Resources 2005).

Concerning other factors which threaten the species, Mayasich et al. (2003) state: "Among other threatening factors, there is some indication that hellbender populations suffer from low genetic variability, that recruitment is limited by endocrine disruption, and that adverse effects could result from a complex of interactions associated with global climate change . . . Hellbenders display lower allozyme variation than other salamanders, suggesting a reduction in genetic variation in their evolutionary history (Merkle et al. 1977, Shaffer and Breden 1989, Routman 1993). Shaffer and Breden (1989) attributed this low allozyme variation to the nontransforming nature of hellbender life history and suggest that non-transforming species which are generally restricted to aquatic habitats are subject to genetic bottlenecks more often than more terrestrial, metamorphosing species. Routman (1993) found within-population mitochondrial DNA (mtDNA) to be less variable than variation in mtDNA between populations, possibly as a result of a severe genetic bottleneck followed by rapid mtDNA evolution with gene flow between rivers remaining lower than within a given river. Routman (1993) also hypothesized that high silt loading may be an impediment to gene flow since it prevents migration and reduces the availability of cover and breeding sites. This hypothesis is based on the logic that sedimentation and dissolved oxygen are negatively correlated and that because sedimentation tends to increase in downstream reaches of lotic systems, hellbender migration is impaired. These small, and increasingly isolated hellbender populations may continue to suffer from decreasing within-population diversity as inbreeding among close relatives, which can lead to problems such as reduced fertility and fitness, increases in likelihood (Noss and Cooperrider 1994). Similarly, the random loss of adaptive genes through genetic drift may function to limit the ability of hellbenders to respond to changes in their environment (Noss and Cooperrider 1994). Small population sizes and inhibited gene flow between hellbender populations may increase the likelihood of local extinction (Gilpin and Soulé 1986). As previously mentioned, hellbenders are long-lived species capable of living up to 30 years (Nigrelli 1954, Taber et al. 1975, Petranka 1998) with sexual maturity estimated at around 4-5 years (Smith 1907, Bishop 1941). Negative aspects associated with delayed reproduction include the risk of death prior to reproduction and lengthened generation times (Congdon et al. 1993). Hellbender specimens less than five years of age are uncommon (Taber et al. 1975, Pfingsten 1990) and recent research has indicated that a shift in age structure has resulted in the prevalence of older individuals (Pfingsten 1990, Wheeler et al. 2003). For example, A. Bresich (pers. comm) reported that data complied by the Endangered Species Unit in the state of New York include approximately 150 records of eastern hellbenders from 1883 to present. Almost all of these were for mature adults and 20 reports include reference to eggs and three indicate that eggs were hatching into larvae. However, there are no reports of finding larvae in New York other than when associated with hatching eggs (A. Bresich, pers. comm.). Likewise, R. Pfingsten (pers. comm.) reported that larvae have not been detected in Ohio waters. He speculated that eastern hellbenders may not be highly dependent on recruitment in order for a population to remain extant, simply because of their longevity. However, empirical and theoretical evidence suggests that the amount of generation overlap within a population (i.e., high survivorship among juveniles) is necessary to maintain stable populations (Congdon et al. 1993, Ellner and Hairston 1994). Lack of sufficient recruitment may be limiting population stability as well as the ability of hellbender populations to maintain genetic diversity as alteration of habitat quality occurs within their range (Wheeler et al. 2003). However, Pfingsten (1990) also cautions that lack of larvae detection could mean that they occupy an unknown microhabitat that has yet to be surveyed. The disruption of endocrine system functions by anthropogenic chemicals may play a role in the near absence of recruitment observed in hellbender populations by causing developmental abnormalities in sexual organs (Colborn et al. 1993). For example, Guillette et al. (1994) found permanent modification of American alligator (Alligator mississippiensis) gonads as a response to estrogen mimicking compounds released into aquatic habitat. Guillette et al. (1994) suggest that these chemicals effectively alter sexual development and result in declining reproductive success. Dr. Yue-Wern Huang at the University of Missouri-Rolla is currently working to develop techniques for monitoring hellbender exposure to endocrine disruptors in Missouri waters (see http://web.umr.edu/~huangy/research.htm for proposal abstract). Climate Change: Dodd (1997) has thoroughly reviewed threats to amphibians of the southeastern states. In addition to addressing the factors listed above, he presents discussions on other factors and activities that conceivably could impact eastern hellbenders; e.g. climate change, low pH (water), and UV-B radiation. Increasing air and water temperatures over the past 30 years are thought to have had serious influence on declines of amphibian populations worldwide (Pounds 2001). Reliance on cool, well oxygenated streams may inhibit the ability of eastern hellbenders to acclimate to higher water temperatures. Changing precipitation patterns have resulted in reduced water depths which may have dried up critical hellbender habitat or increased the amount of UVB radiation penetrating the water column. Kiesecker et al. (2001) documented the connection between pathogen outbreaks in amphibian populations and climate-induced changes in water depth and UV-B exposure. Kiesecker et al. (2001) acknowledge the complex interactions between global climate trends and ecological responses at the local level to UV-B radiation. However, caution must be used when assigning causal relationships between climate change and amphibian declines since the pathways are not fully understood (Pounds 2001). Furthermore, the role of locally mediated interactions with global climate fluctuations must be considered when attempting to predict ecological responses such as population declines (e.g., Kiesecker et al. 2001)."

Similarly, Furniss (2003) states: “Certain population characteristics of Ozark hellbenders cause the species to be fairly vulnerable to extirpations and extinction. The Ozark hellbender, having specialized habitat requirements, is extremely vulnerable to environmental perturbations. When populations are small, they are less likely to rebound following these perturbations. In addition, Ozark hellbenders exhibit very low genetic diversity (Merkle et al. 1977, Wagner et al. 1999). This genetic uniformity is consistent with habitat specialization (Nevo 1978, Wagner et al. 1999). Ozark hellbenders have adapted to a relatively constant environment, and therefore several structural, behavioral, and physiological specializations have resulted (Williams et al. 1981). These specializations, in combination with the stable environment, seem to have resulted in very low levels of genetic diversity (Wagner et al. 1999). This has been exacerbated with the fragmentation of populations by impoundments, habitat degradation, and other impediments to dispersal. Without the level of interchange the hellbender experienced historically, many small, isolated populations do not receive the influx of new genetic material that once occurred. As the populations decrease in size, genetic diversity is lost and inbreeding can occur, which may result in decreased fitness, and the loss of genetic heterozygosity can result in a significantly increased risk of extinction in localized natural populations (Saccheri et al. 1998). With fragmentation, local extinctions cannot be repopulated (Rogers, 2001). Ozark hellbenders do not reproduce until approximately 7 years of age. Declines being observed presently may be the result of activities that occurred years earlier. Because juvenile hellbenders are rarely observed, it takes many years to detect population trends. The lack of recruitment in most all Ozark hellbender populations is a significant sign that little reproduction has occurred in these populations for several years. Delayed reproduction, when paired with a long life span, can disguise declines until they become fairly severe (Rogers, 2001). The present distribution and status of Ozark hellbender populations in the White and Black River systems in Arkansas and Missouri may be demonstrating the characteristics mentioned above. Genetic studies have demonstrated repeatedly very low genetic diversity in hellbender populations, which may be a factor in the decline of the species. The current combination of population fragmentation and habitat degradation may prohibit this species from recovering without the intervention of conservation measures designed to facilitate hellbender recovery (Rogers 2001)."

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Scientific Name:
Crystallaria asprella
Common Name:
Crystal Darter

G Rank:	AFS Status:	IUCN Status:
G3	Special Concern	VU - Vulnerable

Range:
Historically the Crystal Darter was found in the Mississippi River basin, from Wisconsin (Becker 1983) and Minnesota east to Ohio (Trautman 1981) and West Virginia (Cincotta and Hoeft 1987, Osier 2005) and south to southern Mississippi (Ross 2001), northern Louisiana, and southeastern Oklahoma (Miller and Robison 2004), and the Gulf slope in the Escambia, Mobile Basin, and Pearl River drainages (Page and Burr 1991, Ross 2001, Boschung and Mayden 2004). The species is now absent from much of its former range, including almost all of the northeastern portion of the range in Ohio (Trautman 1981), Indiana, Illinois (Smith 1979), Tennessee (Etnier and Starnes 1993), and Kentucky (Burr and Warren 1986), and it has apparently disappeared from much of the upper Mississippi River basin. It is rare in Wisconsin (Becker 1983), Minnesota, Iowa, and Missouri (Pflieger 1997) (NatureServe 2008).

Habitat:
The crystal darter is found in clear to slightly turbid water of raceways and swift to moderately swift riffles of small to medium rivers with expanses of clean sand or gravel. This fish is intolerant of mud or clay substrates and avoids areas of submerged vegetation (Etnier and Starnes 1993, Pflieger 1997, Ross 2001, Boschung and Mayden 2004). It is usually found in water more than 60 centimeters deep (NatureServe 2008).

Populations:
There are now fewer than 100 extant occurrences of this once widely distributed fish. Total adult population size is unknown but is presumably at least several thousand. The crystal darter is common in only a few streams; it is localized and generally rare (Page and Burr 1991). In Missouri, where it was never common, most records are represented by three or fewer specimens (one collection of 11 specimens) (Pflieger 1997). Crystal darters appear to be rare in the Elk River, West Virginia; Osier (2005) captured only two specimens during 20 sampling occasions during 2002-2004.This species is not easily detected using standard fish survey methods (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this species has declined in the short-term by up to 30 percent, and in the long-term by up to 50 percent. It has been extirpated from 5 states in the northeastern portion of the historical range. In Iowa, recent records are available from Turkey Creek and pools 9 and 11 of the Mississippi River. This species is declining in most areas (Mayden, pers. comm., 1994; Burr, pers. comm., 1993; Douglas, pers. comm., 1993; Shute, pers. comm., 1993; Ross 2001, in NatureServe 2008). With continued habitat exploitation and degradation, the decline is expected to continue (Mayden, pers. comm. 1994 in NatureServe 2008). In Alabama, the darter's conservation status has deteriorated since the late 1970s, and the extent of suitable habitat continues to decline (Boschung and Mayden 2004). Lyons (pers. comm., 1994) characterized Wisconsin populations as rare but probably stable. Some populations in the southern portions of the range may be stable (Stewart, pers. comm., 1993 in NatureServe 2008). Populations tend to

fluctuate. A population may appear abundant in a locality for a time and then be essentially absent (Shute, pers. comm., 1994 in NatureServe 2008).

Status:

The crystal darter is extirpated in Illinois and Indiana, critically imperiled in Florida, Iowa, Mississippi, Missouri, and Wisconsin, imperiled in Arkansas and Louisiana, and vulnerable in Alabama and Minnesota (NatureServe 2008). NatureServe's ranking of this species as vulnerable in Alabama is contradicted by Boschung and Mayden's ranking of this fish as threatened in the state. NatureServe ranks this species as vulnerable globally (G3) but this rank does not appear to reflect the species actual status because it is discontinuously distributed, rare, declining, and threatened by ongoing habitat loss and degradation. Concerning the conservation status of this species, Boschung and Mayden (2004) state: "The crystal darter is considered a species of special concern throughout its range; threatened in Florida, and extirpated in several states, having last been seen in Illinois in 1901, Ohio in 1925, Kentucky in 1929, and Tennessee in 1939. It is no longer abundant anywhere in Missouri. It was last collected in the Pascagoula River system in 1933, although what appears to be suitable habitat is still there. Discovery of crystal darters in the Kanawha River in West Virginia offers hope for the survival of the species in the Ohio River basin." (However, in West Virginia this species is highly threatened by coal mining). Boschung and Mayden continue, "The Mississippi River, however, is probably no longer an effective dispersal pathway for the crystal darter because of its increased silt load. The populations remaining in the Mobile Basin are isolated from one another by dams and silty impoundments. Genetically the isolated populations of the crystal darter are highly divergent from one another (Wood and Raley 2000). Every disjunct population examined by those authors is identified as an independent evolutionary lineage and warranting protection. The Elk River population in West Virginia is critically imperiled and is the most divergent lineage within the species. In Alabama, suitable habitats for the crystal darter continue to dwindle. It is now essentially limited to the main channel of the lower Cahaba, lower Tallapoosa, and Conecuh rivers. Despite its widespread imperilment, the crystal darter has no federal status. Only time will tell whether the few individuals in the Tombigbee and its major tributaries represent viable populations or stragglers destined for extirpation. Because the crystal darter's overall wellbeing in Alabama has worsened since the late 1970s, we recommend threatened status" (p. 484, internal citations omitted).

Habitat destruction:

The crystal darter now occurs as declining, fragmented populations that are highly vulnerable to extirpation from habitat loss and degradation.

Jelks et al. (2008) list habitat loss and degradation as the primary threat to the crystal darter.

NatureServe (2008) reports that this fish is threatened by "siltation and other forms of pollution from urbanization, strip-mining, logging, natural gas exploration, and improper agricultural practices, as well as stream alteration projects, such as damming, dredging, and channelization. Dredging for navigation is believed to be a major threat in the upper Mississippi River system. Waterway construction has destroyed and degraded habitat in some areas. Construction of the Tennessee-Tombigbee Waterway, which connected the Tennessee and Tombigbee drainages, was followed by declines in crystal darter populations (Ross 2001, Boschung and Mayden 2004). . . The Mississippi River probably no longer serves as an effective dispersal corridor due to its increased silt load (Bauer and Clemmer, pers. comm., cited by Boschung and Mayden 2004). In the lower Cahaba River, Alabama, the species is threatened by increased siltation and eutrophication perpetuated by upstream urbanization and strip mining (Boschung and Mayden 2004). Populations remaining in the Mobile Basin are isolated from one another by dams and silty impoundments (Boschung and Mayden 2004). This fish requires swift moving currents and therefore is susceptible to water flow modifications (dams, etc.). Altered flows due to hydropower dams are a possible problem in the lower Chippewa and St. Croix rivers in Wisconsin (Lyons, pers. comm., 1994 cited in NatureServe 2008). Crystal darters are relatively tolerant of nondestructive intrusion, though heavy recreational use of habitat potentially could be excessively disruptive."

In the Appalachian region, the crystal darter is threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009). Boschung and Mayden (2004) state that the discovery of crystal darters in the Kanawha River in West Virginia offers hope for the survival of the species in the Ohio River basin, but these populations are directly threatened by mountaintop removal. Wood and Raley (2000) found that the Elk River population in West Virginia is critically imperiled and is the most divergent lineage within the species, making coal mining activity in West Virginia a direct threat to the genetic diversity of this species.

The Arkansas Game and Fish Commission (2005) reports that this species is threatened by channel alteration and maintenance, dams, confined animal feeding operations, agriculture, and grazing.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect this species or its habitat. NatureServe (2008) reports that few (1-3) occurrences of this species are appropriately protected and managed, stating: "At least one site is known to be protected, the lower Bayou Pierre complex in Claiborne and Copiah counties, Mississippi. For the most part, the species is protected from harvest, but generally there is no protection from upstream siltation or pollution sources. Protection from erosion and point-source pollutants should encompass entire watersheds. Broad riparian buffer strips, stiff enforcement of enhanced pesticide regulations, upland erosion control, and modern pollution control systems may be needed to prevent habitat degradation in some areas. Threats from dredging, toxic spills, and regulated flows from hydropower dams need to be addressed. Beneficial management practices include those that limit and/or control activities such as stream channelization, impoundment, removal of riparian vegetation, and careless agricultural practices (Bauer and Clemmer 1983)."

Other factors:

The crystal darter is potentially threatened by the introduction of nonindigenous fish species (Bauer and Clemmer 1983, NatureServe 2008). It is also vulnerable to stochastic genetic and environmental events because of its distribution in localized populations (NatureServe 2008). Across its range, this fish is threatened by water pollution from a variety of sources.

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Scientific Name:
Cumberlandia monodonta
Common Name:
Spectaclecase

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	NT - Near threatened

Range:
The Spectacle Case Pearly Mussel historically occurred in a 5000-20,000 square km area in 45 streams in 15 states in the upper and lower Mississippi (Mulberry, Ouachita Rivers), lower Missouri, Ohio, Cumberland, and Tennessee River Systems (Butler 2003, USFWS 2003, NatureServe 2008). Currently this mussel is only found in riverine reaches downstream of Wilson and Guntersville Dams (Mirarchi et al. 2004). The species is still extant in 20 stream systems in 10 states and 3 Service regions: Alabama (Tennessee River), Arkansas (Mulberry, Ouachita Rivers- both single sites only; Harris et al., 1997), Illinois (Mississippi, Ohio Rivers), Iowa (Mississippi River), Kentucky (Ohio, Green Rivers), Minnesota (Mississippi, St. Croix Rivers; Rush Creek), Missouri (Mississippi, Meramec, Bourbeuse, Big, Gasconade, Big Piney Rivers; Osage Fork), Tennessee (Tennessee, Clinch, Nolichucky, Duck Rivers; Caney Fork), Virginia (Clinch River), West Virginia (Kanawha River), and Wisconsin (Mississippi, St. Croix, Chippewa Rivers). Ahlstedt et al. (2004) recently reported sporadic occurrences (two recent) from the lower Duck River in a reach less than 30 miles long with historical occurrences in the upper Duck as well (NatureServe 2008). Though this species is widely distibuted, it is absent from many historical locations and is now disjunctly distributed.

Habitat:
In comparison to other mussels, the Spectaclecase is a habitat specialist, occurring in large rivers in microhabitats that are protected from the main current, often in outside river bends below bluffs (Baird 2000). Substrates which support this species include gravel, cobble, sand, mud, and boulders, but the species tends to be found in firm mud between large rocks (Stansbery 1967). The mussel occurs in relatively shallow riffles and in shoals with currents ranging from slow to swift, and may prefer quiet water near the current interface (Stansbery 1967, Buchanan 1980, Parmalee and Bogan 1998, Baird 2000, NatureServe 2008). Most mussel species may move around to some degree, but the Spectacle Case seldom moves except to burrow more deeply into the substrate (Oesch 1995, NatureServe 2008). Stranding during drought conditions can lead to death (Oesch 1995, NatureServe 2008). This mussel requires suitable water quality and appropriate host fish for reproduction.

Ecology:
The Spectaclecase is a short-term brooder which is gravid in April and May. White feathery conglutinates have been observed, but it is not known if they were host attractants or merely aborted glochidial contents. Glochidial hosts have not been experimentally determined, but glochidia have been observed on bigeye chub and shorthead redhorse. This mussel often occurs in dense beds, with local densities of 120 per square meter having been reported (Mirarchi et al. 2004).

Populations:
The spectaclecase is known from 20 streams in 10 states (NatureServe 2008). This species is missing from hundreds of river miles and from numerous reaches of historical habitat. Seven of the 20 extant populations consist of only a single individual. In Arkansas where this species was thought to be

extirpated, it is only known from two sites in the Ouachita River that consist of one individual each and a lone site in the Mulberry River with one individual (Harris et al. 1997).

Relatively strong populations of this species survive in the Meramec and Gasconade Rivers in Missouri, in the St. Croix River in Minnesota/Wisconsin, and possibly in the Upper Clinch River in Tennessee (Butler 2003, USFWS 2003), but data from the Tennessee Valley Authority indicate a rapid decline in the Upper Clinch (NatureServe 2008).

Population Trends:
The spectaclecase is very rapidly to rapidly declining in the short term and substantially declining in the long term (50-75 percent). There has been documented rapid decline throughout its former range, except in the Gasconade River, Missouri. In many streams this species has not been reported for decades, and several populations are comprised of single individuals (Butler 2003). In Illinois where it was formerly present in eight drainages, it is now restricted to the Ohio and Mississippi Rivers where it is sporadic and very rare (Cummings and Mayer 1997). The species is absent from hundreds of river miles and from numerous reaches of habitat in which it occurred historically (NatureServe 2008). This mussel's range has been drastically reduced (near 50 percent) and populations continue to decline with many remaining populations with poor or no viability.

Status:
The Spectaclecase is presumed to be extirpated (SX) in Indiana, Kansas, and Ohio, and is critically imperiled (S1) in Alabama, Arkansas, Iowa, Illinois, Kentucky, Virginia, Wisconsin, and West Virginia. It is imperiled (S2) in Minnesota and Tennessee, and is vulnerable (S3) in Missouri (NatureServe 2008). Many populations have been extirpated for decades, and most surviving populations face significant threats (NatureServe 2008). It is a federal candidate species and warrants full protection before populations decline to the point that recovery is impossible. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
The spectaclecase has declined primarily due to habitat loss and degradation. The major causes of habitat loss for this species are impoundments, channelization, mining, and sedimentation (Williams et al. 1993, Neves 1993, Neves et al. 1997, Watters 2000). NatureServe (2008) states even large, viable populations of this species face serious threats and that the Service should "closely monitor and work to alleviate the immediacy of threats to these important spectaclecase populations." Mirarchi et al. (2004) report that this species has suffered extensive habitat loss and fragmentation caused by impoundments of rivers and other human perturbations.

The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that this mussel is threatened by dredging, gravel and sand quarrying, impoundments, stream channelization, coal mine drainage, oil and gas operations, agriculture, silviculture, and urban runoff.

The spectaclecase is also specifically threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, interfering with the food web (Wood 2009).

Overutilization:
NatureServe (2008) states that the spectaclecase is not a commercially valuable species, but may be increasingly sought by collectors as it becomes more rare. Because many populations of this species consist of only a single individual, even small amounts of collection could have deleterious effects on the survival and genetic diversity of this species.

Disease or predation:
NatureServe (2008) states that little is known about the incidence of disease or predation for this mussel, but that these factors could have greater impact on this species because it is particularly long-lived (Butler 2003).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the spectaclecase, and there are no known management programs for this species (NatureServe 2008).

NatureServe (2008) states that few to several (1-12) occurrences of this species are appropriately protected.

In terms of land management, Nature Conservancy reserves protect two stream systems with extant populations of the spectaclecase-- the upper Clinch/Powell River in Tennessee and Virginia, and the upper Green River in Kentucky. Several waterways harboring this species are within or adjacent to public lands. A small portion of the Clinch River watershed (e.g., several small tributaries) is located in the Jefferson National Forest. The St. Croix River population of this mussel is within the St. Croix National Scenic Riverway, Minnesota and Wisconsin (SCNSR). Several state-owned properties (e.g., Chengwatana, Governor Knowles, St. Croix State Forests; Minnesota Interstate, St. Croix, St. Croix Wild River, William O'Brien, Wisconsin Interstate State Parks; St. Croix Islands Wildlife Area; Rock Creek Wildlife Management Area) are adjacent to sections of the scenic river, which could potentially provide some degree of water quality protection if managed appropriately. The Upper Mississippi River National Wildlife and Fish Refuge manages many islands and shoreline acres throughout a significant portion of the upper Mississippi, with in-holdings extending from the mouth of the Chippewa River downstream to Muscatine, Iowa. The Mark Twain National Wildlife Refuge (MTNWR) has numerous in-holdings between Muscatine and Keithsburgs, Illinois, and a disjunct portion, the Gardner Division, is in the area of Canton and La Grange, Missouri. Sections of the lower Big Piney River and several reaches of the upper Gasconade River are adjacent or inside the Mark Twain National Forest; the lower Big Piney also flows through Ft. Leonard Wood Military Reservation. Several units of public land along the Meramec River include Meramec, Pacific Palisades, and River Round Conservation Areas, and Meramec, Onandaga Cave, and Robertsville State Parks (USFWS 2003 in NatureServe 2008).

In terms of management recommendations, NatureServe (2008) suggests that protection of the populations in the Missouri Ozarks and the upper Clinch River should be a priority, given that the upper Clinch is particularly vulnerable due to the rapidly declining numbers. Other recommendations include assessing the feasibility of maintaining viable populations at other sites, and developing management plans and cooperative agreements, including on the upper Mississippi River. NatureServe (2008) further recommends close monitoring of point sources of pollution, upgrading effluent standards, monitoring land use practices in the watershed to reduce siltation resulting from agriculture and construction activities, and avoiding river modifications such as dredging and impoundment.

NatureServe (2008) lists the following recovery objectives: “1) Maintain high quality habitat, consisting of flowing water sites in medium-to-large rivers with good water quality (new national wildlife refuge on Clinch River planned; modified reservoir releases from some dams to improve water quality by Tennessee Valley Authority may allow for potential reintroduction). 2) Monitor and regulate land use upstream to minimize erosion of silt to rivers. 3) Maintain ongoing conservation outreach program focused on the St. Croix River and its mussel fauna (including The St. Croix River Research Rendezvous group)."

Other factors:

Several other factors threaten the spectaclecase. Hypolimnetic releases from reservoirs negatively impact mussel survival and reproduction, and are known to be adversely affecting seven spectaclecase populations. NatureServe (2008) states, "Threats to some populations, such as those isolated and downstream of persistent coldwater releases, clearly have placed them in jeopardy of extirpation (i.e., threats are imminent and the likelihood of survival and recovery are marginal)." Degraded water quality from sedimentation and chemical contamination also threatens this mussel.

Population isolation and lack of recruitment is a dire threat for many populations. NatureServe (2008) states, "Threats and risk of extirpation are clearly imminent for these eleven populations."

Loss of fish host species could preclude reproduction for some spectaclecase populations (NatureServe 2008).

The spectaclecase is potentially threatened by invasive species such as the Asiatic clam, zebra mussel, and black carp (NatureServe 2008).

Mirarchi et al. (2004) state that this species' restricted distribution, specialized habitat requirements, and declining population make it vulnerable to localized extirpation.

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Scientific Name:
Cyprinella callitaenia
Common Name:
Bluestripe Shiner

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	NT - Near threatened

Range:
The bluestripe shiner is endemic to the main channels and lower reaches of major tributaries of the Chattahoochee, Flint, and Apalachicola River Systems in Alabama, Florida, and Georgia (Mayden 1989, Page and Burr 1991, Boschung and Mayden 2004, NatureServe 2008). The bluestripe shiner has lost up to 90 percent of its range in the Chattahoochee River and is at very reduced numbers in Uchee Creek (Shepard et al. 1995, SFC and CBD 2010).

Habitat:
This fish is found in areas of flowing water with little or no aquatic vegetation in large alluvial rivers with open, sand- or rock-bottomed channels. Eggs are deposited into crevices (Lee et al. 1980, Page and Burr 1991).

Populations:
Page and Burr (1991) describe it as localized and generally uncommon. A 1995 survey by Shepard et al. (1995) in the Chattahoochee River system in Alabama found that although the bluestripe shiner was encountered at a number of localities, most collections were small in comparison to historical collections and that although the Uchee Creek system was historically known to produce good collections of the shiner, 12 samples at six stations in the system failed to produce any specimens in the survey. Marcinek (2003) documented that bluestripe shiners are doing well on a 50 km reach of the Upper Flint River in Georgia.

Population Trends:
Boschung and Mayden (2004) report that this species is declining in Alabama. Freeman and Dinkins (2009) report that recent sampling efforts in the Chattahoochee River system documented the absence of the bluestripe shiner from these streams. Shepard et al. (1995) concluded that the "overall abundance" of the blue shiner "has been reduced throughout its range in Alabama." Since that time, the species has continued to decline, particularly in the Chattahoochee (SFC and CBD 2010).

Status:
There are a small number of occurrences of this fish and its habitat has been significantly reduced. It is ranked as critically imperiled in Alabama and as imperiled in Florida and Georgia (NatureServe 2008). It is classified as vulnerable by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and degradation. Although there was a recognition that bluestripe shiners can still be found in decent numbers in the Upper Flint River of Georgia (Marcinek 2003), at a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that this species should be listed as threatened based on sharp declines in the Chattahoochee, which comprises a significant portion of the species range (SFC and CBD 2010).

Habitat destruction:
The bluestripe shiner is threatened by habitat loss and degradation from impoundments, development, forestry, agriculture, withdrawal of ground and surface water, and recreation. This species' habitat in the lower Chattahoochee has been reduced by impoundments; it was formerly present at shoals that are now

innundated by fifteen large impoundments (NatureServe 2008). Marcinek et al. (2003) report that many shoal habitats in the Piedmont of Georgia have been destroyed by reservoir construction, and that the remaining shoals are still threatened. Freeman and Dinkins (2009) report that impoundment threatens this species in the Chattahoochee and Flint River systems.

Urbanization and development are also major threats to this species due to direct habitat loss, water diversion, and pollution from runoff (Holcomb 2005, Freeman and Dinkins 2009). Holcomb (2005) reports that the amount of land development in Georgia increases on a daily basis, stating: “As a result of the unprecedented growth in the region, the Upper Chattahoochee River system is under extreme pressure from sprawl development, water supply reservoir proliferation, increased water withdrawal, increased wastewater discharge and other threats associated with urban development as metro Atlanta continues to move northward. This rapidly expanding human population growth combined with recent technological advances have led to more persistent and ecologically devastating impacts on the landscape, especially in the last 20 years (Noss and Peters 1995).” In the Chattahoochee Watershed, Johnston and Maceina (2009) found a change in fish assemblages between 1965 and 2001 that included a decline in the bluestripe shiner and appeared to correlate with changes in forest cover towards pine plantations and a decline in water availabiltity.

The shiner is also threatened by habitat loss and degradation from agriculture and forestry (Freeman and Dinkins 2009). The Georgia Dept. of Natural Resources (GDNR 2009) reports that this species' Southeastern Plains habitat is threatened by agriculture, withdrawal of ground and surface waters, development, recreation, and dams. Agriculture and other ground-disturbing activities result in erosion and degradation of water quality. Groundwater and surface water withdrawals for agriculture substantially reduce stream flow, and agriculture contributes to nutrient and silt loading which stresses aquatic organisms (GDNR 2009). Development increases sediment levels in streams (GDNR 2009). Unmanaged recreation and ATV use destabilizes streambanks, increases sedimentation, pollutes water with fuel, and crushes aquatic organisms outright (GDNR 2009). Dams and other structures which alter stream flows on the Southeastern Plains cause significant problems for high priority species such as this snail (GDNR 2009). The Florida Wildlife Conservation Commission (2005) reports that this species’ large alluvial stream habitat is highly threatened by dam operations, water-control structures, and channel modification.

Jelks et al. (2008) list habitat loss as a threat to this species.

An impending threat to the bluestripe shiner is a base realignement in Fort Benning that is predicted to result in a substantial increase in human population with concurrent impacts to Uchee Creek (SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect this species. NatureServe (2008) states that no managed areas adequately protect the riverine habitat occupied by this species. This fish is listed as threatened by the state of Florida, but this designation does not confer substantial protection to the species or its habitat.

Other factors:

Several other factors threaten the bluestripe shiner including pollution and invasive species. Johnston and Hartfield (2009) report that the invasive red shiner, (Cyprinella lutrensis) is a highly aggressive species which is spreading in bluestripe shiner habitat and which threatens the bluestripe shiner through hybridization. Freeman and Dinkins (2009) report that siltation from forestry, agriculture, and development threaten this species because the shiner is dependent on small crevices for egg deposition and increasing levels of sedimentation can preclude successful spawning.

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Scientific Name:
Cyprinella xaenura
Common Name:
Altamaha Shiner

G Rank:	**AFS Status:**
G2	Vulnerable

Range:
The Altamaha shiner is limited to the Altamaha River drainage above the Fall Line in north-central Georgia in both the Ocmulgee and Oconee systems (NatureServe 2008). Freeman et al. (2009) report:

"Historically, this species has been recorded from 25 different HUC 10 watersheds within its range. Between 1998 and 2009, this species has been documented within 18 of these watersheds."

Habitat:
This fish occurs in pool habitats in small to moderate-sized streams that are cold and clear (Lee et al. 1980, Page and Burr 1991).

Populations:
NatureServe (2008) states there are fewer than 20 populations based on Lee et al. (1980), who mapped 19 collection sites. In recent surveys, the species was found in 18 of 25 HUC 10 watersheds within its range. Where the species remains, it can be abundant (B. Albanese personal communication).

Population Trends:
Trend information is unavailable for this species, but much of its habitat has been urbanized and it is in the path for future urban sprawl (NatureServe 2008). In some cases, it has persisted in urban watersheds (B. Albanese personal communication), although the long-term viability of these populations is uncertain. It also has bben lost from a large number of watersheds within its range (Freeman et al. 2009).

Status:
This fish has a small range in streams of the Altamaha River drainage, Georgia, where NatureServe (2008) considers it to be imperiled. Jelks et al. (2008) list this fish as vulnerable due to habitat loss and narrow range. The state of Georgia lists it as threatened (Freeman et al. 2009).

Habitat destruction:
Jelks et al. (2008) list this species as vulnerable due to the present or threatened destruction, modification or curtailment of habitat range and a narrow range. Georgia DNR (1999) note principle threats from "degradation and impoundment of tributary streams in the upper Altamaha drainage" resulting from "construction sites and bridge crossings, and increased stormwater runoff from developing urban and industrial areas." They further note that the "range of the Altamaha shiner includes the rapidly developing Piedmont physiographic province where many streams have become damaged by urban development to the point that they support only a very few hardy, tolerant fishes (Georgia DNR 1999).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) states that it is unknown whether any element occurences are protected, but that such protection is necessary given the small number of locations of the species. The Shiner is listed as a threatened species by the state of Georgia. Although this designation prohibits direct harm to the fish, it does not provide any protection for habitat. Given that habitat loss and degradation is the greatest threat to the shiner, this is a critical omission.

Other factors:
Jelks et al. (2008) list this species as vulnerable because of a narrowly restricted range. Georgia DNR (1999) notes that "the invasive red shiner, if it spreads throughout the Altamaha system, could be a very significant threat to the Altamaha shiner through hybridization and competitive displacement effects." The Altamaha shiner is also threatened by pollution (Georgia DNR 1999).

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Scientific Name:
Cyprogenia aberti
Common Name:
Western Fanshell

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	EN - Endangered

Range:
The Western Fanshell occurs in Arkansas, Kansas, and Missouri, and historically in Louisiana, Mississippi, and Oklahoma (NatureServe 2008). In the Ozark and Ouachita mountain ranges, this mussel was known historically from the Little Missouri, Saline, Caddo and Ouachita Rivers in the Red River drainage, from the Spring, Elk, Fall, Caney, Neosho, Verdigris and Shoal Rivers in the Arkansas River drainage, from the Little Black, Black, Buffalo, Current, Spring, Strawberry, and White Rivers, and from Cane and Castor Creeks in the White River drainage, and from the St. Francis River (NatureServe 2008). There are historical reports from the Big Sunflower and Yazoo Rivers in Mississippi, but no extant occurrences in the state (Jones et al. 2005). Serb (2003, 2006) suggests that C. aberti may actually comprise several species.

Habitat:
This mussel uses rock, gravel, and soft mud substrates in flowing water in medium-sized rivers (NatureServe 2008).

Populations:
There are 20 total known extant occurrences for this once widespread species-- nine in Arkansas, seven in Missouri, and four in Kansas. In Arkansas, it occurs in the White, Black, Spring, Ouachita, Saline, Little Missouri, Buffalo, and Strawberry rivers (Gordon 1982, Harris and Gordon 1987, Christian 1995, Harris et al. 1997, Davidson and Gosse 2003). In Missouri, it occurs in the St. Francis, Black, and Spring rivers (Oesch 1995). Ahlstedt and Jenkinson (1991) report that it is extremely rare in the St. Francis River system in Missouri. Obermeyer et al. (1997) reports this species from the Spring, Verdigris, and Fall Rivers, and reports historical occurrences in the Neosho, Elk, and Caney Forks, where it is now extirpated. In Kansas, in the Marais des Cygnes, Elk, and Fall Rivers, only dead shells have been recently reported (Combes and Edds 2005). It is considered to be extirpated in the Spring and Neosho Rivers in Kansas (Couch 1997). It is also extirpated in the Oklahoma portion of the Verdigris and Spring rivers (Vaughn 1998), and from Castor and Cane Creeks in Missouri (Oesch 1995). The population in the Little Black River is not considered to be viable, although some adults still exist in a Missouri reach (Bruenderman, pers. comm. cited in NatureServe 2008). This mussel is rare throughout the majority its range, comprising less than 0.1 percent of a local mussel assemblage (B. Obermeyer, pers. comm. cited in NatureServe 2008, Obermeyer et al. 1997), but is locally abundant in several rivers in Arkansas where it typically makes up two to five percent of a mussel bed, and in some parts of the Black River and Spring River it comprises 5-10 percent of the assemblage (J. Harris, pers. comm. cited in NatureServe 2008, Christian 1995, Davidson 1997, Posey 1997, Harris et al. 1997).

Population Trends:
This mussel has declined from 25-50 percent in the long-term, and is rapidly declining in the short-term, from 30-50 percent (NatureServe 2008). It has been extirpated from much of its range, including all of Oklahoma, Mississippi, and Louisiana (Mather 1990, Vidrine 1993, Jones

et al. 2005). It no longer occurs in the Caney, Elk and Neosho rivers (Obermeyer et al. 1997, Vaughn 1998). It is extirpated from the Oklahoma portion of the Verdigris and Spring rivers (Vaughn 1998), and from Castor and Cane Creeks un Missouri (Oesch 1995). The population in

Status:
This mussel is critically imperiled in Kansas, imperiled in Arkansas and Missouri, and state historical (SH) in Louisiana, Mississippi, and Oklahoma (NatureServe 2008). It is ranked as endangered by the IUCN. NatureServe (2008) states, "The species is a regional endemic that has experienced significant declines in the last 30 years, particularly in the last 10 years, has been extirpated from a large portion of its range, and is quite rare throughout most of its remaining range." It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
This species has already been extirpated from most of its former range due to habitat loss and degradation. NatureServe (2008) reports that most remaining populations of this species are threatened by habitat degradation or destruction. It is threatened by existing and planned impoundments and channelization, gravel mining, and agricultural runoff including siltation and eutrophication (Obermeyer 2000, NatureServe 2008). The Missouri Dept. of Conservation (2010) reports that the Spring River population of this species is threatened by poor water quality downstream from the confluence of Turkey and Center creeks and by channelization, gravel dredging, strip-mine runoff, feedlot runoff, isolation of downstream populations due to dams, and isolation from host fishes. The Arkansas Game and Fish Commission (2005) reports that this mussel is threatened by habitat destruction due to dams, grazing, resource extraction, nutrient loading, confined animal feeding operations, sedimentation, forestry, and road construction. Roe (2004) reports threats to this species as gravel mining, silation, pollution, and impoundments.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that confer substantial protection to this species. Miller (1993) reports an occurrence of this mussel on the Verdigris River Freshwater Mussel Refuge in Kansas.

Other factors:
The zebra mussel now occurs in the Arkansas River drainage and thus potentially threatens this species (NatureServe 2008). Roe (2004) reports invasive species as a threat to this mussel.

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Scientific Name:
Deirochelys reticularia miaria
Common Name:
Western Chicken Turtle

G Rank:
T5

Range:
NatureServe (2008) reports that this subspecies occurs in Arkansas, Missouri, and Mississippi, but that distribution data is known to be incomplete or has not been reviewed for this taxon. Conant and Collins (1998) report that this subspecies occurs in Missouri, Arkansas, Louisiana, Mississippi, Texas, and Oklahoma.

Habitat:
The chicken turtle inhabits still water ponds, marshes, sloughes, and ditches (Conant and Collins 1998).

Populations:
Population information is unavailable for this subspecies.

Population Trends:
Population trend has not been reviewed for this subspecies. Buhlmann and Gibbons (1997) report that it is declining in Arkansas. This subspecies was thought to be extirpated in Missouri but was redetected in 1995 and is now considered Rare in the state (Buhlmann and Johnson 1995). Due to recent collection pressure, this subspecies is thought to be in danger of extinction (Center for Biological Diversity 2008). The Texas Parks and Wildlife Dept. reports that populations in Texas are stable but face many threats (http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_bk_w7000_1672.pdf).

Status:
The status of this subspecies has not been reviewed since 1996 and needs to be updated. NatureServe (2008) ranks this turtle as critically imperiled in Missouri and vulnerable in Arkansas and Mississippi. This species is not currently categorized by the IUCN, which states that its status needs to be updated (http://www.iucn-tftsg.org/deirochelys-reticularia-014/). It is state listed as Endangered in Missouri (http://mdc4.mdc.mo.gov/Documents/145.pdf) and is a Mississippi Species of Greatest Conservation Need (http://www.mdwfp.com/homeLinks/More/Final/Appendix%208.pdf).

Habitat destruction:
The State of Texas reports that habitat loss threatens this subspecies in Texas, including loss of foraging areas (http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_bk_w7000_1672.pdf). The State of Missouri reports that due to habitat loss, this subspecies is now Endangered in Missouri (http://mdc.mo.gov/nathis/herpetol/turtles/). In Missouri, the floodplain swamps in the Bootheel region, where these turtles historically occurred have been almost completely destroyed for agriculture (Buhlmann and Gibbons 1997). The State of Arkansas reports that this subspecies is threatened by habitat destruction due to crop production practices and wetland loss (http://www.wildlifearkansas.com/materials/updates/16reptile.pdf). Buhlmann and Gibbons (1997) report that this is turtle is declining in Arkansas due to loss of shallow weedy ponds and swamps. The State of Mississippi reports that this turtle is threatened by loss of pond habitat due to agricultural conversion, channel modification, dams and impoundments, and forestry

(http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%2011.pdf).

Overutilization:

The State of Arkansas reports that commercial collection is a threat to this subspecies (http://www.wildlifearkansas.com/materials/updates/16reptile.pdf). Reed and Gibbons (2003) report that more than 240 chicken turtles were declared as exported from 1996-2000, at least 132 of which were wild-caught. This does not include the number of unreported and illegally harvested turtles. This number is lower than numbers for other turtles, likely because Western Chicken Turtles are already depleted. Population status of this subspecies is currently unknown, and collection pressure has increased tremendously in recent years (Center for Biological Diversity 2008). Buhlmann and Gibbons (1997) state that even presently abundant southeastern turtle species are threatened by collection because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Western Chicken Turtles are illegally traded over the internet, such as in this advertisement which was accessed in the classified ads on Kingsnake.com on Jan. 27, 2010: "LARGE ADULT FEMALE CHICKEN TURTLE, APPROXIMATELY 9 1/2 INCHES IN LENGTH, DEFINITE FEMALE, SUPER FAT AND HEALTHY, SURE TO BE A GREAT BREEDER OR ADDITION TO ANY POND, RAVENOUS FEEDER, $250 EMAIL OR CALL (954)428-8005. BE SURE TO CHECK US OUT ONLINE AT WWW.UNDERGROUNDREPTILES.COM!" (http://market.kingsnake.com/detail.php?cat=39&de=746851).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect this subspecies. It is state listed as Endangered in Missouri, but this designation provides no substantial regulatory protection. It lacks any legal protection throughout the remainder of its range.

Other factors:

The State of Texas reports that this subspecies is threatened by road mortality (http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_bk_w7000_1672.pdf). Buhlmann and Gibbons (1997) report that road associated mortality is high for this subspecies.

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Scientific Name:
Desmognathus abditus
Common Name:
Cumberland Dusky Salamander

G Rank:
G2

Range:
The Cumberland Dusky Salamander occurs in a small area on the Cumberland Plateau in Tennessee. The northern boundary of its range is just south of the Cumberland Mountains section of the Plateau near Wartburg, Morgan County, Tennessee. The southern and western boundary is near Tracy City in Grundy County. In a narrow zone on Walden Ridge, D. abditus appears to be parapatric or to have hybridized with D. ocoee (Anderson and Tilley 2003, NatureServe 2008).

Habitat:
The Cumberland Dusky Salamander occurs near streams on a forested plateau. Individuals are generally encountered on land within a meter of water. This species is found under rocks, moss, and debris, and on vertical rock faces behind cascades (NatureServe 2008).

Ecology:
The Cumberland Dusky Salamander likely preys on leaf litter invertebrates and is potentially preyed upon by large sympatric Desmognathus, other salamander species, snakes, small mammals, and possibly species of birds that forage in leaf litter (AmphibiaWeb 2009).

Populations:
This salamander is known from approximately 12 locations (Anderson and Tilley 2003). Population size is unknown. Desmognathus abditus is apparently not abundant. Anderson and Tilley (2003) obtained specimens with difficulty (http://www.cumberlandhcp.org/files/natureserve/Amphibians_10.23.08/Cumberland_Dusky_Salamander_10.13.08.pdf).

Population Trends:
Population trend is unknown.

Status:
The Cumberland Dusky Salamander is imperiled in Tennessee. It is ranked as Near Threatened by the IUCN. It lacks legal protective status.

Habitat destruction:

NatureServe (2008) reports that a major threat to the Cumberland Dusky Salamander is habitat loss and degradation due to the building of second and retirement homes.

Gratwicke (2008) cites residential development, energy production and mining as threats to salamanders in the Appalachians, including the Cumberland Dusky.

The State of Tennessee identifies habitat loss, degradation, and fragmentation as the greatest threat to salamanders in the state (http://www.state.tn.us/twra/tamp/salamanders.htm).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: "Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:

The State of Tennessee identifies collection as a threat to the state's salamanders (http://www.state.tn.us/twra/tamp/salamanders.htm). Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:

The state of Tennessee identifies disease as a threat to the state's salamanders (http://www.state.tn.us/twra/tamp/salamanders.htm). New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, see http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and is a threat to this species. Gratwicke (2008) cites disease as a threat to salamanders in the Appalachian mountains. In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Cumberland Dusky Salamander. AmphibiaWeb (2009) states: "Maintaining intact habitat for Cumberland dusky salamanders should be a top priority. This recently described species has had no studies done on population size or viability; they do not receive protection by the state of Tennessee or by the federal government." NatureServe (2008) reports that the species occurs on two protected areas, Frozen Head State Natural Area Reserve and Obed National Scenic River.

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Scientific Name:
Desmognathus aeneus
Common Name:
Seepage Salamander

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The Seepage Salamander is distributed in relatively isolated, local populations in southwestern North Carolina, eastern Tennessee, north-central Alabama, South Carolina, and in a disjunct population in the Piedmont of northeastern Georgia (Harrison 1992, NatureServe 2008). There is a gap in distribution in Alabama between western populations in the Fall Line Hills region and eastern populations in the Blue Ridge and adjacent Piedmont regions. The record for this species in Transylvania County, North Carolina is erroneous (NatureServe 2008).

Habitat:
Seepage Salamanders are found near small creeks, springs, and seepage areas on the forest floor in leaf litter and surface debris in mixed hardwood forests, and in damp shaded ravines. They occur at elevations from 30-1340 m (NatureServe 2008). AmphibiaWeb (2009) provides this description of their habitat: "Adults are terrestrial and live at the interface between the leaf or leaf mold layer and the underlying soil in the vicinity of seepages and small streams in heavily shaded hardwood or mixed forests (Harrison, 1967, 1992; Folkerts, 1968; Jones, 1981; Hairston, 1987; Bruce, 1991). When active, adults are nocturnal (Brandon and Huheey, 1975), typically remain under surface cover, and are not known to climb or actively burrow (Harrison, 1967; Folkerts, 1968; Jones, 1981; and Hairston, 1987). One apparent exception to the lack of scansorial activity by this species was given by Wilson (1984), who observed seepage salamanders climbing on grasses and bushes and jumping from branch to branch at a locality in central Alabama. Harper and Guynn (1999) studied the factors affecting salamander density and distribution within four forest types in the Southern Appalachian Mountains. They found that seepage salamanders and other salamanders preferred moist microsites within each forest type, with the highest densities occurring on sites with a northern and/or eastern exposure and within northern hardwood forests. They noted that densities were lowest on 0–12-yr plots but equal on 13–39 and ≥ 40-yr plots, suggesting a quicker recovery from clearcutting than reported by previous researchers. As plots with salamanders had significantly higher numbers of snails than plots without them, the authors also suggested that snails may be a necessary source of calcium for salamanders and may have a substantial impact on salamander distribution."

Ecology:

Seepage Salamanders are fully terrestrial with no free-living aquatic larval stage. Females move from retreats in leaf litter to the vicinity of streams and seepage areas to lay eggs which are deposited in protected depressions or under moss (Conant and Collins 1998, AmphibiaWeb 2009). AmphibiaWeb (2009) provides the following details on the ecology of this species: "In Alabama, clutches of eggs are found from early February to late May, but most oviposition in west Alabama occurs in February and March (Valentine, 1963c; Folkerts, 1968). In east Alabama, most clutches are found in April, and there is also a fall oviposition period with egg deposition occurring from mid July to early October (Folkerts, 1968). In Georgia and North Carolina, oviposition occurs during late April to early May; hatching takes place from late May to early August (Harrison, 1967). In Tennessee, oviposition occurs from late April to early May and hatching from mid June to mid July (Jones, 1981). Both sexes reach sexual maturity at 18–19 mm SVL (measured to anterior margin of vent) at 2 yr (Harrison, 1967). Arthropods are the principal foods, primarily insects, but arachnids, isopods, amphipods, centipedes, millipedes, nematodes, earthworms, and land snails are also eaten (Folkerts, 1968; Donovan and Folkerts, 1972; Jones, 1981). Donovan and Folkerts (1972) also reported the occurrence of a recently hatched seepage salamander in the stomach of a small adult male. Most of the items consumed are leaf litter species, indicating the confinement of foraging activity to that microhabitat rather than the forest floor surface (Jones, 1981). Predators are unknown, but individuals could be preyed upon occasionally by large sympatric Desmognathus of other species, spring salamanders (Gyrinophilus sp.), ring-necked snakes (Diadophis punctatus), and possibly species of birds that forage in leaf litter. Folkerts (1968) listed ring-necked snakes as an associate of seepage salamanders in his study of Alabama populations. Eggs are deposited under mosses, logs, leaf litter, and root mats or other objects in seepage areas or near streams (Valentine, 1963c; Harrison, 1967; Folkerts, 1968; Jones, 1981). Females lay 3–19 eggs (Bishop and Valentine, 1950; Harrison, 1967; Folkerts, 1968; Jones, 1981; Beachy, 1993a; Collazo and Marks, 1994). For a description of eggs, see Brown and Bishop (1948); for a staging table, see Marks and Collazo (1998)."

Populations:

There are from 21-100 known locations of this salamander in North Carolilna, 14 in Tennessee, 52 in Georgia, two in South Carolina, and from 6-20 in Alabama. Total population size is unknown.

Population Trends:

The Seepage Salamander is declining in the short term and moderately declining to relatively stable in the long term. NatureServe (2008) provides this account of population trend: "In the southern Appalachians, populations fluctuated over a 20-year period (early 1970s to early 1990s), with no apparent long-term trend (Hairston and Wiley 1993). Declining in Alabama (M. Bailey, pers. comm., 1997). Possibly declining in North Carolina (A. Braswell, pers. comm., 1997). Listed in Tennessee as in need of management (Redmond and Scott 1996). Believed stable in South Carolina (S. Bennett, pers. comm., 1997)."

Status:

The Seepage Salamander is critically imperiled (S1) in Tennessee, imperiled (S2) in Alabama, vulnerable (S3) in Georgia and North Carolina, and not ranked in South Carolina. It is classified as Near Threatened by the IUCN. It lacks legal protective status.

Habitat destruction:

NatureServe (2008) reports that the Seepage Salamander is threatened by poor forest management practices. The species is threatened by clearcutting and by the conversion of hardwood forests to pine plantations (Petranka 1998). Some populations in Alabama have been extirpated by logging activities (Folkerts 1968, NatureServe 2008). AmphibiaWeb (2009) reports that roughly half of the known populations in Alabama in the mid-1970's no longer exist, primarily because of various forestry practices (G.W. Folkerts, personal communication). Ford et al. (2002) found higher abundances of seepage salamanders in stands of older, hardwood trees, implicating the loss of mature decidious stands as a threat to this species. Gratwicke (2008) identifies numerous threats to the seepage salamander and other salamanders in Appalachia, including mining, logging, development, and pesticide use.

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd

(1997) states: "The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007).

Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: "Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:

Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, see http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009). In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002).

Inadequacy of existing regulatory mechanisms:

There are no regulatory mechanisms that adequately protect the Seepage Salamander. It is not protected in North Carolina, Tennessee, or Georgia. It is a Priority 2 species of greatest conservation need in Alabama, and a state species of concern in South Carolina, but these designations do not provide regulatory protection. The species occurs on national forest lands, but this does not provide any protection from logging, a primary threat (NatureServe 2008). The U.S. Fish and Wildlife Service (1994c) listed Seepage Salamanders as a Category 2 candidate in 1994, but that designation was removed in 1996 (AmphibiaWeb 2009).

Other factors:
Other factors which may threaten the seepage salamander include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: "Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis" (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: "If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations" (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians. Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: "Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Dexteria floridana
Common Name:
Florida Fairy Shrimp

G Rank:
GH

IUCN Status:
CR - Critically endangered

Range:
NatureServe (2008) states that Dexteria floridiana is only known from the type locality, a "temporary pool approximately 6 km south of Gainesville", Florida. The type locality is probably lost. It is possible (though unlikely) that the Florida fairy shrimp may still exist in some undeveloped portions of Florida or possibly Cuba (Rogers, 2002). The total range is quantified as less than 100 square km (about 40 square miles).

Habitat:
This species was only ever found in a temporary pool (NatureServe 2008).

Populations:
This species is known from only one population which was lost to habitat development. Unless the species is found in other populations, it may be extinct.

Population Trends:
The type locality of this species was lost to development and it is not known from anywhere else (Rogers 2002).

Status:
NatureServe (2008) reports that Dexteria flloridiana may be extinct. It is ranked as critically endangered by the IUCN.

Habitat destruction:
The only known location was destroyed by development (Rogers 2002).

Inadequacy of existing regulatory mechanisms:
No regulatory mechanisms protect this species. The only known population was lost to development.

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Scientific Name:
Distocambarus carlsoni
Common Name:
Mimic Crayfish

G Rank: G2
AFS Status: Special Concern

Range:
The Mimic crayfish occurs in at least three counties in northwestern South Carolina in the Savannah and Saluda river drainages (Eversole and Jones 2004).

Habitat:
NatureServe (2008) reports that D. carlsoni forms complex burrows in sandy clay soil rich in humus with a relatively high water table, but with static water flow.

Ecology:
According to NatureServe (2008) the type colony occupies an area of about 200 square meters. D. carlsoni seems to partition environment with Cambarus carolinus by occupying the area where there is no significant movement in the ground water.

Populations:
NatureServe (2008) crudely estimates that Mimic crayfish have 6-20 populations with a total of 2500-10,000 individuals. It occurs in the Savannah and Saluda River basins in Abbeville, Greenwood, and Saluda Cos., South Carolina (Eversole and Jones, 2004). Population and trend information are unknown.

Status:
NatureServe (2008) ranks this species as globally imperiled and under review in South Carolina (SNR). The American Fisheries Society reclassifed this species from special concern to threatened (Taylor et al. 2007). The State of South Carolina lists it as a Highest Priority Conservation Species (SCDNR 2005).

Habitat destruction:

Concerning threats to this species' habitat, NatureServe (2010) states: "In the Savannah River Basin surface water abstraction from the Savannah river provides drinking water for the municipalities. There are also 183 facilities, including municipalities and industry, authorized to discharge waste water into the Savannah River Basin (Georgia River Network 2002). Habitat destruction and alteration has been stated as 'challenges' to this species (South Carolina Department of Natural Resources 2005)."

Concerning threats to crayfish in South Carolina, SCDNR (2005) reports:

"Physical alteration of habitat also represents a challenge to the survival of crayfish. Some aquatic crayfishes are quite adaptable and can live in ponds, impoundments and roadside ditches, while others are more sensitive to habitat alteration. Some crayfishes are oxygen regulators and are able to increase ventilation rates in response to reduced oxygen conditions, while others, the oxygen conformers, are unable to do this (Hobbs 1991). Therefore, some species are better equipped to survive when the flow of water slows and oxygen levels decline. Some species… have been eliminated from parts of their range as a result of damming activities associated with reservoir construction. Channelization and dredging can also be very detrimental to aquatic crayfish that require rocks, crevices or tree roots along undercut banks as hiding places (Hobbs and Hall 1974). In general, crayfish are not as sensitive to siltation as some aquatic invertebrates such as mussels, but severe siltation has caused declines in or the extirpation of many populations of crayfish (Hobbs and Hall 1974).

Pollution has been known to eliminate crayfish from streams. Ortmann (1909) noted the extirpation of crayfish from some sections of streams and rivers due to mining and oil refineries. Crayfish are harmed by a variety of insecticides, herbicides and industrial chemicals (Eversole et al. 1996). Juvenile crayfish are generally about four times as sensitive to water borne pollution than adults; early instars are about three times as sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were actually more abundant downstream of areas with large amounts of garbage or animal remains. Enrichment may be harmful to crayfish, however, when it results in oxygen depletion (Hobbs and Hall 1974). Pollution of groundwater may impact terrestrial burrowers, because they inhabit water trapped in their burrows.

The most serious known challenge to terrestrial burrowing crayfish is the alteration of soil hydrology. These species appear to be able to coexist with some agriculture and timber harvest practices, although they may not survive frequent tilling of soil. In some areas, fire suppression or the lack of fire management may be a threat, since some species appear to prefer piedmont prairies, savannahs and other open canopy habitats to densely wooded areas."

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms protect this species.

Other factors:

This species is potentially threatened by the spread of invasive crayfish. According to SCDNR (2005): "The arrival of introduced species is probably the greatest challenge to crayfish (Lodge et al. 2000 a,b). The ranges and abundances of many native crayfish may have been reduced by invasive crayfish, both in the United States and in Europe (Lodge et al. 2000a; Hobbs et al. 1989). Prevention of future introductions is most likely the only effective way to deal with the challenges caused by nonnative crayfish. No methods for eliminating invasive species without also harming native species are currently available."

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Scientific Name:
Distocambarus devexus
Common Name:
Broad River Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
The range of Distocambarus devexus is less than 100-250 square km (less than about 40 to 100 square miles) according to NatureServe (2008). It is found in the Savannah River basin in Elbert, Oglethorpe, and Wilkes counties, Georgia (Hobbs, 1989). A very experienced collector in an extensive multi-year program found only three localities.

Habitat:
NatureServe (2008) reports that this species burrows in floodplain in sandy clay soil. According to Skelton (2008), this species occupies "[s]imple and complex burrows adjacent to streams or in low areas where the water table is near the surface of the ground. A single specimen was collected from a burrow that did not penetrate the water table and was only damp in the bottom. This species, particularly juveniles, are frequently collected in temporary pools and ephemeral streams."

Ecology:
The Broad River Burrowing crayfish is a primary burrower with moderately complex burrows, as reported by NatureServe (2008).

Populations:
There are five reported occurrences of this species (Barry and Skelton 2004), with far less than 1000 total individuals. Hobbs (1981) estimated the largest colony at less than 24 adults.

Population Trends:
Trend information is not available for this very rare species.

Status:
This species has a restricted range. NatureServe (2008) ranks this crayfish as critically imperiled, while the State of Georgia classifies Distocambarus devexus as threatened. Barry and Skelton (2004) found five occurrences and consider the Broad River Burrowing Crayfish to be endangered. It is ranked as endangered by the American Fisheries Society (2008) and as vulnerable by the IUCN.

Habitat destruction:
Distocambarus devexus is historically and currently stressed by impoundment of the Savannah River, according to NatureServe (2008). Skelton (2008) says that "[t]he small range of this species makes it vulnerable to land disturbing activities around streams and wetlands."

Inadequacy of existing regulatory mechanisms:
Skelton (2008) recommends that "[a]reas with burrows should be protected from land disturbing activities." This crayfish is listed as threatened by the state of Georgia, but this designation does not protect the species' habitat.

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Scientific Name:
Distocambarus youngineri
Common Name:
Newberry Burrowing Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	VU - Vulnerable

Range:
Distocambarus youngineri is only known from the Saluda River drainage in Newberry County, South Carolina (Eversole and Jones 2004). Price (2006) states that "it has been found only in Newberry County, primarily within a portion of the Saluda River basin but also at one site within the Broad River basin."

Habitat:
The Newberry Burrowing crayfish can be found in complex burrows in sandy clay soil with dense growth of Pinus, Quercus, and Nyssa surrounding small woodland pools (NatureServe 2008). According to Price (2006): “D. youngineri is found in moist terrestrial areas with leaf litter and a mixed-hardwood overstory, usually near stream headwaters or intermittent streams. Although it is found in the general area of headwater streams, it is not found very close to streambanks and does not appear to be directly associated with the streams themselves. In areas where D. youngineri is found, the soil becomes saturated and may be covered with shallow water during periods of precipitation in the winter, spring and sometimes into the early summer. Water has been found in the burrows even under drought conditions. This species appears to have been extirpated from its type locality following a clearcut in the area during 1989. Most of the sites where D. youngineri has been recorded are in moist wooded areas, but it has also been found in a selectively logged pine stand and in grass lawn areas.”

Populations:
NatureServe (2008) estimates that there are 6 - 20 populations with less than 1000 individuals extant. A recent status survey by an experienced collector found ten locations. Eversole (1995) found this species at two historical sites and four new sites within the Saluda River basin in Newberry Co., South Carolina.

Population Trends:
According to NatureServe (2008), this species is facing a short-term decline of 10-30 percent based on the fact that the species is no longer present at its type-locality. The area around the type-locality was clearcut in 1989 and repeated attempts have been made to recollect there without success.

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of South Carolina lists it as a species of Highest Conservation Priority. It was also a Federal C-2 Candidate species before that list was abolished. It is ranked as vulnerable by IUCN and as endangered by the American Fisheries Society.

Price (2006) reports: “There is concern that D. youngineri may be in decline. Eversole (1995) found the species at only six sites despite intensive survey efforts; it now appears to be extirpated from one of those sites. A more recent survey (Welch and Eversole unpublished data) found populations at three new sites. However, all of these new locations were still within a small portion of Newberry County. Given the extremely restricted distribution and low population numbers of D. youngineri, it should be protected. Land that this species inhabits should be protected, since its restricted distribution makes D. youngineri so vulnerable.”

Habitat destruction:

This species was extirpated from its type locality by a clearcut, and logging activities could threaten other populations (NatureServe 2008). Water drawdown also threatens this species' habitat.

SCDNR (2005) reports: "Physical alteration of habitat also represents a challenge to the survival of crayfish. Some aquatic crayfishes are quite adaptable and can live in ponds, impoundments and roadside ditches, while others are more sensitive to habitat alteration. Some crayfishes are oxygen regulators and are able to increase ventilation rates in response to reduced oxygen conditions, while others, the oxygen conformers, are unable to do this (Hobbs 1991). Therefore, some species are better equipped to survive when the flow of water slows and oxygen levels decline. Some species… have been eliminated from parts of their range as a result of damming activities associated with reservoir construction. Channelization and dredging can also be very detrimental to aquatic crayfish that require rocks, crevices or tree roots along undercut banks as hiding places (Hobbs and Hall 1974). In general, crayfish are not as sensitive to siltation as some aquatic invertebrates such as mussels, but severe siltation has caused declines in or the extirpation of many populations of crayfish (Hobbs and Hall 1974). Pollution has been known to eliminate crayfish from streams. Ortmann (1909) noted the extirpation of crayfish from some sections of streams and rivers due to mining and oil refineries. Crayfish are harmed by a variety of insecticides, herbicides and industrial chemicals (Eversole et al. 1996). Juvenile crayfish are generally about four times as sensitive to water borne pollution than adults; early instars are about three times as sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were actually more abundant downstream of areas with large amounts of garbage or animal remains. Enrichment may be harmful to crayfish, however, when it results in oxygen depletion (Hobbs and Hall 1974). Pollution of groundwater may impact terrestrial burrowers, because they inhabit water trapped in their burrows.

The most serious known challenge to terrestrial burrowing crayfish is the alteration of soil hydrology. These species appear to be able to coexist with some agriculture and timber harvest practices, although they may not survive frequent tilling of soil. In some areas, fire suppression or the lack of fire management may be a threat, since some species appear to prefer piedmont prairies, savannahs and other open canopy habitats to densely wooded areas."

Inadequacy of existing regulatory mechanisms:

This species was found is in the Andrew Pickens Ranger District of the Sumter National Forest, but the majority of its populations are on private land (Eversole 1995). No existing regulatory mechanisms protect this species or its habitat. Even on the National Forest, it is threatened by logging activities.

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Scientific Name:
Elassoma boehlkei
Common Name:
Carolina Pygmy Sunfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	NT - Near threatened

Range:
The Carolina pygmy sunfish is limited to tributaries of the Waccamaw and Santee Rivers in North and South Carolina, where it has an irregular and localized distribution (Quattro et al. 2001, Sandel and Harris 2007). Rohde and Arndt (1987) reported that the species occurs in two areas in the Waccamaw River drainage, and one in the middle Santee River drainage. In the upper Waccamaw of North Carolina, the species occurs in Juniper Creek, which joins the Waccamaw downstream of Lake Waccamaw in Brunswick and Columbus counties, and in a roadside ditch that drains into Big Creek, which is a tributary to Lake Waccamaw, Columbus County (Rohde and Arndt 1987). In the lower Waccamaw in South Carolina, the species occurs in old ricefield ditches off Jericho Creek in the Samworth Game Management Area, near Georgetown, Georgetown County (Ibid.). Finally, in the Santee River in South Carolina, the species occurs in "a small pool adjacent to Big Pine Tree Creek, near Camden, Kershaw County" (Ibid.) Quattro et al. (2001) and Sandel and Harris (2007) both report a small number of additional populations in these general areas, including in the Lumber and Cape Fear Drainages in North Carolina and in additional tributary ditches to the Waccamaw in South Carolina.

Habitat:
Sandel and Harris (2007) observe that the species occupies heavily vegetated, tannic swamps and sloughs with substrates of mud or fine sand covered by leaf litter. The species is found in roadside ditches, which may be a means to avoid competition and predation from congeners that have excluded the species from more optimal habitat (Sandel and Harris 2007).

Ecology:
Rohde and Arndt (1987) observed that the species is subject to pronounced variations in abundance, which may have the effect of increasing the risk of local extirpations.

Populations:
Total abundance of the Carolina pygmy sunfish has not been estimated or reported. Rohde and Arndt (1987) showed four collection sites in three population centers and reported that the species can undergo pronounced fluctuations in abundance, which in their view may "explain an apparent disjunct population." At the time, the authors believed further sampling would potentially identify more populations in the lower Waccamaw and Santee, but that extensive sampling had occurred in the upper Waccamaw without documentation of additional populations (Rohde and Arndt 1987). Sandel and Harris (2007) refer to a few additional populations. They note that the species' occurrence is irregular and localized, that it can be common in the few known habitat patches, and finally, that it can undergo large seasonal fluctuations in abundance (Sandel and Harris 2007).

Population Trends:
Sandel and Harris (2007) observe that populations in South Carolina seem stable, but that populations near Lake Waccamaw in North Carolina seem to be in decline.

Status:
NatureServe (2008) lists the species as critically imperiled in both North and South Carolina, Jelks et al. (2008) list the species as threatened, and the U.S. Fish and Wildlife Service list it as a species of concern. It is also listed as threatened by both North and South Carolina. Sandel and Harris (2007) specifically recommended "a federal listing of threatened" for the Carolina pygmy sunfish. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the Carolina pygmy sunfish should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) list the present or threatened destruction, modification or reduction in habitat or range as a primary factor in the Carolina pygmy sunfish being considered a threatened species. Sandel and Harris (2007) report that "roadside populations are certainly affected by pollution and habitat alteration," and that "urbanization has been associated with local extirpation events." Likewise, Rohde and Arndt (1987) observe that the few number of populations and their "occurrence mostly along roadsides, with attendant high risks from various types of potential habitat alteration or pollution, underscores" the species' status as vulnerable and emphasize that it should be "given a large measure of protection by the appropriate state governments as well as by the Federal Government."

Overutilization:
Sandel and Harris (2007) note that "some populations are at considerable risk of over-harvesting by private aquarists."

Disease or predation:
Sandel and Harris (2007) note that predation from congeners may be a factor in this species occurring in roadside ditches, which are likely less than optimal habitat.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that none to few occurrences are appropriately protected and that the species occurs in very few if any protected areas. It is listed as threatened by both North and South Carolina, which raises its profile and perhaps provides some protection from collection, but does not provide substantial protections from habitat destruction and pollution, which are major threats to the species.

Other factors:
There are a number of other threats to the continued existence of the Carolina pygmy sunfish. Sandel and Harris (2007) report that "competition with congeners may exclude this species from optimum habitat," and that "recent droughts have severely affected the populations in North Carolina," indicating that both of these factors are threats to the species. Given the threat of droughts, climate change may be an additional threat should it result in more climate variability, including more extreme droughts.

Pollution is a major threat to the species. A "Comprehensive Wildlife Conservation Strategy" developed by the South Carolina Department of Natural Resources divides the state into various ecobasins, identifies species of concern in those ecobasins, and characterizes the condition of habitats (Available at http://www.dnr.sc.gov/cwcs/). The Carolina pygmy sunfish occurs in the Pee Dee Coastal Plain Ecobasin, which is identified as having serious problems with water pollution, including within rivers that provide habitat for the sunfish. The Conservation strategy notes:

"Water quality was impaired at 70 of 110 sites (64 percent) sampled by SCDHEC. Aquatic life uses were not supported at 23 sites due to low dissolved oxygen levels (11 sites), abnormal pH values (5 sites), copper contamination (3 sites), lack of invertebrate diversity (3 sites) and zinc contamination (1 site). Recreational uses were not supported at three sites due to the presence of high concentrations of fecal coliform bacteria. Due to high levels of mercury in fish tissue, SCDHEC has issued a fish consumption advisory for the entire length of every major river (Pocotaligo River, Black River, Black Mingo Creek, Lynches River, Pee Dee River, Little Pee Dee River, Lumber River, Waccamaw River) in the ecobasin."

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Scientific Name:
Elimia acuta
Common Name:
Acute Elimia

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The range of the Acute Elimia occurs in a narrow range in Alabama and Tennessee. This freshwater snail occurs in the main channel of the Cahaba River in north Central Alabama near Booth's Ford in Shelby County (Mirarchi 2004, NatureServe 2008). In the Tennessee River basin, this snail occurs in discrete stream drainages (P. Johnson, AL DCNR, pers. comm., November 2006 cited in NatureServe 2008). This snail occurred historically in the Little Cahaba River in Bibb County, but was not detected there in 1993 (Bogan and Pierson 1993). There are historical records for the Acute Elimia in the Coosa River basin, but they are disputed (NatureServe 2008). Goodrich (1941) reported this species from tributaries of the Tennessee River in northern Alabama and southern Tennessee.

Habitat:
The Acute Elimia occurs in moderate to fast current on bedrock and slabs (NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are from 6 - 20 populations of Acute Elimia, providing the following details: "Goodrich (1930) documented this species at Muscle Shoals, (Tennessee River), Jackson and Franklin Cos., Alabama; the Tennessee River, Flint River, Piney Creek (Limestone Co., Alabama), and Elk River. Bogan and Pierson (1993) recently identified this species at 2 sites. Elimia acuta is more broadly distributed in the Tennessee River basin, however, populations are restricted to discrete stream drainages (P. Johnson, AL DCNR, pers. comm., November 2006)." Total population size for Acute Elimia is estimated at less than 1000 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the Acute Elimia is very rare and apparently declining (estimated 10-30 percent decline). Only one occurrence has been reported from recent surveys (Pierson 1997 pers. comm. in NatureServe 2008).

Status:
NatureServe (2008) ranks the Acute Elimia as critically imperiled in Alabama and Tennessee. The IUCN classifies this snail as Vulnerable. It is a Tier One Species of Greatest Conservation Need in Tennessee. It is a Federal Species of Concern.

Habitat destruction:
The Acute Elimia is threatened by habitat loss and degradation due to a variety of activities. This species may have been extirpated from the Coosa River due to construction of the Logan Martin and Lay Dams (NatureServe 2008). This snail has declined in the Cahaba and Little Cahaba Rivers due to excessive sedimentation and eutrophication (Hartfield 1994). This species is threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000).

Sedimentation threatens the Acute Elimia because it causes shell erosion, decreases the survival of eggs, and inhibits the growth of algae on which snails depend for food (Hart and Fuller 1974, Neves et al.

1997, Herrig and Shute 2002). This snail is vulnerable to extinction because of habitat loss and alteration, and barriers to dispersal created by dams (Herrig and Shute 2002). The Elimia's habitat is also threatened by spring modification and diversion, which alters the aquatic conditions to which springsnails are adapted, and by groundwater withdrawal which negatively affects the quantity and quality of spring water and artificially creates drought-like conditions (Hobbs 1992, Hubbs 1995, Herrig and Shute 2002). Agricultural activities and livestock grazing also potentially threaten the Acute Elimia, as springsnails are particularly vulnerable to decreased water quality and are known to be negatively impacted by grazing (Herrig and Shute 2002).

In Tennessee, the Acute Elimia is threatened by habitat loss and degradation due to forestry, mining, agriculture, grazing, commercial and industrial development, oil and natural gas drilling, dams and impoundments, and withdrawal of ground and surface water (Tennessee Wildlife Action Plan, available at: http://www.wildlifeactionplans.org/tennessee.html Last accessed June 9, 2009).

Inadequacy of existing regulatory mechanisms:

There are no regulatory mechanisms to protect the Acute Elimia. NatureServe (2008) reports that no occurrences are adequately protected and managed. It has no protective status in either Alabama or Tennessee. This snail is a Tier One Species of Greatest Conservation Need in Tennessee, but this classification affords no regulatoray protection. This snail is a Federal Species of Concern (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=G09A Last accessed June 8, 2009), but this designation does not confer any regulatory protection.

Other factors:

Several other factors threaten the Acute Elimia including pollution and invasive species. Aquatic habitats in southern forests are threatened by immediate and persistent impacts of pollution from petroleum spills, urban and agricultural pesticides, and chemical, manufacturing, and wood product wastes (Abell et al. 2000, Hart and Fuller 1974, Herrig and Shute 2002). Native mollusk species such as the Acute Elimia are also threatened by competition and predation from invasive species such as zebra mussels (Hart and Fuller 1974, Herrig and Shute 2002, Tennessee Wildlife Action Plan 2005).

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Thompson, F.G. 1984. North American freshwater snail genera of the hydrobiid subfamily Lithoglyphinae. Malacologia, 25(1): 109-142.

Scientific Name:
Elimia alabamensis
Common Name:
Mud Elimia

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The extant range of the Mud Elimia covers less than 100 square km (less than about 40 square miles) in Alabama (NatureServe 2008). This snail is endemic to the middle reaches of the Coosa River and adjunct tributaries (Mirarchi 2004).

Habitat:
The Mud Elimia occurs in flowing water environments (Mirarchi 2004).

Populations:
There are fewer than five extant populations of Mud Elimia, and possibly only one (Bogan and Pierson 1993, Mirarchi 2004, NatureServe 2008). The only recent record of this species is from a single site on the Coosa below Mitchell Dam (Bogan and Pierson 1993). Goodrich (1936) reported this species in the Coosa from Ft. William Shoals in Talladega County to Lonigan Shoals in St. Clair County, and from Yellowleaf Creek in Shelby County. Burch (1989) reports this species from middle sections of the Coosa from creeks in Talladega County. Dillon (1989) cites occurrences at the tailwaters of Mitchell Dam in Chilton County. Total population size of this species is unknown.

Population Trends:
NatureServe (2008) reports that the Mud Elimia is very rapidly declining to declining (decline of 10-70 percent) in the short-term, and that this species has experienced a large to moderate long-term decline of 25-90 percent.

Status:
The Mud Elimia is ranked by NatureServe (2008) as critically imperiled, and by the IUCN as vulnerable. It is on the Alabama Freshwater Snail Watch List as a species of moderate conservation concern. The moderate ranking is due to an insufficiency of data on distribution. The distribution of this species is now "extremely contracted" (NatureServe 2008). The species has only been recorded recently from a single site (Bogan and Pierson 1993). The Mud Elimia is a former Candidate for ESA protection (FWS 1994).

Habitat destruction:
The range of the Mud Elimia is now severely constricted and this species has only been recently reported from a single site. As such, this species is particularly vulnerable to further habitat degradation. Aquatic habitats on the Coosa have been lost and degraded by impoundment, pollution, and siltation (NatureServe 2008). A variety of land uses and activities threaten the Mud Elimia's habitat, including sedimentation and nutrient enrichment caused by gravel mining, feedlots, cropland erosion, agriculture, silviculture, mining, and urbanization (ADCNR 2005).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Mud Elimia. It is on the Alabama Freshwater Snail Watch List but this does not convey legal protection. The Mud Elimia was formerly a Candidate for ESA protection (FWS 1994).

Other factors:

The Mud Elimia is threatened by a variety of other factors. Low population size and restricted range make this species vulnerable to stochastic genetic and environmental events, such as droughts and flooding. Any factor which decreases water quality threatens this species.

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U.S. Fish and Wildlife Service. 1994. Endangered and Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species. November 15, 1994. http://www.epa.gov/EPA-SPECIES/1994/November/Day-15/pr-42.html

Scientific Name:
Elimia ampla
Common Name:
Ample Elimia

G Rank:
G1

IUCN Status:
CR - Critically endangered

Range:
The range of the Ample Elimia is less than 100 square km (less than about 40 square miles) in Alabama where it is restricted to the main channel of the Cahaba River (Stein 1976). There are historical records for this species from Centerville and Lily Shoals in Bibb County (Goodrich 1941, Burch 1989). This mussel is currently extant between Centreville and Booth Ford in Shelby County (Mirarchi et al. 2004).

Habitat:
This muscle occurs in shoals with moderate to fast current (Mirarchi et al. 2004).

Populations:
NatureServe (2008) reports that there are from 1-5 populations of Ample Elimia. Bogan and Pierson (1993) detected this species at nine sites, not all of which may represent separate breeding occurences (Mirarchi et al. 2004).

Total population size for this species is estimated at fewer than 1000 individuals. Stein (1976) reported that this species has never been detected in large numbers. Pierson (1997 pers. comm. cited in NatureServe 2008) described the Ample Elimia as "very rare," with only one occurrence being reported in the most recent surveys.

Population Trends:
NatureServe (2008) states that the Ample Elimia is declining rapidly (decline of 30-50 percent) throughout its range.

Status:
The Ample Elimia is now restricted to one section of the Cahaba River where it is considered uncommon even where detected. NatureServe (2008) ranks this snail as critically imperiled. The IUCN classifies the Ample Elimia as critically endangered. It is an Alabama Species of Greatest Conservation Need.

Habitat destruction:
NatureServe (2008) states that the Ample Elimia is very threatened throughout its range due to sedimentation, siltation, and impoundments. Sedimentation threatens the Ample Elimia because it causes shell erosion, decreases the survival of eggs, and inhibits the growth of algae on which snails depend for food (Hart and Fuller 1974, Neves et al. 1997, Herrig and Shute 2002). This snail is vulnerable to extinction because of habitat loss and alteration, and barriers to dispersal created by dams (Herrig and Shute 2002). The Elimia’s habitat is also threatened by spring modification and diversion, which alters the aquatic conditions to which springsnails are adapted, and by groundwater withdrawal which negatively affects the quantity and quality of spring water and artificially creates drought-like conditions (Hobbs 1992, Hubbs 1995, Herrig and Shute 2002). Agricultural activities and livestock grazing also potentially threaten the Ample Elimia, as springsnails are particularly vulnerable to decreased water quality and are known to be negatively

impacted by grazing (Herrig and Shute 2002). The Alabama Dept. of Conservation and Natural Resources. (2008) reports that the state's aquatic snails are threatened by habitat degradation, and identifies this snail as a Species of Greatest Conservation Need (http://www.outdooralabama.com/research-mgmt/cwcs/Chapter1.pdf Accessed February 1, 2010).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Ample Elimia, and no occurrences are appropriately protected and managed (NatureServe 2008). The Ample Elimia is an Alabama Species of Greatest Conservation Need, but this does not provide the snail with any regulatory protection.

Other factors:

Several other factors threaten the Ample Elimia including pollution and invasive species. Aquatic habitats in southern forests are threatened by immediate and persistent impacts of pollution from petroleum spills, urban and agricultural pesticides, and chemical, manufacturing, and wood product wastes (Abell et al. 2000, Hart and Fuller 1974, Herrig and Shute 2002). Native mollusk species such as the Ample Elimia are also threatened by competition and predation from invasive species such as zebra mussels (Hart and Fuller 1974, Herrig and Shute 2002).

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Hart, C.W., Jr.; and S.L.H. Fuller. 1974. Pollution ecology of freshwater invertebrates. New York: Academic Press. 312 p.

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Scientific Name:
Elimia annettae
Common Name:
Lilyshoals Elimia

G Rank:
G1

IUCN Status:
CR - Critically endangered

Range:
The extant range of the Lilyshoals Elimia consists of less than 100 square km in Alabama (NatureServe 2008). Goodrich (1941) describes this species' range as the transition zone of the Cahaba River, from Lily Shoals to Pratt's Ferry. Stein (1976) and Burch (1989) report that this snail is restricted to the main stem of the Cahaba River in Bibb County. Mirarchi et al. (2004) describe this species' distribution as the mainstem of the Cahaba from Centreville to the Bibb/Shelby County line, the lower Little Cahaba, and the mouth of Six Mile Creek (Bogan and Pierson 1993).

Habitat:
Goodrich (1941) reports that this snail appears to prefer areas of moderate current. Mirarchi (2004) states that this snail occurs in shoal habitats with fast to moderate current (Mirarchi 2004).

Populations:
Bogan and Pierson (1993) identified this species at six sites, but each of these may not represent separate occurrences after populations are delineated (NatureServe 2008). Pierson (1997 pers. comm. cited in NatureServe 2008) reported two to three occurrences for this species in recent surveys. Total population size for this species is estimated at fewer than 1000 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this species is declining in the short-term (decline of 10-30 percent) and moderately declining (decline of 25 - 50 percent) in the long-term.

Status:
NatureServe (2008) ranks the Lilyshoals Elimia as critically imperiled. The IUCN ranks this species as critically endangered. Stein (1976) classifies this species as endangered. It is a Priority 2 Species of High Conservation Concern in Alabama. There is some uncertainty concerning the taxonomic delineation of this species (NatureServe 2008).

Habitat destruction:
The limited distribution of the Lilyshoals Elimia makes this species particularly vulnerable to habitat degradation. Aquatic habitats in the Cahaba and Little Cahaba have been degraded by excessive sedimentation and eutrophication (Hartfield 1994). Sedimentation threatens the Lilyshoals Elimia because it causes shell erosion, decreases the survival of eggs, and inhibits the growth of algae on which snails depend for food (Hart and Fuller 1974, Neves et al. 1997, Herrig and Shute 2002). This species is threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000). The Elimia’s habitat is also threatened by spring modification and diversion, which alters the aquatic conditions to which springsnails are adapted, and by groundwater withdrawal which negatively affects the quantity and quality of spring water and artificially creates drought-like conditions (Hobbs 1992, Hubbs 1995, Herrig and Shute 2002). Agricultural activities and livestock grazing also potentially threaten the Lilyshoals Elimia, as springsnails are particularly vulnerable to decreased water quality and are known to be negatively impacted by grazing (Herrig and Shute 2002). FWS (2007) states that

physical alteration of the Cahaba River and water quality degradation present significant challenges to the survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development in Jefferson, Shelby and St. Clair Counties (Ibid.). FWS (2007) states that rampant development of Jefferson and Shelby Counties, and decades of coal mining have degraded river water quality and hydrologic flows that continue to place stress on present-day populations of freshwater mollusks in the Cahaba River.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Lilyshoals Elimia, and no occurrences are appropriately protected (NatureServe 2008). Mirarchi et al. (2004) state that this snail is listed as endangered in Alabama, citing Stein 1976, but the Alabama Natural Heritage Program Tracking List (Available at : www.alnhp.org/track_2008.pdf . Last accessed June 30, 2009) does not indicate that this species has any protective status in Alabama.

Other factors:

Pollution threatens the Cahaba Pebblesnail (NatureServe 2008). The Cahaba River receives domestic and industrial wastewaters, and there are at least 103 industrial discharge permits in the Cahaba Basin, which release a variety of toxic metals, chemicals and other substances (FWS 2007). There are six municipal wastewater treatment plants in the upper basin with a combined discharge of 19 million gallons a day. River testing has revealed high levels of nitrogen and phosphorus, heavy metals, low dissolved oxygen, organic enrichment, siltation, and chemical spills in the upper basin. Water quality is degraded by historic and current coal mine drainage. FWS (2007) states: “Characterization of Cahaba River water quality by the U.S. Environmental Protection Agency (Howard et al. 2002) documented the following problems in the basin:

• Excessive sedimentation and nutrient enrichment are affecting watershed biology;
• A decline in pollution-sensitive fish species with a concomitant increase in pollution-tolerant fish species;
• A prominence of the filamentous green algae Cladophora, which is often associated with nutrient enrichment and nuisance conditions;
• Total phosphorus and total nitrogen ranged from 12 to 960 ppb and 230 to 21,094 ppb, respectively (12 ppb TP and 230 ppb TN considered adequate);
• Excessive sediments have degraded and altered benthic community and species diversity in portions of the river;
• Dramatic increase in “disturbed land” in the basin since 1990; and
• High incidence of NPDES permit violations for nutrient or nutrient related parameters over the last several years.”

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U.S. Fish and Wildlife Service. 2007. Cahaba River National Wildlife Refuge Draft Habitat Management Plan. February 2007. Available online at: www.fws.gov/cahabariver/pdf/Final%20Draft%20Cahaba%20River%20HMP Last accessed June 12, 2009.

Scientific Name:
Elimia arachnoidea
Common Name:
Spider Elimia

G Rank:
G2

Range:
The range of the Spider Elimia encompasses 250-1000 square km in east Tennessee and southwest Virginia. This snail is known from Claiborne County, Tennessee (Burch 1989). Garner (in NatureServe 2008) detected the Spider Elilmia in 21 streams that are tributaries to the Tennessee River in eastern TN, but not all of these populations were viable. Dillon and Robinson (2007) detected the Spider Elilmia in a tributary to the Clinch River in TN near the Virginia border. In southwest Virginia, Dillon and Robinson (2007) found this snail at 13 sites in Lee and Wise counties, including tributaries of the Powell River (NatureServe 2008). Historical records of the species in tributaries of the Holston River were not confirmed.

Habitat:
The Spider Elimia occurs in small streams.

Populations:
NatureServe (2008) crudely estimates that there are between 6-80 populations of the Spider Elimia. Overall population size is unknown.

Population Trends:
The Spider Elimia has experienced wide population decline, has been extirpated from much of its former habitat, and some remaining populations are not viable (NatureServe 2008).

Status:
The Spider Elimia is critically imperiled in Virginia and imperiled in Tennessee. This snail still occurs in "a few streams" in Tennessee and is rare in southwest Virginia, where it is state listed as endangered (NatureServe 2008).

Habitat destruction:
The Spider Elimia is threatened by siltation, pollution, and run-off (Dillon and Robinson 2007). Gordon (1993) reports that "a lot of former habitat has been catastrophically impacted." Surface coal mining is prevalent in east Tennessee and southwest Virginia and is a common source of water pollution in the region. Any activity that negatively affects water quality is likely detrimental for this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms in place to protect the Spider Elimia. It is state listed as endangered in Virginia, but this designation does not convey substantial regulatory protection.

Other factors:
Any factor which reduces water quality threatens the Spider Elimia.

References:

Burch, J.B. 1989. North American Freshwater Snails. Malacological Publications: Hamburg, Michigan. 365 pp.

Dillon, R.T., Jr. and J.D. Robinson. 2007. The Goniobasis ("Elimia") of southwest Virginia, I. Population genetic survey. Final Report (Part I) to the Virginia Division of Game and Inland Fisheries, Richmond, Virginia. 25 pp.

Goodrich, C. 1935. Studies of the gastropod family Pleuroceridae-IV. Occasional Papers of the Museum of Zoology, University of Michigan, 311: 1-11.

Scientific Name:
Elimia bellacrenata
Common Name:
Princess Elimia

G Rank:
G1

Range:
The extant range of the Princess Elimia consists of less than 100 square km in Alabama (NatureServe 2008). This snail is endemic to tributaries of the Cahaba River in Bibb, Shelby, and Tuscaloosa Counties (Goodrich 1941, Burch 1989, Mirarchi 2004). Goodrich (1941) documented this species at Limestone Spring, Davis Creek, Clear Creek, and Spring Creek in Shelby County, at Miller and Woodstock Springs in Bibb County, and at Cahaba River tributaries in Tuscaloosa County. This species has only been detected recently at Shoal Creek in Shelby County (Mirarchi et al. 2004).

Habitat:
This snail occurs in springs and small streams (Mirarchi 2004).

Populations:
There is only one known extant population of Princess Elimia (NatureServe 2008). Genetic samples taken by Campbell and Harris (2006) in the Upper Little Cahaba system upstream from Montevallo could increase the known occurrences of this species. Total population size is unknown.

Population Trends:
The Princess Elimia is very rapidly to rapidly declining (decline of 30-70 percent) in the short-term, and has experienced a large to substantial long-term decline of 50-90 percent (NatureServe 2008).

Status:
The most recent survey of the Cahaba River detected only one population of Princess Elimia (Mirarchi et al. 2004). NatureServe (2008) ranks this species as critically imperiled. It is a Priority 1 Species of Highest Conservation Concern in Alabama.

Habitat destruction:
Mirarchi et al. (2004) report that the single known extant site for this species is degraded by heavy algal growth, which suggests nutrient pollution. This snail is extremely vulnerable to habitat degradation because of its existence at only a single location. Aquatic habitats in the Cahaba have been degraded by excessive sedimentation and eutrophication (Hartfield 1994). This species is threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000). FWS (2007) states that physical alteration of the Cahaba River and water quality degradation present significant challenges to the survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development (Ibid.).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Princess Elimia. This snail is on the Alabama Natural Heritage Program Tracking List, but this does not confer regulatory protection.

Other factors:

Mirarchi et al. (2004) state that the Princess Elimia is vulnerable to extinction due to limited distribution, specialized habitat requirements, and declining population trend. Because this species is currently known from only a single population, it is vulnerable to stochastic genetic and environmental events. This species is also significantly threatened by water pollution.

References:

Burch, J.B. 1989. North American Freshwater Snails. Malacological Publications: Hamburg, Michigan. 365 pp.

Campbell, D. and P. Harris. 2006. Report on molecular systematics of poorly-known freshwater mollusks of Alabama. Report to the Alabama Department of Conservation and Natural Resources, Montgomery, Alabama. 34 pp.

Goodrich, C. 1941. Distribution of the gastropods of the Cahaba River, Alabama. Occasional Papers of the Museum of Zoology, University of Michigan, 428: 1-30.

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Scientific Name:
Elimia bellula
Common Name:
Walnut Elimia

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Walnut Elimia is less than 100 square km in the middle reaches of the Coosa River and Yellowleaf and Choccolocco Creeks in Alabama (Burch 1989, Bogan and Pierson 1993, Mirarchi 2004). It is no longer extant in the mainstem of the Coosa (C. Lydeard, University of Alabama, pers. comm., 2000 cited in NatureServe 2008). Goodrich (1936) reported this species in the Coosa River from Wetumpka to Fitz's Ferry.

Habitat:
This snail occurs in lotic habitats (Mirarchi 2004).

Populations:
There are two extant populations of this snail, and total population size is unknown (NatureServe 2008).

Population Trends:
This snail has experienced a large to moderate long-term decline of 25-90 percent (NatureServe 2008). Populations in the mainstem of the Coosa have been extirpated (Lydeard 2000 in NatureServe 2008).

Status:
This snail is critically imperiled (G1S1) (NatureServe 2008). It is categorized as vulnerable by the IUCN.

Habitat destruction:
This snail is no longer extant in the mainstem of the Coosa, likely due to habitat degradation. The remaining populations are extremely vulnerable to habitat degradation, as they occur in two creeks in a river system that is heavily impacted by impoundments and also degraded by pollution and siltation from a variety of activities including gravel mining, feedlots, cropland erosion, agriculture, silviculture, mining, and urbanization (ADCNR 2005, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect this species.

References:

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Scientific Name:
Elimia chiltonensis
Common Name:
Prune Elimia

G Rank:
G2

Range:
The range of the Prune Elimia consists of 250-1000 square km (about 100-400 square miles) in Alabama where it is endemic to tributaries of the Coosa River (Mirarchi 2004). Burch (1989) reports this species from Weguska Creek in Coosa County and from Waxahatchee Creek and three of its tributaries in Chilton and Shelby Counties. This snail was originally described from Warsan Creek in Chilton County (Goodrich 1941). Bogan and Pierson (1993) report that this species occurs in six Coosa River tributaries.

Habitat:
The Prune Elimia uses lotic habitats (Mirarchi 2004).

Populations:
There are six extant occurrences of Prune Elimia, in six different tributaries of the Coosa River (Bogan and Pierson 1993).

Population Trends:
NatureServe (2008) reports that the Prune Elimia is stable in the short-term (10 percent fluctuation) and relatively stable (25 percent change) in the long-term.

Status:
NatureServe (2008) ranks the Prune Elimia as imperiled. This snail is on the Alabama Natural Heritage Program Tracking List.

Habitat destruction:
Habitats for aquatic species in the Coosa River basin have been degraded by a variety of human activities and are heavily impacted by impoundments, water pollution, and siltation (NatureServe 2008). Rare aquatic snails in the Coosa Basin including the Prune Elimia are threatened by sedimentation and nutrient enrichment caused by gravel mining, feedlots, cropland erosion, agriculture, silviculture, mining, and urbanization (ADCNR 2005).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Prune Elimia. This species is on the Alabama Natural Heritage Program Tracking List, but this does not confer regulatory protection.

Other factors:
The Prune Elimia is threatened by water quality degradation and invasive species. Aquatic habitats in the Coosa basin are classified as impaired due to organic enrichment, low dissolved oxygen concentration, altered pH, and altered flow regimes due to impoundment, industrial discharges, and urban and rural non-point source pollution (Alabama Department of Conservation and Natural Resources 2005). Non-native crayfish also pose a threat to native aquatic species in the Coosa basin (ADCNR 2005).

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Scientific Name:
Elimia cochliaris
Common Name:
Cockle Elimia

G Rank:
G1

Range:
The range of the Cockle Elimia consists of less than 100 square km (less than about 40 square miles) in central Alabama (NatureServe 2008). Historically this species occurred in springs and springbrooks of the Little Cahaba River in Bibb, Jefferson, and Tuscaloosa counties (Goodrich 1941). Bogan and Pierson (1993) report that this snail is extant at only one to two localities in Bibb County. Mirarchi et al. (2004) report that it is extant at a single small spring that is a tributary to the Little Cahaba.

Habitat:
Mirarchi et al. (2004) describe this snail's habitat as springs and small spring-fed streams.

Populations:
There are only one to two extant populations of Cockle Elimia. This snail is known from a spring that is a tributary to the Little Cahaba (Bogan and Pierson 1993, Mirarchi et al. 2004, Campbell and Harris 2006), and potentially from another site where it is pending confirmation (NatureServe 2008). Total population size is unknown but likely low.

Population Trends:
The Cockle Elimia has experienced a very large long-term decline of over 90 percent, and is also severely declining in the short-term (NatureServe 2008).

Status:
NatureServe (2008) ranks the Cockle Elimia as critically imperiled meaning it is at very high risk of extinction throughout its range. This snail is confirmed to be extant at only a single site. It is a Priority 1 Species of Highest Conservation Concern in Alabama.

Habitat destruction:
NatureServe (2008) reports that there are ongoing threats to the Cockle Elimia's habitat.This snail occurs at only one to two sites and is thus severely vulnerable to habitat degradation. NatureServe (2008) reports that habitat in the Cahaba River is vulnerable to development impacts. Herrig and Shute (2002) and Buckner et al. (2002) describe multiple threats to aquatic species' habitat in the Cahaba Basin including development, agriculture, recreation, spring development and diversion, logging, and mining. This species is also threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000). FWS (2007) states that physical alteration of the Cahaba River and water quality degradation present significant challenges to the survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development in Jefferson, Shelby and St. Clair Counties (Ibid.). FWS (2007) states that rampant development of Jefferson and Shelby Counties, and decades of coal mining have degraded river water quality and hydrologic flows that continue to place stress on present-day populations of freshwater mollusks in the Cahaba River.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Cockle Elimia, and no occurrences are appropriately protected and managed (NatureServe 2008). This species is on the Alabama Natural Heritage Program Tracking List, but this does not confer regulatory protection.

Other factors:

Several other factors threaten the Cockle Elimia. This species is vulnerable to random extirpation events due to limited dispersal capability, restricted range, and low population number (NatureServe 2008). Mirarchi et al. (2004) state that this species is vulnerable to extinction due to extremely limited distribution, specialized habitat requirements, and declining population trend. Water quality in the Cahaba Basin has been degraded, and continues to be degraded, by a variety of factors (Herrig and Shute 2002, Buckner et al. 2002). Any factor which decreases water quality threatens the survival of the remaining 1-2 population(s) of Cockle Elimia.

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Scientific Name:
Elimia cylindracea
Common Name:
Cylinder Elimia
G Rank:
G2
Range:
The current range of the Cylinder Elimia consists of less than 100 square km (less than about 40 square miles) in Alabama and Mississippi (NatureServe 2008). Historically this species was widespread in the Tombigbee River system in Alabama (Mirarchi 2004). Goodrich (1936) also reported this species from the Black Warrior River. This snail was considered to be possibly extinct, but was detected in Noxubee Creek, Noxubee County, Mississippi (Lydeard et al. 1997) and in the Sucarnoochee River, both tributaries of the Tombigbee (McGregor et al. 1999). This snail is also known from Clay, Lowndes, and Oktibbeha counties in Mississippi (NatureServe 2008).

Habitat:
Mirarchi (2004) reports that this snail occurs on rock ledges, and is generally found in areas with at least some current.

Populations:
There are two confirmed extant populations of Cylinder Elimia-- Noxubee Creek (Lydeard et al. 1997) and the Sucarnoochee River (McGregor et al. 1999), and possibly other extant populations. Total population size is unknown but likely low.

Population Trends:
NatureServe (2008) reports that the Cylinder Elimia is rapidly declining in the short term (decline of 30-50 percent) and that it has experienced a very large long-term decline of 75-90 percent.

Status:
NatureServe (2008) ranks the Cylinder Elimia as imperiled in Alabama and as not ranked in Mississippi. This species was previously thought to be extinct and is now known from only a few populations.

Habitat destruction:
Because of its limited range and limited mobility, this snail is very vulnerable to habitat loss and degradation. The Cylinder Elimia was previously thought to be extirpated due to habitat destruction of the Tombigbee River (NatureServe 2008). Because the range of this snail is now severely restricted, any further impacts to its habitat could result in extirpation. This snail is threatened by habitat impacts from impoundments and sedimentation, which degrade water quality and isolate populations (Herrig and Shute 2002). Sedimentation inhibits the growth of algae on which snails depend for food (Neves et al. 1997), causes the erosion of snail shells, and negatively affects the survival of snail eggs (Hart and Fuller 1974). Sedimentation of snail habitat results from a variety of sources and land-use activities (Neves et al. 1997). The Alabama Rivers Alliance (1999) reports that aquatic species in the Tombigbee watershed, including the Cylinder Elimia, are threatened by sedimentation, sand and gravel mining, impoundment, and pollution from domestic sewage and agricultural and animal feedlot runoff.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Cylinder Elimia. It does not have any state or federal protective status.

Other factors:
The Cylinder Elimia is threatened by any factor which degrades water quality. Chronic pollution and pollution events such as chemical spills threaten this species (Hart and Fuller 1974, Neves et al. 1997, Herrig and Shute 2002). Exotic species such as zebra mussels also potentially threaten the Cylinder Elimia (Hart and Fuller 1974, Herrig and Shute 2002).

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Scientific Name:
Elimia lachryma
Common Name:
Nodulose Coosa River Snail

G Rank:
G1

IUCN Status:
EX - Extinct

Range:
There are two common names for this snail, the Teardrop Elimia and the Nodulose Coosa River Snail. The extant range of this species is less than 100 square km in Alabama (NatureServe 2008). Historically this species occurred in the Coosa River from Hall's Island in Talladega County to Ten Acre Island in Etowah County (Goodrich 1936, Mirarchi 2004). Burch (1989) describes this species' distribution as from Gilbert's Ferry in Etowah County to near Childersburg in Talladega County. Today this species only occurs at a single location below Lake Logan Martin (NatureServe 2008).

Populations:
There is only one extant population of this snail. This species was considered to be extinct until a population was rediscovered below Lake Logan Martin in 2004 (NatureServe 2008). Total population size is unknown but likely low.

Population Trends:
This species has undergone a large long-term decline of over 90 percent, with only one population remaining (NatureServe 2008).

Status:
NatureServe (2008) ranks the Nodulose Coosa River Snail as critically imperiled. It is classified as extinct by the IUCN, but this needs to be updated, as a population was rediscovered in 2004. It is on the Alabama Natural Heritage Program Tracking List.

Habitat destruction:
All of the former habitat of the Nodulose Coosa River Snail has been impounded (NatureServe 2008). This species now persists in a single population below Lake Logan Martin. Because the range of this species is so severely constricted, it is highly vulnerable to any further habitat degradation. Aquatic snails are vulnerable to siltation, sedimentation, and other habitat degradation from a variety of human activities (Neves et al. 1997, Herrig and Shute 2002). Threats to mollusks in the Coosa are well documented (ADCNR 2005).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this snail. This species is on the Alabama Natural Heritage Program Tracking List, but this does not provide any regulatory protection.

Other factors:
Because the Nodulose Coosa River Snail now exists in only a single population, it is very vulnerable to stochastic genetic and environmental events. This snail is also threatened by any factor which degrades water quality.

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Scientific Name:
Elimia melanoides
Common Name:
Black Mudalia

G Rank:
G2

IUCN Status:
CR - Critically endangered

Range:
The range of the Black Mudalia now consists of less than 100 square km (less than about 40 square miles) in Alabama (NatureServe 2008). Historically, this snail occurred in the upper half of the Black Warrior River drainage, in and above Tuscaloosa (Minton et al. 2003). It now occurs only in portions of the Locust Fork of the Black Warrior River and the Little Warrior River in Blount and Marshall Counties (Minton et al. 2003; Mirarchi et al. 2004). Before the detection of these populations, this snail was considered extinct (Turgeon et al. 1998)

Habitat:
Elimia melanoides occurs in shoals and riffles with clean gravel, cobble, or boulder substrate. It has also been detected on submerged logs (USFWS 2007). Mirarchi et al. (2004) describe this species habitat as "margins of channels on rocks or vegetation," stating that it appears to be tolerant of minor sedimentation, but may be sensitive to alterations in hydrologic regime.

Populations:
There are approximately eight known populations of Black Mudalia (P. Johnson, AL DCNR, pers. comm., November 2006 cited in NatureServe 2008). Minton et al. (2003) reported seven populations at two disjunct locations. Goodrich (1922) recorded this species from the Black Warrior River and possibly the Alabama River. The Black Mudalia is currently extant in two shoals in Gurley Creek in Jefferson County (Pierson, 2006); five localized shoals in an approximately 30 mile reach of the upper Locust Fork of the Black Warrior River in Blount County (Minton et al. 2003); two shoals in a one mile reach of the Blackburn Fork of the Little Warrior River (Clark in litt, 2006 cited in NatureServe 2008), and at a tributary to Blackburn Fork in Blount County (USFWS 2007). This snail was detected at Sipsey Fork in the Bankhead National Forest in Winston County in 1985, 1990, 1993, and 2006 (Wendell Haag, U.S. Forest Service, pers. comm. 2006 cited in NatureServe 2008, Pierson 2006).

Total population size for this species is estimated at 1000-100,000 individuals. In 1922 Goodrich described this snail as "perhaps a vanishing race" due to its low numbers and small range. Stein (1976) reported it as possibly extinct, and Turgeon et al. (1998) reported it as presumed extinct. It was redetected in 1996 (Minton et al., 2003). In 2006, densities of 248 to 616 individuals per square meter were reported from one shoal at Blackburn Fork (Pierson, 2006). Population estimates for other locations are not available but may be higher (P. Johnson, AL DCNR, pers. comm., November 2006 cited in NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the Black Mudalia has severely declined in the short term (decline of greater than 70 percent) and has experienced large decline in the long term (decline of 75-90 percent). This snail has been extirpated from more than 80 percent of its former range (USFWS 2007).

Status:
NatureServe (2008) ranks the Black Mudalia as critically imperiled in Alabama. The IUCN classifies this snail as Critically Endangered. It is a Federal Candidate for listing under the Endangered Species Act. It is a Species of Greatest Conservation Need in Alabama.

Habitat destruction:
Habitat destruction and modification is the primary threat to the Black Mudalia (NatureServe 2008). Over 150 miles of this snail's habitat was degraded and/or destroyed by the construction of dams on the Black Warrior River in 1940 and 1966, and on the lower Sipsey Fork in 1975 (FWS 2007). Unimpounded areas of this species habitat are threatened by coal mine drainage, agricultural runoff, and industrial and municipal pollution, including non-point source pollution from a variety of land-use activities (FWS 2007).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Black Mudalia and no occurences are appropriately protected and managed (NatureServe 2008). It is a Species of Greatest Conservation Need in Alabama, but this designation does not confer regulatory protection. Stein (1976) reports this species as Endangered in Alabama, but the Alabama Wildlife Action Plan does not currently list it as a protected species. It is a Federal Candidate species for listing under the Endangered Species and is in dire need of ESA protection to prevent its extinction.

Other factors:
The Black Mudalia is threatened by water pollution. In the Black Warrior drainage, this species' habitat has been polluted by coal mine drainage, industrial and municipal pollution, and agricultural runoff (FWS 2007). The quality of this snail's habitat was rated as poor at stations in the Calvert Prong of the Little Warrior River (USFWS 2007). FWS (2007) states: "Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases. Excessive sediments can impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species, including pleurocerid snails."

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Scientific Name:
Elimia nassula
Common Name:
Round-rib Elimia

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The extant range of the Round-rib Elimia consists of less than 100 square km in north-central and northwestern Alabama (NatureServe 2008). Populations have been recently reported from five springs in four counties: Buzzards Roost and Tuscumbia Springs in Colbert County, Wheeler Spring in Lawrence County, Big Spring in Madison County, and Cave Spring in Morgan County (Burch 1989, Burch and Tottenham 1980) but the population at Tuscumbia Springs may be extirpated (Mirarchi et al. 2004). The historical range of this species was broader, with documented occurrences at Big Spring and Graham Spring in Huntsville and at Muscle Shoals in the Tennessee River system (Goodrich 1930).

Habitat:
The Round-rib Elimia occurs in springs and spring branches on gravel and cobble substrates, and on submerged macrophytes (Mirarchi et al. 2004).

Populations:
There are 4-5 extant populations of Round-rib Elimia. This species has been recently reported from five springs, but may have since been extirpated at one of them (Mirarchi et al. 2004).

Population Trends:
NatureServe (2008) reports that the Round-rib Elimia is declining in the short-term (decline of 10-30 percent), and has undergone moderate long-term decline (25 - 50 percent).

Status:
NatureServe (2008) ranks the Round-rib Elimia as critically imperiled. It is classified as vulnerable by the IUCN. This snail is a Priority 1 Species of Greatest Conservation Need in Alabama (www.masgc.org/gmrp/plans/AL%20DCNR%20II.pdf).

Habitat destruction:
The Round-rib Elimia has a very restricted range in which it faces imminent threats to its habitat (Buckner et al. 2002, Mirarchi et al. 2004). Mirarchi et al. (2004) state that the Round-rib Elimia has low tolerance for silty conditions. One of the springs where this species occurs lies in an urban setting, which makes it particularly susceptible to habitat disturbance (Mirarchi et al. 2004). The population at Tuscumbia Spring may have been extirpated by recent "improvements," in which water was diverted from the channel while substrata were removed with heavy equipment (Mirarchi et al. 2004). Buckner et al. (2002) state that the Wheeler Lake watershed, where this species occurs, is threatened by habitat fragmentation and conversion, sedimentation from residential and commercial development, and degradation from agriculture, forestry, and gravel mining. This snail is also threatened by habitat loss due to declining water supplies, water management issues, and groundwater depletion (Buckner et al. 2002).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Round-rib Elimia. This species is on the Alabama Natural Heritage Program Tracking List (www.alnhp.org/pdf/track_2007.pdf) but this classification does not confer regulatory protection. This snail was a former candidate for protection under the Endangered Species Act (FWS 1994).

Other factors:

Mirarchi et al. (2004) state that limited distribution, highly specific habitat requirements, and declining population trend make this species vulnerable to extinction. Freshwater snails are sensitive to degradation in water quality (Neves et al. 1997). The Round-rib Elimia is threatened by point and non-point source pollution, toxins, and contaminants in the Wheeler Lake watershed (Buckner et al. 2002). Because the watershed where this species occurs is already threatened by water management issues and groundwater depletion (Buckner et al. 2002), global climate change threatens this snail because freshwater resources in the Southeastern United States are expected to become increasingly stressed by drought and warming climate conditions (Karl et al. 2009).

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Scientific Name:
Elimia olivula
Common Name:
Caper Elimia

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The extant range of the Caper Elimia consists of less than 100 square km (less than about 40 square miles) in central Alabama (NatureServe 2008). Historically this species was known from the Alabama River from Claiborne in Monroe County to west of Camden in Wilcox County and to Selma and north of Tyler in Dallas County, and from the lower Cahaba River near Marion in Perry County below Falls Line, and from the Tombigbee River (Goodrich 1936, 1941, Burch 1989). Bogan and Pierson (1993) did not detect this species in the lower Cahaba in Dallas County where it was previously known to occur. This species is currently known only from a tributary to the Alabama River in Montgomery County (McGregor et al. 1999) and from the lower Cahaba (C. Lydeard, University of Alabama, pers. comm., 2000 cited in NatureServe 2008).

Habitat:
This snail occurs in medium to large river habitats, and has been detected on soapstone substrate (NatureServe 2008). McGregor et al. (1999) report this species from a creek habitat.

Populations:
There are only two known extant populations of Caper Elimia. McGregor et al. (1999) detected this species in Pintlalla Creek, an Alabama River tributary, in Montgomery County during surveys in the mid 1990's. A personal communication in NatureServe (2008) reports that Pierson detected an extant population of this species in the lower Cahaba (C. Lydeard, University of Alabama, pers. comm., 2000). Mihalcik and Thompson (2002) report a snail species from the Escambia River system in southern Alabama that was previously thought to be Elimia curvicostata but that may be more closely related to Elimia olivula. Total population size for this species is unknown (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the Caper Elimia is declining severely to very rapidly (decline of 50 percent to greater than 70 percent) in the short term, and has experienced a large to very large long-term decline of 75-90 percent.

Status:
NatureServe (2008) ranks the Caper Elimia as critically imperiled, meaning it is at very high risk of extinction throughout its range. The IUCN classifies this snail as Vulnerable. There are only two known extant populations of this snail. This species is on the Alabama Natural Heritage Program tracking list. It was formerly a federal candidate for listing under the Endangered Species Act.

Habitat destruction:
Habitat loss and degradation pose a dire threat to the two surviving populations of Caper Elimia. The population in the Cahaba is threatened by habitat degradation. FWS (2007) states that physical alteration of the Cahaba River and water quality degradation present significant challenges to the

survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development in Jefferson, Shelby and St. Clair Counties (Ibid.). FWS (2007) states that rampant development of Jefferson and Shelby Counties, and decades of coal mining have degraded river water quality and hydrologic flows that continue to place stress on present-day populations of freshwater mollusks in the Cahaba River. This species is also threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Caper Elimia. This snail is on the Alabama Natural Heritage Program tracking list, but this classification does not bestow any regulatory protection. The Caper Elimia was formerly a federal candidate for listing under the Endangered Species Act (FWS 1994, Available at: www.epa.gov/EPA-SPECIES/1994/November/Day-15/pr-42.html . Last accessed June 15, 2009).

Other factors:
The Caper Elimia is very vulnerable to extinction because it now occurs in only two isolated populations. Any factor which degrades water quality is a threat to the survival of this species. The one remaining population of this species in the Cahaba is particularly threatened by water pollution. The Cahaba River receives domestic and industrial wastewaters, and there are at least 103 industrial discharge permits in the Cahaba Basin, which release a variety of toxic metals, chemicals and other substances (FWS 2007). There are six municipal wastewater treatment plants in the upper basin with a combined discharge of 19 million gallons a day. River testing has revealed high levels of nitrogen and phosphorus, heavy metals, low dissolved oxygen, organic enrichment, siltation, and chemical spills in the upper basin. Water quality is degraded by historic and current coal mine drainage. FWS (2007) states: "Characterization of Cahaba River water quality by the U.S. Environmental Protection Agency (Howard et al. 2002) documented the following problems in the basin:

- Excessive sedimentation and nutrient enrichment are affecting watershed biology;
- A decline in pollution-sensitive fish species with a concomitant increase in pollution-tolerant fish species;
- A prominence of the filamentous green algae Cladophora, which is often associated with nutrient enrichment and nuisance conditions;
- Total phosphorus and total nitrogen ranged from 12 to 960 ppb and 230 to 21,094 ppb, respectively (12 ppb TP and 230 ppb TN considered adequate);
- Excessive sediments have degraded and altered benthic community and species diversity in portions of the river;
- Dramatic increase in "disturbed land" in the basin since 1990; and
- High incidence of NPDES permit violations for nutrient or nutrient related parameters over the last several years."

References:

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Last accessed June 12, 2009.

Scientific Name:
Elimia perstriata
Common Name:
Engraved Elimia
G Rank:
G1
Range:
The range of the Engraved Elimia is confined to a few springs and small streams of northern Alabama. This species has been extirpated from historical locations in Jackson and Franklin counties at Muscle Shoals in the Tennessee River and in Bird Spring Creek in Madision County (Goodrich 1930, 1936). It has only been detected recently in Big Spring Branch and Indian Creek in Madison County and in Fox and Sandy Creeks in Lawrence County (NatureServe 2008).
Habitat:
Burch (1989) describes this species' habitat as springs and small streams. Mirarchi et al. (2004) state that this snail uses sand, gravel, or cobble substrates, and that it appears to have low tolerance to silt.
Populations:
There are from one to five extant populations of Engraved Elimia (NatureServe 2008). This species is known to be extant in Big Spring Branch and Indian Creek in Madison County, Alabama, and in Fox and Sandy creeks in Lawrence County (Mirarchi et al. 2004). Total population size is unknown.
Population Trends:
The Engraved Elimia is declining (decline of 10-30 percent) in the short-term and moderately declining in the long-term (decline of 25 - 50 percent) (NatureServe 2008).
Status:
The Engraved Elimia is critically imperiled in Alabama (NatureServe). It is a former candidate species for protection under the Endangered Species Act. It is a Priority 1 Species of Highest Conservation Concern in Alabama. Mirarchi et al. (2004) state that limited distribution, declining population trend, and specific habitat requirements make this species vulnerable to extinction.
Habitat destruction:
Mirarchi et al. (2004) state that the Engraved Elmiia has a low tolerance for silt and that the springs and small streams where it occurs are easily disturbed and destroyed. Both Big Spring Branch and Indian Creek are threatened by impacts from urbanization in and around Huntsville (Mirarchi et al. 2004). The populations in Fox and Sandy creeks are threatened by impacts from agriculture, including sedimentation, pollution from pesticides and fertilizers, and water withdrawal for irrigation (Mirarchi et al. 2004).

The Engraved Elimia occurs in waters in or adjacent to Wheeler National Wildlife Refuge Complex. The Comprehensive Conservation Plan and Environmental Assessment for Wheeler (FWS 2007) states that habitat loss and fragmentation and the degradation of aquatic ecosystems are two of the most important ecological threats facing the complex. Habitat has been lost and degraded for development to support burgeoning human population. The region surrounding the refuge is one of the fastest growing areas in Alabama. Habitat has been lost and degraded for agriculture, flood-control projects, transportation corridors, and residential development (FWS

2007). The Conservation Plan states that aquatic ecosystems have been greatly deteriorated by human activities including impoundment and other activities that cause erosion and sedimentation.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Engraved Elimia. It is on the Alabama Natural Heritage Program Tracking List, but this does not confer regulatory protection.

Other factors:

The Engraved Elimia is threatened by other factors including invasive species and water quality degradation. The Engraved Elimia occurs in waters in or adjacent to Wheeler National Wildlife Refuge Complex. The Comprehensive Conservation Plan and Environmental Assessment for Wheeler states that the proliferation of invasive species is one of the most important ecological threats facing aquatic species in the complex and the region (FWS 2007). Mirarchi et al. (2004) state that the Engraved Elimia is threatened by water pollution from runoff from agriculture and urbanization, and by water withdrawals for irrigation. FWS (2007) states that aquatic habitats in and adjacent to Wheeler National Wildlife Refuge have been degraded by point and non-point source pollution from fertilizers, pesticides and herbicides, and toxic discharges, and by the persistent effects of organochlorine pesticides (e.g., DDT, PCB's, toxaphene, dieldrine, and lindane), and heavy metals, such as mercury.

References:

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Scientific Name:
Elimia showalteri
Common Name:
Compact Elimia

G Rank:
G1

Range:
The range of the Compact Elimia consists of less than 100 square km (less than about 40 square miles) in the main channel of the upper Cahaba River in Bibb County, Alabama (Goodrich 1941, McGregor et. al. 1999). Burch (1989) reports that this snail occurs from Lily Shoals to two miles east of Harrisburg.

Habitat:
The Compact Elimia occurs in moderate-current shoals on cobble-boulder-slab substrate (Mirarchi 2004).

Populations:
There are only two to three occurrences for this species (Pierson pers. comm. cited in NatureServe 2008). Bogan and Pierson (1993) identified this snail at 13 sites in the upper Cahaba basin, but each of these cites may not represent an individual occurrence. Total population size for this species is estimated at fewer than 1,000 individuals (NatureServe 2008).

Population Trends:
The Compact Elimia is severely to rapidly declining (decline of 30 percent to greater than 70 percent) in the short-term, and has experienced substantial long-term decline of 50 to over 90 percent (NatureServe 2008).

Status:
NatureServe (2008) ranks the Compact Elimia as critically imperiled, meaning it is at very high risk of extinction throughout its range. This species is on the Alabama Natural Heritage Program Tracking List.

Habitat destruction:
The Compact Elimia is particularly vulnerable to habitat loss and degradation because its range is restricted to a short section of the Cahaba River where it is threatened by habitat impacts from agricultural and industrial land uses, impoundment, and urbanization (NatureServe 2008). Herrig and Shute (2002) and Buckner et al. (2002) describe multiple threats to aquatic species' habitat in the Cahaba Basin including development, agriculture, recreation, spring development and diversion, logging, and mining. FWS (2007) states that physical alteration of the Cahaba River and water quality degradation present significant challenges to the survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development in Jefferson, Shelby and St. Clair Counties (Ibid.). FWS (2007) states that rampant development of Jefferson and Shelby Counties, and decades of coal mining have degraded river water quality and hydrologic flows that continue to place stress on present-day populations of freshwater mollusks in the Cahaba River. This species is also threatened by poor water quality in the Cahaba River due to high nutrient inputs (McGregor et al. 2000).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Compact Elimia. This species is on the Alabama Natural Heritage Program Tracking List but this does not confer regulatory protection. NatureServe (2008) reports that no occurrences of this species are adequately protected and managed.

Other factors:

Other factors which threaten the Compact Elimia include degraded water quality and reduced viability. NatureServe (2008) states that only one to two populations of of Compact Elimia are considered to have decent viability. Small isolated populations are inherently more vulnerable to extinction. The remaining populations of this species are highly vulnerable to degraded water quality. This snail faces water quality degradation from agricultural and industrial pollution, impoundment, and human settlement (NatureServe 2008). The Cahaba River receives domestic and industrial wastewaters, and there are at least 103 industrial discharge permits in the Cahaba Basin, which release a variety of toxic metals, chemicals and other substances (FWS 2007). There are six municipal wastewater treatment plants in the upper basin with a combined discharge of 19 million gallons a day. River testing has revealed high levels of nitrogen and phosphorus, heavy metals, low dissolved oxygen, organic enrichment, siltation, and chemical spills in the upper basin. Water quality is degraded by historic and current coal mine drainage. FWS (2007) states: "Characterization of Cahaba River water quality by the U.S. Environmental Protection Agency (Howard et al. 2002) documented the following problems in the basin:
• Excessive sedimentation and nutrient enrichment are affecting watershed biology;
• A decline in pollution-sensitive fish species with a concomitant increase in pollution-tolerant fish species;
• A prominence of the filamentous green algae Cladophora, which is often associated with nutrient enrichment and nuisance conditions;
• Total phosphorus and total nitrogen ranged from 12 to 960 ppb and 230 to 21,094 ppb, respectively (12 ppb TP and 230 ppb TN considered adequate);
• Excessive sediments have degraded and altered benthic community and species diversity in portions of the river;
• Dramatic increase in "disturbed land" in the basin since 1990; and
• High incidence of NPDES permit violations for nutrient or nutrient related parameters over the last several years."

References:

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www.fws.gov/cahabariver/pdf/Final%20Draft%20Cahaba%20River%20HMP
Last accessed June 12, 2009.

Scientific Name:
Elimia teres
Common Name:
Elegant Elimia

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The total global range of the Elegant Elimia consists of less than 100 square km in Tennessee (NatureServe 2008). This snail occurs only in small streams on Walden Ridge (Goodrich 1940, Burch 1989).

Habitat:
This snail occurs in small streams (Goodrich 1940, Burch 1989).

Populations:
NatureServe (2008) reports that there are from 1-5 populations of Elegant Elimia. This snail occurs on a single ridge in Tennessee, and total population size is unknown.

Population Trends:
Population trend information is not available for this species.

Status:
NatureServe (2008) ranks this snail as critically imperiled (G1S1). It is a Tier 1 Species of Greatest Conservation Need in Tennessee. It is categorized as vulnerable by the IUCN.

Habitat destruction:
This snail is imminently threatened by surface coal mining. This species occurs only on Walden Ridge, which was named one of the most endangered mountains in America by the environmental group Appalachia Voices (2008) due to a pending mountaintop removal coal mining proposal. Mountaintop removal has "pervasive and irreversible" ecosystem impacts (Palmer et al. 2010) and could extirpate this limited-range species. Coal exploration drilling was completed recently in the Rock Creek Watershed in southern Bledsoe County. Highland Lands Company and America Energy Company are seeking a permit for surface coal mining of approximately 1700 acres in this snail's watershed.

Walden Ridge is also threatened by logging, proposed impoundments, and other land uses which are incompatible with maintaining riparian and stream habitats (FWS 2007). Timber removal activities on Walden Ridge often do not employ adequate streamside management zones or best management practices for road construction (FWS 2007). Aquatic snails are very sensitive to sedimentation and water quality degradation resulting from logging, mining, and impoundments (Neves et al. 1997). The Tennessee Wildlife Resource's Agency (2005) states that impoundments and pollution have taken a great toll on the state's mollusk fauna.

The Elegant Elimia is also threatened by urbanization. NatureServe (2008) states that this snail is threatened by the expanding urban areas of Knoxville and Oak Ridge. Buckner et al. (2002) reports that development is burgeoning in previously rural areas around Knoxville, with resultant impacts on aquatic species. From 1990-2000 the population of Tennessee increased by 17 percent, increasing the pressures on land and water resources.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechansims to protect this critically imperiled snail. Due to imminent threats to this species' habitat, it is in dire need of Endangered Species Act protection.

Other factors:
Any factor which degrades the water quality of its small stream habitat threatens the survival of this species.

References:

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Scientific Name:
Elimia vanuxemiana
Common Name:
Cobble Elimia

G Rank:
G1

IUCN Status:
EX - Extinct

Range:
The range of the Cobble Elimia consists of less than 100 square km (less than about 40 square miles) in Alabama. This species is endemic to the middle and lower reaches of the Coosa River and the mouths of a few of its tributaries (Burch 1989, Mirarchi 2004). Goodrich (1936, 1941) recorded this species in the Coosa from Wetumpka in Elmore County to center Landing in Cherokee County and in the Alabama River from Claiborne in Monroe County to Selma in Dallas County. This snail was thought to be extinct, and is now known from only one population that was redetected in 2004 in the Coosa below Lake Logan Martin (The Birmingham News, May 3, 2005 cited in NatureServe 2008).

Habitat:
The historical habitat of this snail consisted of shallow backwater areas with still or gentle current where it used stone or log substrate (Goodrich 1936).

Populations:
There is only one known surviving population of Cobble Elimia, below Lake Logan Martin in the Coosa River in Alabama. Population size is unknown, but likely low.

Population Trends:
The Cobble Elimia has experienced a very large long-term decline of over 90 percent, and was thought to be extinct, with only one remaining population of this species having been detected in 2004.

Status:
NatureServe (2008) ranks the Cobble Elimia as critically imperiled. It is ranked by the IUCN as extinct, but this needs to be revised, as a single population was redetected in 2004. It is on the Alabama Natural Heritage Program Tracking List. It was formerly a Federal Candidate for ESA protection.

Habitat destruction:
The majority of the Cobble Elimia's habitat was destroyed by impoundment (NatureServe 2008), driving this species to the brink of extinction. Habitat degradation poses a dire threat to the single remaining population of this species, as a single habitat disturbing event could extirpate the species. Impoundments have caused extensive loss, degradation, and fragmentation of habitat for aquatic snails in the Coosa River and remaining free-flowing habitats are severely limited (Alabama Department of Conservation and Natural Resources (ADCNR) 2005). The Cobble Elimia's small remaining habitat is threatened by degradation from sedimentation and nutrient enrichment caused by gravel mining, feedlots, cropland erosion, agriculture, silviculture, and urbanization (ADCNR 2005).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Cobble Elimia. It is on the Alabama Natural Heritage Program Tracking List, but this does not confer regulatory protection. It was formerly a federal candidate for protection under the Endangered Species Act (FWS 1994

Available at: www.epa.gov/EPA-SPECIES/1994/November/Day-15/pr-42.html . Last accessed June 15, 2009).

Other factors:

The Cobble Elimia is highly vulnerable to extinction because there is only one surviving population of this species, which faces increased susceptibility to stochastic genetic and envrionmental events. This snail is further threatened by water quality degradation and invasive species. Aquatic habitats in the Coosa basin are classified as impaired due to organic enrichment, low dissolved oxygen concentration, altered pH, and altered flow regimes due to impoundment, industrial discharges, and urban and rural non-point source pollution (Alabama Department of Conservation and Natural Resources 2005). Non-native crayfish also pose a threat to native aquatic species in the Coosa basin (ADCNR 2005).

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Scientific Name:
Elliptio ahenea
Common Name:
Southern Lance

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The southern lance is confined to Florida where it is known from the St. Mary's, St. Johns, Kissimmee, and Suwannee rivers, but is absent from several of the smaller Gulf drainages. Elliptio ahenea may also be present in the Ochlockonee River system (Johnson 1970, 1972, Williams and Butler 1994). NatureServe (2008) reports that the total range of this species will not be known accurately until a genetic analysis is conducted on Elliptio species in Florida.

Habitat:
This mussel prefers stable soft silty sand and mud substrates in slow currents (Johnson 1972). The lower portion of the Black Creek population in the St. Johns basin occurs in the tidally influenced portion of the stream.

Ecology:
This mussel is apparently the smaller stream counterpart of E. waltoni. It is not as abundant as sympatric congeners E. buckleyi, E. Icterina, and E. monroensis.

Populations:
Most occurrences of this species are in the lower and middle tributaries of the St. Johns River system, and unknown occurrences may exist (NatureServe 2008). Recent occurrences are in the upper Suwannee River mainstem and lower Withlacoochee River mainstem. There were possibly historic occurrences exist in the Kissimmee River sytem. This species may also be present but rare in the Ochlockonee River system (J. Brim Box, pers. obs. in NatureServe 2008). This species is seldom abundant or dominant like other congeners, except at some sites in the lower Withlacoochee River where it appears to be the only Elliptio. It appears to be rare in the mainstem of the Suwannee River system (NatureServe 2008).

Population Trends:
Trend information is unknown for this species due to historical confusion with Elliptio jayensis, but it is possibly fairly stable. Mussel populations in general appear to be in decline in Suwannee River tributaries, including the Santa Fe and New rivers (J. Brim Box, pers. obs. in NatureServe 2008).

Status:
NatureServe (2008) ranks this species as vulnerable globally (G3) and under review in Florida (SNR). Evidence of severe decline is lacking and this species appears stable with some exceptions (e.g. Suwannee River tributaries), but it has a restricted range that is threatened by continuing urban development and is often uncommon or rare when found. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
The Southern Lance is threatened by eutrophication, pollution, and excessive urban runoff as a result of tremendous growth in central Florida, in Orlando County in particular (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which adequately protect this species. NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected. A possible occurrence exists in the Wekiwa River (springs) State Park (occurrence in lower Wekiwa River).

Other factors:

Water pollution is a significant threat to this mussel (NatureServe 2008).

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Scientific Name:
Elliptio arca
Common Name:
Alabama Spike

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	DD - Data deficient

Range:
The Alabama Spike occurs in the Mobile Basin in Alabama, Georgia, Mississippi, and Tennessee (NatureServe 2008). In Mississippi, it also occurs in the Pearl River, Pascagoula River, and Tombigbee River drainages (Jones et al. 2005), and in Georgia, it occurs in the Coosa River Basin (Williams and Hughes 1998, NatureServe 2008).

Habitat:
This species has been detected in lateral gravel bars in swift currents (Hartfield and Jones 1990, NatureServe 2008). It uses lotic areas in medium to large streams, and occurs at highest densities in swift, shallow shoals in gravel-sand substrates. Individuals have also been detected in runs with slow, steady current and deep gravel and sand bottoms. This mussel rarely occurs in pools, silty stream margins, or backwater areas (Mirarchi et al. 2004). USFS (2007) states that this mussel requires habitat stability, including substrate and water quality.

Ecology:
This mussel is a short-term brooder, with females releasing glochidia in June and July. Glochidia are released with copious amounts of mucus, and while the exact method of host infestation is unknown, the mucus may serve to entangle fishes. Redspotted and blackbanded darters are the primary hosts for glochidia, and the southern sanddarter is a marginal host (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 6-80 populations of Alabama Spike. The number of extant and historical occurrences of this bivalve is difficult to assess due to taxonomic uncertainty and because rangewide surveys have not been conducted. The current distribution is disjunct across five states and some populations have limited to poor viability. This mussel has been detected at 11 sites in the Buttahatchee River in Mississippi and Alabama (Hartfield and Jones 1990). This species is widespread in the Mobile Basin in Alabama, but the only healthy populations are in the Sipsey River (Mirarchi et al. 2004) and Yellow Creek (Williams et al. 2008). Parmalee and Bogan (1998) report extant occurrences in the Conasauga River in Bradley and Polk counties in Tennessee. The species also occurs in the Conasauga River of northwestern Georgia (GA NHP, pers. comm., March 2007 in NatureServe 2008). Vidrine (1993) and Brown and Banks (2001) report it from the Amite River in Louisiana and Pearl River in Mississippi and possibly into Louisiana. This mussel is known in Mississippi from creeks in Lowndes, Jones, Itawamba, Monroe, Clark, and Wayne Cos. (MS NHP, pers. comm. 2006 in NatureServe 2008), and from the Pearl, Pascagoula, and Tombigbee drainages (Jones et al. 2005). In the Coosa River basin in Georgia, it appears to be extant only in the Coosawattee drainage (Williams and Hughes 1998). It is very rare in the Black Warrior River in Tuscaloosa and Greene/Hale Cos. and the upper Tombigbee River in Sumter and Greene Cos., Alabama (Williams et al. 1992).

Population Trends:

This mussel is rapidly declining to declining in the short term, and appears to be moderately declining to relatively stable in the long term (NatureServe 2008). There is a paucity of information on population viability and trends for this species, but in some drainages this mussel is known to have undergone recent declines (NatureServe 2008). The population in the Buttahatchee River in Alabama and Mississippi appears stable at over 200 individuals (Yokley 1978, Hartfield and Jones 1990), but Hartfield and Jones (1990) note that unionid mussels have been virtually extirpated from the mouth of the Buttahatchee River to U.S. Hwy 45. The Sipsey River population appears to be the only healthy occurrence in the Mobile Basin in Alabama (Mirarchi et al. 2004). Williams et al. (2008) report that this mussel is now extant only in several disjunct populations, and that it is uncommon everywhere except the Sipsey River and Yellow Creek in the Tombigbee drainage. The species has not been recently detected at historical occurrences in the Coosa, Etowah, Oostanaula River drainages in Georgia, but is still extant in the Coosawattee (Williams and Hughes 1998).

Status:

The Alabama Spike is critically imperiled (S1) in Georgia, imperiled in Alabama and Tennessee (S2), vulnerable in Mississippi (S3), and not ranked in Louisiana (SNR) (NatureServe 2008). This mussel is listed as endangered by the state of Georgia, is a Priority 1 Species of Greatest Conservation Need in Alabama, and is a Tier 1 Species of Greatest Conservation Need in Mississippi. This mussel is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

The Alabama Spike is threatened by habitat loss and degradation including sedimentation, channelization, mining, and impoundment. Within this species' range in Louisiana and Mississippi, abandoned and active gravel mines have led to the disappearance of numerous mussel species (Hartfield and Ebert 1986, Brim Box and Mossa 1999). Kaolin strip mining has also lowered water quality in this species' habitat (Hartfield and Jones 1990).The construction of reservoirs and other waterway projects such as the Tenn-Tom Waterway are known to have negatively altered mussel habitat.

Mirarchi et al. (2004) state that the small remaining populations of this species in the Black Warrior, Coosa, and Tombigbee River systems "could be easily lost with further habitat degradation" (p. 44).

The Georgia Dept. of Natural Resources (Wisniewski 2008) lists the following threats to this mussel: "Excess sedimentation due to inadequate riparian buffer zones, development, and agriculture covers suitable habitat and could potentially suffocate mussels. Poor agricultural practices may also cause eutrophication and degraded water quality. Incompatible dam operations on the Coosawattee River are thought to be a reason for the possible extirpation of this species from the river" (available at: http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=89&txtPage=15).

USFS (2007) states that the Alabama Spike is sensitive to water quality degradation and sedimentation from ground-disturbing activities within a watershed. This species occurs in the Bankhead National Forest and is thus potentially threatened by logging and recreational activities.

The Alabama Spike is also threatened by habitat inundation, alterations in the timing and duration of flow, and interrupted connectivity due to the operation of the Martin Hydroelectric Project (Takats 2009).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect this species, and no occurrences are appropriately protected and managed (NatureServe 2008). This mussel is listed as Endangered by the state of Georgia, is a Priority 1 Species of Greatest Conservation Need in Alabama, and a Tier 1 Species of Greatest Conservation Need in Mississippi, but these designations do not provide any meaningful regulatory protection. This mussel has no state status in Tennessee or Louisiana.

The Georgia Dept. of Natural Resources (Wisniewski 2008) lists the following management recommendations for this mussel: "Changing the operations of Carters Reservoir was identified as a high priority management need for the restoration of the Alabama spike to the Coosawattee River. Irregular flow regimes coupled with cold hypolimnetic discharges are believed to have caused the decline of the species in the Coosawattee and Oostanaula rivers. Minimizing the impacts of sedimentation within the Conasauga River may improve existing habitat within the river and provide suitable areas for reintroduction/augmentation of the species. Surveys should be done to assess the abundance and distribution of the Alabama spike in the Upper Coosa River Basin" (available at:
http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=89&txtPage=15).

Other factors:

This mussel is vulnerable to extinction because of its restricted distribution, rarity, and declining population trend. It is now distributed primarily in small, isolated populations which heightens its susceptibiliity to extinction (Mirarchi et al. 2004). In addition, any factor which leads to decreased water quality threatens this species. The Alabama Spike is also threatened by any factor which threatens the host fish on which it depends for reproduction.

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Scientific Name:
Elliptio arctata
Common Name:
Delicate Spike

G Rank:	**AFS Status:**
G2	Special Concern

Range:
The Delicate Spike occurs in the Alabama-Coosa River systems, and in the Escambia River system discontinuously east to the Apalachicola River system and west to the Pearl River system in Mississippi (Parmalee and Bogan 1998). Elliptio arctata was historically known throughout the Coosa, Cahaba, Tallapoosa and Tombigbee drainages in Alabama, Georgia, Mississippi, and Tennessee, with early surveys and museum records indicating that this species was once abundant in headwater steams and shoals of large rivers (van der Schalie 1938, Hurd 1974). Recent records are available for the Alabama-Coosa River systems (Gangloff 2003, Johnson 1997, Williams and Hughes 1998), ACF basin (Brim Box and Williams 2000), Choctowhatchee, Yellow and Escambia basin (Williams et al. 2000, Blalock et al. 1998, Pilarczyk et al. 2006), and Cahaba River (McGregor et al. 2000). This species is likely extirpated from historical sites in the Chattahoochee River system. Although it is reported from throughout the Mobile Basin, there is some taxonomic uncertainty (Mirarchi et al. 2004). It occurs in Mississippi in the Pearl, Pascagoula, and Tombigbee River drainages (Jones et al. 2005). Parmalee and Bogan (1998) report it from the Conasauga River in Bradley and Polk Cos., Tennessee. Johnson (1970) describes the range as the Atlantic Coast drainages from the Cape Fear River in North Carolina south to the Savannah River in Georgia and South Carolina, however, records from the Atlantic slope are likely erroneous (Parmalee and Bogan 1998). This mussel appears to be missing from drainages south of the Savannah River in Georgia, peninsular Florida, and Gulf drainages east of the Apalachicola Basin (Brim Box and Williams 2000). Records from the Peace River in peninsular Florida (van der Schalie 1940) are likely erroneous (NatureServe 2008).

Williams et al. (2008) describe the distribution of this species as most of the eastern Gulf Coast drainages from the Apalachicola Basin in Georgia and Florida west to the Pearl River drainage, Mississippi, including the Mobile Basin. In the Mobile Basin, this species is widespread but uncommon and highly fragmented. Williams et al. (2008) state that there is no evidence to support reports of this species in Atlantic Coast drainages.

Habitat:
This mussel has been found among and under rocks along the shoreline in rivers (Johnson 1970), in sand-gravel and sand-limestone substrates (Brim Box and Williams 2000), and in fine gravel and sand in moderate currents (Heard 1979). Parmalee and Bogan (1998) describe this species habitat as coarse sand and gravel, often under and around large rocks, and usually in current. Hurd (1974) reports that this mussel is found packed vertically under large rocks. Catena Group (2007) found this species associated with hard substrates in run habitats under rocks.

Ecology:
Little is known about the ecology of this mussel, but it is presumed to be a short-term brooder similar to its congeners (Mirarchi et al. 2004).

Populations:

NatureServe (2008) reports that there are from 6-80 populations of Delicate Spike. Many historical populations are no longer extant. This mussel has been recently detected in the Coosa drainage in Little River and in Hatchet, Kelly, Big Canoe, and Terrapin creeks, and in the Tallapoosa Drainage in Choctafaula, Saugahatchee, and Loblockee creeks (Godwin and Shelton 1999, Gangloff 2003). In Alabama, it is now extremely rare in the Coosa and Tallapoosa drainages. It is also extremely rare in the Connasauga (Evans 2001) and Upper Tallapoosa drainages (Johnson 1997). In the Pea River system it was recently detected at two historic occurrences and six new occurrences (Blalock et al. 1998), but was absent at 42 other surveyed locations (Blalock et al. 1998). This species was only detected at 17 of 324 sites recently surveyed sites in the Apalachicola, Chattahoochee, and Flint (ACF) rivers of Alabama, Florida, and Georgia, in contrast to 91 historical records from 66 sites in the ACF Basin (Brim Box and Williams 2000). The species was only detected at 2 of 13 historical sites in the Escambia River drainage (Williams et al. 2000).This species is also missing from two historical sites in the Yellow River drainage (Williams et al. 2000). Of 179 surveyed sites in the Escambia and Yellow rivers, only one individual was found at a single site in the Conecuh (Williams et al. 2000). Only relict shell materials have been detected in Jefferson and Bibb counties in Alabama, in the Cahaba River at the Little Cahaba confluence, and in the North River in Tuscaloosa County, Alabama (Pierson pers. comm. 1997 in NatureServe 2008). This species was reported from the Cahaba River in 1991, but was absent in 2000 (McGregor et al. 2000). This mussel was only detected at two of 24 surveyed sites in the Choctawhatchee, Yellow, and Conecuh-Escambia River drainages in southern Alabama in 2004 (Pilarczyk et al. 2006). Williams and Hughes (1998) report that it not been collected live recently in Georgia in the Coosa, Etowah, Oostanaula, or Conasauga River drainages. Vidrine (1993) reports that this species is absent in Louisiana, but present nearby in the Strong River in the Pearl River drainage, however, Darden et al. (2002) report that this species appears to be missing in the Strong River in Mississippi (cited in NatureServe 2008). Catena Group (2007) detected this species at three sites in the Savannah River with the sites supporting 1, 4, and 13 invididuals.

Historical abundance is difficult to estimate due to taxonomic uncertainty. The species is now uncommon in the Escambia, Yellow and Pea rivers (Blalock et al. 1998, Williams et al. 2000) and in many other areas throughout its historic range (NatureServe 2008).

Population Trends:

The Delicate Spike is declining in the short term and moderately declining to relatively stable in the long term (NatureServe 2008). These trends are based on poor historical records and may understate the level of decline this species has experienced based on very low population abundance or total absence at many occurrences. Many populations throughout the historical range are known to be dwindling, and the species is extirpated from some river systems and declining in most, particularly in the Coosa-Tallapoosa and Choctawhatchee-Escambia drainages (NatureServe 2008).

Status:

The Delicate Spike is critically imperiled in Mississippi and Georgia, imperiled in Alabama, Florida, and Tennessee, and not ranked in South Carolina (NatureServe 2008). It is listed as Endangered by the state of Georgia, and is a Tier 1 Species of Greatest Conservation Need in Mississippi, and a Priority 1 Species of Greatest Conservation Need in Alabama. Its rank is being changed from special concern (Williams et al. 1993) to threatened by the American Fisheries Society (draft 2010, in review).

Habitat destruction:

Habitat loss and degradation from a variety of factors has caused the extirpation of many populations of Delicate Spike and pose an ongoing threat to this declining species (NatureServe 2008). The Delicate Spike is significantly threatened by poor land management practices which result in decreased water quality due to sedimentation, and by bank and streambed destabilization and water withdrawals (NatureServe 2008). This mussel is threatened by impoundment (Williams et al. 1992). The widescale conversion of hardwood forests to pine plantations threaten this mussel (NatureServe 2008). Catena Group (2007) report that mussel habitat in the Savannah River has been degraded by bank instabililty and unstable, shifting sediments. The Georgia Dept. of Natural Resources (2008) reports that this mussel is threatened by sedimentation and eutrophication resulting from agriculture, development, and inadequate riparian buffer zones. This mussel is also threatened by incompatible dam operations on the Coosawattee River. Water withdrawals for agriculture in the Lower Flint basin threaten populations in small streams, particularly during periods of drought (GDNR 2008). Gillies et al. (2003) report that urbanization threatens this species in the Atlanta area.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Delicate Spike, and no occurrences are appropriately protected and managed (NatureServe 2008). It is listed as Endangered by the state of Georgia, and is a Tier 1 Species of Greatest Conservation Need in Mississippi, and a Priority 1 Species of Greatest Conservation Need in Alabama, but these designations do not provide any substantial regulatory protection. It is not listed in Tennessee, South Carolina, or Florida. NatureServe (2008) states, "Because E. arctata is now rare, has a highly restricted range (Mobile Endemic), and specific microhabitat requirements, E. arctata should be considered for federal protection."

Other factors:

The Delicate Spike is threatened by factors which decrease water quallity or negatively affect host-fish populations. This mussel is threatened by runoff, chemical pollutants, and siltation (NatureServe 2008). Because many populations of this species have been extirpated, it is threatened by population isolation. Mirarchi et al. (2004) state, "Limited distribution, rarity, and specialized habitat requirements make E. arctata vulnerable to extinction" (p. 45).

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Scientific Name:
Elliptio fraterna
Common Name:
Brother Spike

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	DD - Data deficient

Range:
The Brother Spike is a naturally rare mussel known only from the Flint and Chattahoochee Rivers of Alabama and Georgia, and the Savannah River drainage of South Carolina (Mirarchi et al. 2004). This distribution is disjunct, and there are no known records from intervening drainages (Brim Box and Williams 2000, NatureServe 2008).

Habitat:
This species has been found on sand bars in the mainstem of the Savannah River (Britton and Fuller 1979). Johnson (1970) describes its habitat as sandy substrates in the main channel of rivers and larger tributaries in swift currents, but this may have been in reference to a closely related species (NatureServe 2008).

Ecology:
Mirarchi et al. (2004) report that this mussel is likely a short-term brooder like its congeners.

Populations:
There are less than five populations of Brother Spike, with five records being known from three occurrences (NatureServe 2008). Catena Group (2007) recently detected this species at 3 sites in the Savannah River, with one individual being encountered per site. Before this, the species had last been reported from the Savannah drainage in 1972 (Britton and Fuller 1979), which at the time was the only record from the drainage since the species' description in 1852. This mussel was last detected in the ACF Basin in the Flint River in 1929. A recent survey of 324 sites in the ACF basin failed to detect this mussel (Brim Box and Williams 2000).

Total population size is estimated at 50 - 2500 individuals (NatureServe 2008), but this is likely an overestimate, as there are only seven known specimens from the Chattahoochee and Flint drainages, and three from the Savannah River (Catena Group 2007), with the Savannah River individuals having been collected for genetic analysis.

Population Trends:
The Brother Spike is rapidly declining in the short term and substantially to moderately declining in the long term (NatureServe 2008). This species is considered to be naturally rare in the Savannah system, and historically uncommon in the Chattahoochee and Flint drainages as well (NatureServe 2008). The species is probably extirpated in Alabama (Mirarchi et al. 2004).

Status:
NatureServe (2008) ranks the Brother Spike as extirpated in Alabama (SX), and critically imperiled in Georgia and South Carolina. This species was historically rare and is now limited to less than five fragmented occurrences. It is possibly extirpated from the Chattahoochee and Flint rivers of Alabama and Georgia (NatureServe 2008). The American Fisheries Society ranks Elliptio fraterna as Endangered (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
This mussel is threatened by habitat loss and modification including damming, dredging, extremely low water levels, and sedimentation resulting from poor land management practices (NatureServe 2008). Catena Group (2007) state that unstable banks and substrates threaten mussels in the Savannah River, which may harbor the only extant populations of this species. The South Carolina Dept. of Natural Resources (2005) reports that this mussel is sensitive to channel modification, pollution, sedimentation and low oxygen conditions.

Overutilization:
Overutilization threatens the survival of this mussel because so few individuals survive in the wild. This species had not been detected in the Savannah River since 1972 and was thought to be extirpated in that system. The three individuals which were detected in the Savannah were removed from the wild for genetic analyses (Catena Group 2007), which could contribute to the extirpation of Brother Spike in the Savannah drainage if they were not returned.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect this species. This mussel is likely extirpated in Alabama, and is not protected by the states of Georgia or South Carolina. NatureServe (2008) reports that no occurences are appropriately protected and managed.

Other factors:
Any factor which reduces water quality or quantity will negatively affect this species. This mussel is threatened by decreased survival and reproductive success due to decreased water quality resulting from pollutants and sedimentation (NatureServe 2008). It is also threatened by rarity, low population size, and drastically reduced range.

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Scientific Name:
Elliptio lanceolata
Common Name:
Yellow Lance

G Rank:	AFS Status:	IUCN Status:
G2	Endangered	NT - Near threatened

Range:
The yellow lance is a freshwater mussel native to the Coastal Plain of the southeastern United States. It occurs in Virginia and North Carolina, and possibly in Maryland and South Carolina. There are unresolved taxonomic issues for this mussel in Maryland, and if it ever existed there, it may now be extirpated. Taxonomy of this species is also unresolved in South Carolina.

Natural heritage records indicate that this species is known from Duplin, Edgecombe, Franklin, Granville, Halifax, Johnston, Nash, Vance, Wake, Warren, and Wayne Counties in North Carolina, potentially in Abbeville, Chesterfield, Edgefield, Greenwood, Lancaster, Laurens, McCormick, Newberry, Oconee, and Saluda Counties in South Carolina, and in Alleghany, Amherst, Bath, Bedford, Botetourt, Brunswick, Buckingham, Buena Vista, Chesterfield, Craig, Culpeper, Cumberland, Dinwiddie, Emporia, Fauquier, Fluvanna, Goochland, Greensville, Hanover, Louisa, Lunenburg, Madison, Nelson, Nottoway, Orange, Powhatan, Prince William, Rappahannock, Rockbridge, Southampton, and Spotsylvania Counties in Virginia. It is likely extirpated from Fairfax and Stafford Counties in Virginia (NatureServe 2008).

Habitat:
The yellow lance inhabits creeks and medium-sized rivers and is found in areas with low flow rates, in sandy, rocky, or mud substrates (Johnson 1970). It may deeply entrench itself in sandy substrate and incidentally migrate with moving sand, although major dispersal typically only occurs by means of glochidial host movement in the larval phase (NatureServe 2008).

Ecology:
The yellow lance reproduces as do most other freshwater mussels: larvae are parasitic on various fish species, though glochidial host species for E. lanceolata are unknown (NatureServe 2008).

Populations:
Numerous historic occurrences of this species are likely extirpated. There are possibly 15 extant occurrences of this mussel in North Carolina, and several in Virginia. Within the range where the yellow lance is currently recognized to occur, Johnson (1970) lists three historical occurrences from the Neuse River drainage, two from the Tar River, two from the Roanoke River system, one from the Chowan River system, seven from the James River drainage, two from the South Anna River drainage, and four from the Rappahannock River system. It may currently be extirpated from the Roanoke River system and from the main stem of the Rappahannock River (J. Alderman, pers. comm. cited in NatureServe 2008). In Virginia, this mussel is extirpated, or nearly so, from the Lower Chesapeake and James River basins with extant occurrences only in the Rapidan-Upper Rappahannock and Mattaponi, and the Upper James and Middle James-Willis (J. Alderman, pers. comm., 2000; VA NHP, pers. comm., 2006, both cited in NatureServe 2008).

The abundance of Elliptio lanceolata is unknown, but it is thought that there are at least 2500 individuals. This mussel appears to be declining in abundance throughout most of its historical range. For example, only one individual was found in a recent survey of parts of the South Anna River drainage (J. Alderman, pers. comm. cited in NatureServe 2008).

Population Trends:

NatureServe (2008) reports that this species has declined by up to 30 percent in the short-term, and up to 50 percent in the long-term stating: "It is extremely threatened with extirpation in the Neuse River system. Stable populations exist in the Tar River, but these are patchily distributed and therefore vulnerable to extirpation. It appears to be extirpated from historical occurrences in the Tar River below Rocky Mount, North Carolina (J. Alderman, pers. comm.). It also appears to have been recently extirpated from Ruin creek in Vance County and the Tar River in Edgecombe County, North Carolina. Elliptio lanceolata occurs in the Chowan River basin, but has a restricted range within that system. Is now very rare in the James, S. Anna, and Rappannock rivers, and no information is available regarding its current status in the Roanoke River (J. Alderman, pers. comm.). . . In Virginia, it is extirpated, or nearly so from the Lower Chesapeake and James River basins with extant occurrences only in the Rapidan-Upper Rappahannock and Mattaponi, and the Upper James and Middle James-Willis (J. Alderman, pers. comm., 2000; VA NHP, pers. comm., 2006)." If this species ever occurred in Maryland, it is likely now extirpated from the state. Records from South Carolina are taxonomically uncertain. NatureServe (2008) states, " Despite questions about its taxonomy, whether it eventually is deemed to be a species or species complex, the taxon is clearly beginning to experience the effects of decline throughout much of its range."

Status:

NatureServe (2008) reports that the yellow lance is critically imperiled in North Carolina and imperiled in Virginia; its status has not been evaluated in Maryland or South Carolina due to taxonomic uncertainty. It is listed as endangered in North Carolina and as a species of special concern in Virginia. Many remaining populations are small and of dubious viability. It is ranked as endangered by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

The yellow lance is threatened across its range by habitat degradation and loss resulting from agriculture, logging, and municipal development. Additionally, in parts of its range, this mussel is threatened by impoundment and channelization.

In North Carolina, aquatic species in the Neuse drainage have been negatively affected by the construction of Falls Lake, which has significantly altered water temperatures below the dam. Thermal alteration and general pollution problems around Raleigh have reduced habitat in the upper Neuse River (NatureServe 2008). The Neuse is routinely considered to be an endangered basin (American Rivers Foundation 2007) with impacts such as urban wastewater, fertilizer, industrial development and animal operations all contributing to eutrophication (Pinckney et al. 1997, Paerl et al. 1998). In-stream habitat in the Neuse Basin has been lost and degraded by forestry, urban and residential development, impoundments, and effluent (North Carolina Department of Environment and Natural Resources 2002). Agriculture and farming operations have contributed to habitat degradation, and development is rapidly increasing (Midway 2008). The North Carolina Wildlife Resources Commission (2005) reports that aquatic species in the Neuse Basin are threatened by agriculture, forestry, impoundments, water withdrawals for irrigation, development, wastewater discharges, and increasing human population. The human population within the basin is expected to grow by more than 867,000 by 2020 to almost 3 million people. Development, confined animal feeding operations, and forestry also threaten aquatic species in the Tar River basin, but to a lesser extent than the Neuse (Starnes 2002).

Aquatic species in the Tar River basin are threatened by erosion, sedimentation, channelization, agriculture, irrigation withdrawals, confined animal feeding operations, and increasing human population growth and development pressure (North Carolina Wildlife Resources Commission 2005b).

In Virginia, the yellow lance is threatened by sediment load alteration from agriculture, forestry, and municipal development, by channel and shoreline alteration from agriculture, and by hydrologic regime alteration from municipal development (Virginia Dept. of Game and Inland Fisheries 2010).

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the yellow lance. Though it is listed as endangered in North Carolina and as a species of special concern in Virginia, these designations offer this species no substantial regulatory protections from habitat destruction or degradation and cannot be deemed sufficient. NatureServe (2008) reports that no occurrences of this species are appropriately protected and managed.

Other factors:

Water pollution threatens the survival of this mussel. The Virginia Dept. of Game and Inland Fisheries (2010) reports that the yellow lance is threatened by toxins from roadways and from municipal development, and by organic matter from agriculture. Aquatic species in Virginia's Mid-Atlantic Coastal Plain are threatened by water pollution including low dissolved-oxygen levels, high fecal coliform counts, and altered pH resulting from agricultural and urban runoff. In Virginia's Southern Piedmont, water is polluted by these same sources and by abandoned mine runoff. In the Blue Ridge mountains, aquatic species face the same threats and are also contaminated with mercury and PCBs (Virginia Wildlife Action Plan 2006a, 2006b, 2006c). Water pollution is also a documented threat to this species in North Carolina (North Carolina Wildlife Resources Commission 2005a, 2005b).

The yellow lance is also threatened by any factor which threatens the host fish on which it is dependent for reproduction.

This mussel is also threatened by stochastic genetic and environmental events due to its extant distribution primarily in small, isolated populations.

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Scientific Name:
Elliptio monroensis
Common Name:
St. John's Elephantear

G Rank:
G2

Range:
The St. John's elephantear is endemic to the St. Johns River system in Florida with the intervening St. Marys and Satilla Rivers separating this species from the similar Elliptio dariensis in the Altamaha River system in Georgia (Butler 1994).

Habitat:
This mussel occurs in sandy substrates in lakes and in streams with little current (Heard 1979).

Populations:
Within the single river system where it occurs, this mussel is found in Black Creek, Lake Monroe, and the St. Johns River in the St. Johns River system (Butler 1984, Johnson 1972). Johnson (1972) lists St. John's River drainage specimens (as Elliptio dariensis) from the Econlockhatchee River near the St. John's River confluence, the St. John's River in Osceola and Sanford (Seminole Co.), Lake Monroe (also Seminole Co.), and Lakes Beresford and Woodruff in Volusia Co., as well as the St. Johns River in Georgetown (Putnam Co.). It has also been reported from Julington Creek just south of Jacksonville (St. Johns River drainage) (NatureServe 2008). Population data are not available.

Population Trends:
NatureServe (2008) does not have population data for this species. It is considered to be threatened by the American Fisheries Society (2010 draft, in review) which indicates likely decline.

Status:
NatureServe (2008) ranks this mussel as imperiled globally and under review in Florida (G2SNR). It is being ranked as threatened by the American Fisheries Society (2010 draft, in review).

Habitat destruction:
This species is endemic to one small river system and is thus particularly vulnerable to habitat degradation. The St. John's river is highly threatened by eutrophication from urban runoff (St. Johns River Water Management District 2010).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this mussel, and NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected.

Other factors:
This mussel is threatened by water pollution.

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Scientific Name:
Elliptio purpurella
Common Name:
Inflated Spike

G Rank:
G2

Range:
The range of the Inflated Spike is estimated at 250-1000 square km in the Apalachicola Drainage Basin in Alabama, Florida, and Georgia below the Fall Line. Historically this mussel occurred in the mainstem and tributaries of the Flint, Chattahoochee, and Chipola rivers, but is now extant only in tributaries of the Flint River in Georgia, and is possibly extirpated from the Chipola and Chattahoochee river drainages and from the mainstem of the Flint River (Brim Box and Williams 2000, Gagnon et al. 2006). The species is possibly extirpated in Alabama where it formerly occurred in the Chattahoochee and Chipola River systems, but recently detected unconfirmed indiviudals from Big Creek in the Chipola River headwaters in Houston Co. appear to be Elliptio purpurella (Mirarchi et al. 2004). Williams et al. (2008) report that this mussel is extant in Alabama only in the headwaters of the Chipola River.

Habitat:
The Inflated Spike occurs in creeks and rivers, mostly in areas of flowing water, but occasionally in lakes under some conditions. Sand and clay substrates are preferred, and this mussel is associated with limestone (Brim Box and Williams 2000).

Ecology:
This mussel is likely a short-term brooder that is gravid during spring. Glochidial hosts are uknown (Williams et al. 2008).

Populations:
NatureServe (2008) estimates that there are from 6-20 populations of Inflated Spike. There are 14 known sites in tributaries of the Flint River on the coastal plain of Georgia in the Apalachicola/Chattahoochee/Flint basin (Brim Box and Williams 2000). In southwestern Georgia, this mussel occurs in about a dozen tributary streams in the lower Flint River Basin (Golladay et al. 2004). There is one extant population in Alabama (Williams et al. 2008).

In tributaries of the Flint River, 369 live individuals were recorded in 1991-1992 (Brim Box and Williams 2000). This mussel made up 1.03 percent (relative abundance) of the 14,873 mussels collected in surveys of 46 sites in 12 tributary streams of the lower Flint River Basin, Georgia in 1999 (Gagnon et al. 2006). In 1999 and 2001, this species was found in 10 sites (99 specimens) and 8 sites (161 specimens), respectively, in surveys of 21 sites (each year) in about a dozen tributary streams of the lower Flint River Basin, in southwestern Georgia (Golladay et al. 2004).

Population Trends:
The Inflated Spike is declining in the short term, and moderately declining in the long term (decline of 25-50 percent). This species is now known from a restricted range in one river drainage in Georgia, and it is nearly extirpated in Alabama. In Georgia and Alabama it is likely extirpated from the Chattahoochee River drainage and from the mainstem of the Flint River (Brim Box and Williams 2000).

Status:
The Inflated Spike is critically imperiled in Alabama and imperiled in Georgia (NatureServe 2008). It is a Priority 1 Species of Greatest Conservation Need in Alabama, and is a Threatened species in Georgia. It is extirpated in Florida. It is being ranked as vulnerable by the American Fisheries Society (2010 draft, in review).

Habitat destruction:
Because this species is either extirpated or nearly extirpated in Alabama and occurs in a single drainage in Georgia, it is highly vulnerable to habitat alteration. Freshwater mussels are threatened by any activities which decrease water availability or water quality including diversion, impoundment, and ground-disturbing activities. The Georgia Dept. of Natural Resources (Wisniewski 2008) lists the following threats for this species: "Excess sedimentation due to inadequate riparian buffer zones, development, and agriculture covers suitable habitat and could potentially suffocate mussels. Poor agricultural practices may also cause eutrophication and degrade water quality. Excessive agriculture water pumping in the lower Flint River basin appears to stress the aquatic resources of the basin in periods of extreme drought" (available at: http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=89&txtPage=15). The Alabama Clean Water Partnership (2006) reports that Big Creek, a Chipola River tributary which is the only extant site for this species in Alabama, contains excessive nutrients, organic enrichment, and low dissolved oxygen, potentially from stormwater from urbanized industrial areas and wastewater discharges (p. 1-13). Water quality in the Chipola Basin is threatened by nonpoint source pollution including sediment, nutrients, animal and human waste, and petroleum products from widespread, hard-to-identify sources (ACWP 2006).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Inflated Spike, and no occurrences of this mussel are appropriately protected and managed (NatureServe 2008). It is a Priority 1 Species of Greatest Conservation Need in Alabama, and is a Threatened species in Georgia, but these designations do not provide any substantial regulatory protection.

The Georgia Dept. of Natural Resources (Wisniewski 2008) lists the following management recommendations for this mussel: "Examination of basic life history was identified as a top research priority needed for the conservation of this species during the 2005 Georgia Wildlife Action Plan. Understanding the basic life history of this species will provide the foundation upon which all other research and conservation actions should be built. Investigating the effects of groundwater withdrawals on the distribution and abundance of rare species in the lower Flint River basin was also identified as a high priority research need for this species" (available at: http://georgiawildlife.dnr.state.ga.us/content/displaycontent.asp?txtDocument=89&txtPage=15).

Other factors:
Mirarchi et al. (2004) state that limited distribution and rarity make this species vulnerable to extinction. In addition, any factor which decreases water quality or quantity threatens this species, including drought and pollution. After a drought in 1999-2001, this mussel declined in abundance in the Flint River drainage in Georgia (Chastain et al. 2005).

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Scientific Name:
Elytraria caroliniensis var. angustifolia
Common Name:
Narrowleaf Carolina Scalystem

G Rank:
T2

Range:
Narrowleaf Carolina scalystem is endemic to southern Florida, where it is found only in Dade, Collier, Lee, and Broward counties (NatureServe 2008).

Habitat:
This plant is largely restricted to calcareous areas within wet woodlands, seepage slopes, wet prairies, or pine rocklands (NatureServe 2008).

Populations:
There are nine known occurrences of this plant , but population sizes are not reported (NatureServe 2008). It is most common in and around Long Pine Key (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that populations are stable in the short-term, but longer-term trends are not known. This plant is no longer found along the edges of the "finger glades" that transect the Miami ridge pinelands.

Status:
This plant is endemic to a small range in southern Florida, within which it is relatively rare and restricted to particular habitat type (calcareous marshes). It no longer occurs in parts of its historical range. NatureServe (2008) ranks this species as imperiled.

Habitat destruction:
The scalystem is threatened by anthropogenic alteration of wetland hydrology (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
The occurrences of this plant in Everglades National Park are fairly well-protected, and this plant may also occur in Big Cypress National Park. It also occurs in some state parks, where protections are minimal. In sum, no existing regulatory mechanisms adequately protect the Carolina scalystem or its habitat.

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Wunderlin, R.P. 1982. Guide to the vascular plants of central Florida. Univ. Presses Florida, Gainesville. 472 pp.

Scientific Name:
Encyclia cochleata var. triandra
Common Name:
Clam-shell Orchid

G Rank:
T2

Range:
E. cochleata var. triandra is a rare orchid endemic to the state of Florida, and is likely restricted to three counties within the state, though conclusive surveys have not been conducted. Its total range probably covers less than 100 square miles (NatureServe 2008).

Habitat:
This orchid is found in tropical hammocks, buttonwood (Platanus spp.), and cypress strands (NatureServe 2008).

Ecology:
The orchid is an epiphytic perennial.

Populations:
Population size for E. c. var triandra is not known, but very few populations are confirmed throughout its small range (NatureServe 2008).

Population Trends:
Trend information is not available for this species.

Status:
This orchid is very rare and is endemic to a small range in northern Florida. NatureServe (2008) reports that the clam-shell orchid is imperiled throughout this range.

Overutilization:
Widespread collection of this species poses the greatest threat to its persistence and has caused significant reductions to several local populations (NatureServe 2008)

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

References:

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Scientific Name:
Epidendrum strobiliferum
Common Name:
Big Cypress Epidendrum

G Rank:
G4

Range:
This small orchid species is widely distributed in Central America, but found in just one site in Florida, in Collier County (NatureServe 2008). It is present in Southern Florida, from Mexico to Brazil, in Cuba, Hispaniola, the Lesser Antilles, and Trinidad.

Habitat:
In Florida, this epiphyte grows on pop ash (Fraxinus caroliniana) and pond apple (Annona glabra) within cypress sloughs. In more southerly portions of its range, this species is found in tropical hammocks at up to 4500 ft in elevation (NatureServe 2008).

Ecology:
The big cypress epidendrum is a small, perennial, epiphytic orchid (NatureServe 2008)

Populations:
Global population size is not known, but this species is reportedly rare at the one site where it occurs in Florida, but widespread in Central America (NatureServe 2008).

Population Trends:
Population trends are not reported.

Status:
Though this species is widespread in Central America, it is found in just one site in Florida. The state of Florida lists it as endangered as it is considered highly rare (Ward et al. 2003). In Florida, it is ranked as critically imperiled (N1) by NatureServe (2008).

Habitat destruction:
Habitat destruction is a factor in the decline of many epiphytic orchids in the Southern U.S., including Epidendrum strobiliferum (McCartney 1985). Development, pollution and siltation generated by agriculture or industry, and logging are among the primary drivers of habitat destruction within this species' range.

Overutilization:
This species is threatened by overexploitation by orchid collectors (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that few occurrences are appropriately protected or managed: one population occurs within Fahkahatchee Strand State Preserve in southern Florida. It is listed as endangered by the state of Florida, but this designation does not protect the species from habitat destruction, a primary threat to its survival.

Other factors:
Because the range of this species within the U.S. is already so limited, fragmentation or destruction of suitable habitat is enormously harmful: isolated, small populations are vulnerable to stochastic extinction events and inbreeding depression. E. strobiliferum also appears to be

something of a habitat specialist, which makes the protection of its preferred habitat all the more imperative (NatureServe 2008).

References:

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NatureServe. 2008. NatureServe Explorer: an online encyclopedia of life. Version 7.1. NatureServe, Arlington, VA. Available online: http://www.natureserve.org/explorer. Accessed November 25, 2009.

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Scientific Name:
Epioblasma triquetra
Common Name:
Snuffbox

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	NE - Not evaluated

Range:
The snuffbox is a freshwater mussel species endemic to the eastern United States and Canada. It has experienced a drastic reduction in range in recent decades; historically widespread in the upper Mississippi and Ohio River drainages and throughout the Tennessee River system, it is now limited to a much smaller range. Fewer than 50 reproducing populations are known, and the majority of remaining populations are small and geographically isolated (R.J. Neves as cited in NatureServe 2008). Populations are currently known in Alabama (Paint Rock River, Mirarchi 2004, Williams et al. 2008), Arkansas (few sites with very small populations in the White, Spring, and Strawberry Rivers, Harris and Gordon 1987, Harris et al. 1997), Illinois (short reach of the Embarras River, Cummings and Mayer 1997), Indiana (few scattered populations within Wabash River tributaries, Fisher 2006), Kentucky (sporadically found in the upper Green River, Cicerello and Schuster 2003), Michigan (Clinton River, the southeastern portion of Lake Michigan, and the Pine and Belle River basins, Trdan and Hoeh 1993, Strayer 1980, Badra and Goforth 2003), Minnesota (lower St. Croix River, Sietman 2003), Missouri (Bourbeuse, Meramac, and St. Francis Rivers, Oesch 1995), Mississippi (Tennessee River drainage, Jones et al. 2005), Ohio (Scioto River tributaries, Big Darby Creek, Watters 1992, 1995), Ontario (Sydenham River, possible small population in lower reaches of the Thames River, Metcalfe-Smith et al. 2003, Cudmore et al. 2004), Pennsylvania (Muddy Creek in the Erie National Wildlife Refuge, Mohler et al. 2006), Tennessee (few areas throughout the Clinch, Powell, North and South Fork Holston, lower Nolichucky, Little, Elk, Duck, Cumberland, Obey, and Tennessee Rivers, Parmalee and Bogan 1998), West Virginia (locations unreported), and Wisconsin (Wolf and St. Croix drainages, WI NHP 2007 as cited in NatureServe 2008). It is likely extirpated from New York, though two empty shells (the first state records since 1950) were recently collected in the Towanda Creek Basin (Strayer and Jirka 1997, Marangelo and Strayer 2000).

Habitat:
The snuffbox is generally found in medium-sized and large rivers with swift current and rock or sand substrate, often buried in the river bottom (Baker 1928). It is intolerant of poor water quality: the sites where it remains show little disturbance to substrate or nearby riparian areas (NatureServe 2008).

Ecology:
Known glochidial host species include the Ozark sculpin, Cottus hypselarus, blackspotted topminnow, Fundulus olivaceous, banded sculpin, Cottus Carolina, blackside darter, Percina maculata, mottled sculpin, Cottus bairdi, and the logperch, Percina caprodes (Hill 1986, Sherman 1993, Yeager and Saylor 1995, Hove et al. 1998, 2003, Hillegrass and Hove 1997, Barnhart and Baird 1998, Hove et al. 2000, Hove and Kapuscinski 1998, Watters et al. 2005).

Populations:
There are less than 50 extant reproducing occurrences of this mussel; NatureServe (2008) reports that "several dozen occurrences remain." Total population size is unknown, but it is thought that there are at least 2500 individuals. This mussel has become "increasingly rare" and many remaining populations are small (NatureServe 2008). The extant distribution of the snuffbox is widespread, but greatly fragmented. NatureServe (2008) states: "It was historically widespread in the Midwest. . . In Minnesota, this species has been extirpated from the Mississippi River below St. Anthony Falls (Sietman, 2003). It was recently documented in the Fox River basin in Illinois by a single weathered valve in Nippersink Creek with no specimens on the Wisconsin side of the basin (Schanzle et al., 2004). The species has not been collected alive in New York (historically known from Niagara River, Lake Erie, Buffalo River) since 1950 (Strayer and Jirka, 1997) but spent shells have been found recently. Historically in Canada it occurred in Ontario in Lake St. Clair, Lake Erie, the Thames, Grand, Niagara, Ausable, and Saudenham Rivers but has been extirpated from all but the latter two (Metcalfe-Smith and Cudmore-Vokey, 2004)."

Population Trends:
Numerous sources report that this species has experienced major reductions in overall range and abundance and that declines are continuing (e.g., NatureServe 2008, Parmalee and Bogan 1998). NatureServe (2008) estimates that this species has declined by up to 50 percent in the long-term and by up to 30 percent in the short-term. The long-term viability of most populations is questionable.

Status:
NatureServe (2008) ranks the snuffbox as critically imperiled in Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Mississippi, Missouri, Ohio, Pennsylvania, Virginia, and Wisconsin, imperiled in Minnesota, West Virginia, and Ontario, vulnerable in Tennessee, and reports that it is extirpated from Kansas and New York. It is listed as endangered in Indiana, Kentucky, Virginia, West Virginia, Illinois, Michigan, Mississippi, and Wisconsin, and as threatened in Ohio and rare in Missouri (Cummings and Mayer 1992). It is endangered in Canada. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Across its range, the habitat of the snuffbox is threatened by many factors. Impoundments reduce water flow that is necessary for essential physiological activities such as feeding, waste removal, and reproduction, and may also reduce dissolved oxygen levels, increase siltation, disrupt population connectivity, and interfere with host-fish dispersal and migration (NatureServe 2008). Many sources cite impoundment as a threat to this species (Carman and Goforth 2000, Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006).

The snuffbox is also known to be threatened by habitat fragmentation, dredging, channelization, riparian zone removal for agriculture, forestry, or development, gravel and sand mining, coal mining, oil and gas drilling, grazing, and recreation (Arkansas Game and Fish Commission 2005, Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006, Pennsylvania Fish and Boat Commission 2010).

This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Concerning threats to this mussel in Pennsylvania, for example, the Pennsylvania Fish and Boat Commission (2010) states: "[T]he lock and dam system in the Allegheny and Ohio Rivers, combined with maintenance/commercial sand and gravel dredging have destroyed Snuffbox habitat, eliminated habitat continuity and genetically isolated upstream subpopulations from other subpopulations. Large impoundments such as the Allegheny Reservoir, Pymatuning Reservoir and Shenango River Lake have also destroyed Snuffbox habitat and eliminated genetic/host connectivity to downstream subpopulations. . . Sedimentation from oil and gas developments, forestry and agricultural practices could have an adverse effect on mussel/host interactions. The Snuffbox uses a unique strategy (fish capture) to lure hosts and transmit glochidia (parasitic larvae phase of freshwater mussels). Excessive turbidity associated with increased sedimentation would likely alter host numbers or behavior and reduce Snuffbox recruitment."

Inadequacy of existing regulatory mechanisms:

Though some populations occur in areas that are ostensibly protected by designation as a wildlife sanctuary or natural area, even these protected areas are not immune to watershed-level disturbances (e.g., pollution, siltation, impoundment, or diversion) and should not be considered adequate to restore or sustain effective populations.

No existing regulatory mechanisms adequately protect the snuffbox from the habitat loss and degradation that endangers it. Though this mussel is listed by several states, these designations do not provide regulatory protection for the species' habitat.

Other factors:

Several other factors threaten the continued existence of the snuffbox. Water pollution is a dire threat to this species. Known causes of pollution in snuffbox habitat include siltation from impoundments, logging, agriculture, dredging, mining, and development, chemical pollution from mining, urban runoff, and agriculture, waste water discharge, and accidental chemical spills, and nutrient loading from grazing, confined animal feeding operations, and urban development (Carman and Goforth 2000, Arkansas Game and Fish Commission 2005, Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006). Acute or chronic pollution events could destroy isolated populations of this species (Pennsylvania Fish and Boat Commission 2010).

Invasive species, such as the zebra mussel, Dreissena polymorpha, and the Asian clam, Corbicula fluminea, also threaten the snuffbox (Neves 1999, Michigan Dept. of Natural Resources 2006, NatureServe 2008). Zebra mussels are known to have destroyed the Lake Erie subpopulation and to have colonized the Allegheny River, Ohio River. and French Creek. Ongoing snuffbox mortality from zebra mussel infestation is expected (Pennsylvania Fish and Boat Commission 2010).

Declines in glochidial host species may threaten the snuffbox in parts of its range (Carman and Goforth 2000, NatureServe 2008).

The snuffbox is also threatened by stochastic genetic and environmental events due to isolated population distribution, small population size, and low gene flow (Kentucky Department of Fish and Wildlife Resources 2005, Pennsylvania Fish and Boat Commission 2010).

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Scientific Name:
Erimystax harryi
Common Name:
Ozark Chub

G Rank:	AFS Status:
G3	Vulnerable

Range:
The Ozark chub occurs in the St. Francis and White river drainages of southern Missouri and northern Arkansas. The Current and Jack Fork rivers are considered to be this species' stronghold (NatureServe 2008).

Habitat:
This fish generally occurs in large, medium-gradient, moderately clear streams and rivers with clean gravel bottom where it prefers riffle, run, and flowing pool habitats over gravel or rubble (Page and Burr 1991). It is often found in shoal areas with moderate flow (Lee et al. 1980).

Populations:
In Arkansas, Robison and Buchanan (1988) mapped approximately 44 collection sites for this fish from 1960-1987. In Missouri, Pflieger (1997) mapped 45-50 collection sites. Total population size is unknown. This fish is reported as common in appropriate habitat.

Population Trends:
The Ozark chub has declined in the short-term by 10-30 percent (NatureServe 2008). In Missouri, it was formerly widespread in most of the larger streams in the southern Ozarks, but drastic declines have occurred in the White, Black, and St. Francis rivers since dams were erected (Pfleiger 1997).

Status:
NatureServe (2008) categorizes this species as vulnerable in Arkansas and as not rated in Missouri. It is classified as vulnerable by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and degradation.

Habitat destruction:
Impoundment is a primary threat to the Ozark chub. Drastic population declines occurred in the White, Black, and St. Francis rivers in Missouri following construction of reservoirs (Pfleiger 1997). The chub is intolerant of turbidity and siltation (Robison and Buchanan 1988) and remaining populations are thus threatened by a variety of activities. The Arkansas Game and Fish Commission (2005) report that this fish is threatened by sedimentation from grazing, resource extraction, and road construction. The Missouri Dept. of Conservation (2010) reports that fish in the White River watershed are threatened by urbanization, livestock grazing, gravel mining, and reservoir operations. Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species.

Other factors:
The chub is threatened by water pollution from siltation (NatureServe 2008).

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Scientific Name:
Eriocaulon koernickianum
Common Name:
Small-headed Pipewort
G Rank:
G2
Range:

Also known as the dwarf pipewort or gulf pipewort, E. koernickianum is restricted to small areas of the Interior Highlands portion of Arkansas and Oklahoma, adjacent coastal plains of Oklahoma and Texas, and a disjunct area of the Georgia Piedmont. In Texas, this species is reported from Anderson, Henderson, Limestone, van Zandt, and Gillespie Counties (extirpated from Brazos County, Poole et al. 2007). In Oklahoma, there are current reports from Pushmataha and Atoka Counties (extirpated from Muskogee County), in Arkansas, it is found in Calhoun, Frankling, Johnson, Madison, Pope, Saline, and Van Buren Counties (believed extirpated from Benton, Conway, Logan, Montgomery, and Pulaski Counties), and in Georgia, E. koernickianum is considered extant in Clarke, DeKalb, Greene, Gwinnett, Hancock, Meriwether, Newton, Rockdale, and Walton Counties (NatureServe 2008, Smith 1988, Jones and Coile 1988).

Habitat:
Habitat usage varies across the pipewort's range; in Georgia, this species is found in seeps and wet depressions in granite outcroppings, and in Arkansas, Oklahoma, and Texas, it is most often noted in sandy hillside seepage areas, along bog margins, and less often along prairie streambanks. Considered an early successional species, it rarely establishes among dense vegetation, prefers open sites maintained by fire or drought, and is intolerant of shade.

Ecology:
This plant is either an annual or weak perennial, and reproduces by seed only. It appears to be somewhat fire-maintained, at least in the western portion of its range (Watson et al. 1994).

Populations:
Approximately 47 occurrences of this species are believed to be currently extant; 21 historical occurrences could not be confirmed by recent surveys and are therefore considered extirpated. The majority of remaining populations are found in Arkansas and Georgia. Populations are highly variable in size, those in Arkansas are small, while in Oklahoma, E. koernickianum may be locally abundant under suitable conditions.

Population Trends:
NatureServe (2008) determined that this species is relatively stable in the short-term, but roughly one-third of historical occurrences have not been recently confirmed, and threats to its long-term persistence are substantial.

Status:
This species is considered vulnerable based on its reliance on disturbance, low genetic variability, and low recruitment at some sites. NatureServe (2008) ranks E. koernickianum as critically imperiled in Georgia, Oklahoma, and Texas, and imperiled in Arkansas. It is state listed as endangered in Arkansas, as a species of special concern in Georgia, and was previously a federal candidate species.

Habitat destruction:

Threats to this species' habitat include drainage, impoundment, or other hydrological alterations, fire suppression, and residential and agricultural development (NatureServe 2008). Fire suppression has been linked with population loss in Oklahoma (Watson et al. 1994). Off-road vehicle (ORV) recreation is a threat in some places (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

Many occurrences of this species are found within the Ozark National Forest, and these may be protected if properly managed. In other locations, no existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Eriocaulon nigrobracteatum
Common Name:
Black-bract Pipewort

G Rank:
G1

Range:
This recently described species is endemic to the Gulf Coastal Lowlands in the east-central Florida panhandle: natural heritage records indicate the species is present in Bay, Calhoun, and Gulf Counties (NatureServe 2008, Atlas of Florida Vascular Plants 2008).

Habitat:
This species is restricted to deep sapric soils within acidic mires; little wood or Sphagnum moss is present in the muck it seems to prefer. Within these fen habitats, black-bract pipewort is abundant in water-saturated areas (Orzell and Bridges 1993).

Ecology:
E. nigrobracteatum is a perennial herb that forms dense clumps of short, linear leaves. It blooms in March and April (NatureServe 2008). This species reproduces vegetatively.

Populations:
Eleven occurrences are reported in Orzell and Bridges (1993). Total global population size is not reported, but NatureServe (2008) estimates that there are fewer than 2500 individuals rangewide.

Population Trends:
Population trends are unreported but based on habitat loss and degradation, this species is likely in decline (NatureServe 2008).

Status:
This species is endemic to a small range in the Florida panhandle, within which it occupies a narrow range of environmental conditions. NatureServe (2008) ranks the black-bract pipewort as critically imperiled. It is also state-listed as endangered in Florida.

Habitat destruction:
Anthropogenic alteration of habitat or area surrounding habitat is detrimental to this species: diversions or dams, pollution, and siltation generated by agriculture, industry, or development are among the primary threats to the black-bract pipewort and its habitat (NatureServe 2008). This species may be shaded out by shrubby undergrowth that is able to establish because of fire suppression or other anthropogenic changes to habitat.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that no occurrences are appropriately protected or managed, and it seems clear that no existing regulatory mechanisms adequately protect the black-bract pipewort. Though it is listed as endangered in Florida, this designation offers the species no substantial regulatory protections and cannot be deemed sufficient to ensure persistence or recovery.

Other factors:
The pipewort is threatened by siltation from a variety of activities.

References:

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Scientific Name:
Etheostoma bellator
Common Name:
Warrior Darter

G Rank:	**AFS Status:**
G2	Vulnerable

Range:
The warrior darter is endemic to the Black Warrior River system above the Fall Line in the Sipsi Fork, Mullberry Fork, Locust Fork and Valley Creek (Boschung and Mayden 2004). In the Locust Fork, the warrior darter is "currently only known from three miles of Mill Creek" and recent efforts to collect the species in two historic locations were unsuccesful (Kuhajda 2004). In the Sipsi Fork, it is known only from the Fork itself and three tributaries and is presumed extirpated in the lower Sipsi Fork by Lewis Smith Reservoir (Ibid.)

Habitat:
The warrior darter occurs in small and medium sized streams with bedrock, cobble, or gravel substrates and slack to fast currents (Boschung and Mayden 2004).

Populations:
Boschung and Mayden (2004) mapped approximately 20-30 locations within the warrior darter's highly limited range. It is very uncommon in collections (SFC and CBD 2010).

Population Trends:
Current information on population trend is not available.

Status:
NatureServe (2008) classifies the warrior darter as imperiled. Jelks et al. (2008) list it as vulnerable. Boschung and Mayden (2004) conclude that because "much of the warrior darter's limited habitat is in industrial and suburban areas," the species should be granted "special concern status."

Habitat destruction:
NatureServe (2008) concludes that the warrior darter is "threatened by habitat alteration and modification due to development and impoundments." Jelks et al. (2008) classify the warrior darter as vulnerable because of the present or threatened destruction, modification or reduction of habitat or range. Boschung and Mayden (2004) note that the warrior darters limited habitat is predominated by suburban and industrial areas. Dewatering of streams is a problem, for example populations in Five-Mile Creek were severely impacted by a quarry that dewatered the stream (SFC and CBD 2010). Development from Birmingham threatens a number of populations, as does sod farming in a portion of range (Ibid.) Kuhajda (2008) noted that Mill Creek has "sedimentation problems associated with agriculture and urbanization," and that Sipsi Fork and primarily its tributaries suffers from "some sedimentation associated with poor forestry management."

Inadequacy of existing regulatory mechanisms:
The warrior darter is not protected by any law or regulation and is not currently the subject of any major conservation efforts.

Other factors:

The warrior darter is vulnerable because of a narrow, restricted range (Jelks et al. 2008).

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Suttkus R.D. and R.M. Bailey. 1993. Etheostoma colorosum and E. bellator, two new darters, subgenus Ulocentra, from southeastern United States. Tulane Studies in Zoology and Botany 29(1): 1-28.

Scientific Name:
Etheostoma brevirostrum
Common Name:
Holiday Darter

G Rank:	**AFS Status:**
G2	Endangered

Range:
The holiday darter actually represents a species complex including as many as five distinct forms that are all endemic to the upper Coosa River system of Georgia, Alabama and southeastern Tennessee (Page and Burr 1991, Etnier and Starnes 1993, Boschung and Mayden 2004, Georgia DNR 2009). One form of this darter occurs in Alabama in Shoal Creek and three springs in the Choccolocco Creek system (Boschung and Mayden 2004, Pierson 2004, Freeman and Hagler 2009). The four other forms are found in Georgia in the upper Conasauga system, upper Coosawattee system, and upper Etowah River system (Freeman and Hagler 2009). In the Etowah, one form is found in the upper Etowah River and its tributaries, and another in Amicalola Creek and its tributaries (Ibid.) These various forms likely qualify as distinct population segments and should be considered as such.

The species was recently determined to have dissapeared from lower Shoal Creek in Alabama (Pierson 2004).

Habitat:
The holiday darter occurs in small creeks to moderate sized rivers with cool, clear water and bedrock and gravel substrates, where it is frequently associated with lush growths of river weed (Etnier and Starnes 1993, Boschung and Mayden 2004).

Populations:
A recent review considered the holiday darter to be uncommon in its limited range in the Coosa River System of Alabama and rare in the upper Coosa of Tennessee and Georgia (Boschung and Mayden 2004). Freeman and Hagler (2009) observed that the species can be locally abundant in the Etowah and Conasauga River systems.

The following summary of population status comes from SFC and CBD (2010):

"1) The nominal population in Shoal Creek used to extend down into Chocolocco Creek; existing Shoal Creek populations are fragmented by two or three small impoundments in the Talladega National Forest. It has been relatively common at the type locality since at least 1992. 2) It is moderately common in tributaries and patchily distributed in the mainstem Conasauga River; abundance increases above agricultural areas adjacent to the Cherokee National Forest, TN and upstream into the Chattahoochee National forest, GA. 3) The Coosawattee River population occurs in tributaries above Cartersville Reservoir, NW of Ellijay in upper half of Mountaintown Creek, including the tributary Bear Creek where it is relatively common in limited portions of the creek, and NE of Ellijay in Turniptown and lower Little Turniptown Creeks, and in Rock Creek, but is absent from tributaries of the Cartecay River SE of Ellijay. Total range in the Coosawattee is limited and tributary populations may be fragmented, possibly be reduced water quality of the Ellijay and Cartecay rivers. 4) The Amicalola Creek system population is the most abundant of the five allopatric populations; it is relatively common in tributaries. 5) The uppermost mainstem

Etowah River population is the most restricted population; darters are relatively uncommon, patchily distributed and have a limited range occurring in ca 12-15 stream miles total."

Population Trends:

NatureServe (2008) classify as declining to stable, noting that "trends appear to be highly variable or unknown with some populations declining or possibly extirpated and others possibly stable." Boschung and Mayden (2004) note that "prime habitat" for the holiday darter in Shoals Creek was destroyed by impoundment.

Status:

Jelks et al. (2008) list the holiday darter as endangered in Amicalola and Shoal Creeks, and in the Conasauga, Coosawattee, and Etowah Rivers. Boschung and Mayden (2004) recommend that the species should be of special concern in Alabama. NatureServe (2008) list it as critically imperiled in Alabama and Tennessee and imperiled in Georgia. Etnier and Starnes (1993) state that because of the holiday darter's "restricted range in small portions of only three states, it is likely a candidates for future consideration for Federal protected status." Georgia DNR (2009) consider the species endangered in the state. In Alabama, Pierson (2004) warned that "any further decline in distribution, or reduction in population size, would make species a likely candidate for some level of federal protection." At a metting of the Southeastern Fishes Council and Center for Biological Diversity, there was general support for listing the holiday darter as endangered (SFC and CBD 2010).

Habitat destruction:

Jelks et al. (2008) list several populations as endangered based on the present or threatened destruction, modification or curtailment of habitat or range. NatureServe (2008) states that the holiday darter is threatened by logging, road building, impoundments, and any activities which remove riparian cover. Urban sprawl is rampant throughtout its range, including houses right along the Coosawatee (SFC and CBD 2010). Freeman and Hagler (2009) identified a number of threats to the holiday darter, stating:

"potential threats to the holiday darter are habitat loss due to excess silt and sediment runoff, reduced water quality and stream impoundment. The holiday darter is a montane species, and poor riparian management practices, including inadequate implementation of Forestry Best Management Practices (BMPs), pose a significant threat to the species. Sedimentation may also result from failure to control erosion from construction sites and bridge crossings. Holiday darters require clean cobble or other stable substrate for spawning, thus excess sediment could inhibit spawning success. Stream degradation results from increased stormwater runoff from developing urban and industrial areas."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) observes that few to several occurrences of the holiday darter are appropriately protected. The species is listed as a priority one species of greatest conservation need in Alabama, as threatened in Tennessee, and as endangered in Georgia. None of these designations, however, provide substantial protection for the species or its habtiats.

Other factors:

Jelks et al. (2008) list several populations as endangered because of a narrow, restricted range. This fish is also threatened by water pollution, primarily siltation (NatureServe 2008).

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Etheostoma cinereum
Common Name:
Ashy Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	VU - Vulnerable

Range:
The ashy darter is patchily distributed in the Tennessee, Cumberland, and Duck Rivers in Kentucky and Tennessee (Etnier and Starnes 1993). It has been extirpated from Georgia, Alabama, and Virginia (Jenkins and Burkhead 1994). NatureServe (2008) reports that ashy darters have been found in the Big South Fork and Rockcastle rivers in the Cumberland River Watershed in Kentucky and Tennessee, and Buffalo, Little, Emory, and Elk rivers in the Tennessee River Watershed. Powers et al. (2004) noted that degradation of habitats has "fragmented the range of E. cinereum into several disjunct populations and eliminated it from many historical localities" and further that populations inhabitating the Cumberland, Duck, and upper Tennessee River drainages show genetic and morphological differences warranting recognition of separate management units. Given these differences it is clear that any one of these units could be considered either a distinct population segment or a significant portion of range.

Habitat:
The ashy darter inhabits clear flowing small to moderate streams, where it appears to require clean gravel and rubble substrates, pools with some current, and cover from undercut banks, boulders or vegetation (Lee et al. 1980, Etnier and Starnes 1993, Jenkins and Burkhead 1994).

Populations:
Powers et al. (2004) report that recent collections of the ashy darter have been restricted to seven river reaches with single specimens found in two additional rivers. Of the three management units, the ashy darter is most in trouble in the upper Tennessee (Powers et al. 2004).

Population Trends:
NatureServe (2008) reports substantial to moderate long term declines, citing Shepard and Burr (1984) to conclude that it "has been extirpated or nearly extirpated from about half of the tributary systems in which it is known to have been extant during the past few decades." Powers et al. (2004) report that between 1993 and 2002, ashy darter in Little River, Tennessee declined from being quite common to "very rare" and identify urbanization as the likely reason.

Status:
Powers et al. (2004) conclude that "The rarity of this species and apparent extirpation from the majority of its former range caused it to be considered threatened in Tennessee (Etnier and Starnes, 1993), a species of special concern in Kentucky (Kentucky State Nature Preserves Commission, 2000), threatened throughout its range by Warren et al. (2000), and a category II candidate species prior to the elimination of the category by U.S. Fish and Wildlife Service (Federal Register, 1996)." NatureServe (2008) lists the species as vulnerable in Kentucky, imperiled in Tennessee and critically imperiled in Virginia. AFS (2008) list this species as endangered and declining in the lower Tennessee River, endangered in the upper Tennessee, and vulnerable in the Duck and upper Cumberland.

Etnier and Starnes (1993) listed the largest populations as being in Big South Fork and Buffalo Rivers in the Tennessee River system. In the Emory and Elk rivers, only single specimens were found, indicating "very small populations may exist there" (see Powers et al. 2004). It is likely that additional populations were extirpated prior to discovery (Etnier and Starnes 1993).

Habitat destruction:

Powers et al. (2004) observe that "habitat degradation is widespread throughout the range of E. cinereum and has caused fragmentation into small populations with linear distributions." The ashy darter's dependence on pools with flow makes it particularly sensitive to impoundment and pollution, particularly siltation (Etnier and Starnes 1993). Given these habitat dependencies, the species has experienced substantial declines in response to extensive impoundment and severe siltation related to agriculture, logging and urban sprawl and is now found in a limited number of isolated populations that continue to be threatened by these and other factors (Etnier and Starnes 1993, Powers et al. 2004, NatureServe 2008).

Jelks et al. (2008) lists this fish as endangered and vulnerable because of the "present or threatened destruction, modification, or reduction of a taxon's habitat or range."

The ashy darter is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) noted that "few (1-3) occurrences" are appropriately protected, identifying protection for only the populations in the Big South Fork River, which receives some protection in the "Big South Fork National Rivers and Recreation Area" and in the Emory and Obed River systems in Tennessee, which receive some protection in the Obed National Wild and Scenic River.

The ashy darter is listed as a secies of greatest conservation need in Kentucky and as threatened by the state of Tennessee. Neither of these designations provide regulatory protection for the darter's habitat.

Other factors:

AFS (2008) lists the ashy darter as vulnerable and endangered because of "a narrowly restricted range." This fish is also threatened by pollution from a variety of sources (Etnier and Starnes 1993).

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Scientific Name:
Etheostoma forbesi
Common Name:
Barrens Darter

G Rank:
G1

Range:
The barrens darter is limited to a small number of tributaries of the Barren Fork and lower Collins River in Tennessee and may have occurred formerly in the adjacent Duck River system (Page et al. 1992, Etnier and Starnes 1993, NatureServe et al. 2008).

Habitat:
The barrens darter inhabits pools and gently flowing riffles in small streams with cobble substrates (Etnier and Starnes 1993, Hansen et al. 2006)

Populations:
The barrens darter is likely one of the rarest freshwater fishes in North America (Page et al. 1992, Hansen et al. 2006). Surveys in 1994 identified barrens darter at 11 sites in nine streams with the largest population apparently in Charles Creek (Madison 1995). A 2004 survey of ten sites, including nine of the 1994 sites, found the species in eight sites (Hansen et al. 2006). In contrast to the 1994 survey, the species was found in low abundance in Charles Creek in 2004 and was not found in two streams where it occurred in 1994 (Witty and Mud Creeks). Abundances were generally low in both the 1994 and 2004 surveys (Madison 1995, Hansen et al. 2006).

Population Trends:
NatureServe (2008) listed the barrens darter as having a stable short term trend based on surveys by Madison (1995) and Hansen et al. (2006) and as having experienced a moderate to relatively stable long term trend.

Status:
The barrens darter has a very restricted range, where it receives little protection and faces threats from livestock grazing and agricultural water withdrawal and pollutiion (NatureServe 2008). NatureServe (2008) lists it as critically imperiled and Jelks et al. (2008) list it as threatened. Hansen et al. (2006) conclude "[d]ue to its restricted distribution, small population sizes, and current threats, the Barrens darter warrants consideration for federal listing as an endangered species." At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the barrens darter should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) classify this species as threatened due to habitat loss and degradation. NatureServe (2008) describe increasing threat from agriculture, including increased groundwater withdrawal that is leading to declining stream flows and degraded water quality from siltation and pesticides. Madison (1995) reports that this fish is threatened by heavy silt loads at some sites due to livestock grazing. Bergen et al. (2008) that a population in Mud Creek had low abundance and that the stream appearerd to be "suboptimal" because of dewatering and poor water quality. A gorwth in nurseries in the area has increased water demands and stream withdrawals (SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) determined that no known locations are appropriately protected. The barrens darter is listed as endangered in the state of Tennessee, but this designation does not provide any protection for the species' habitat.

Other factors:

The barrens darter is potentially threatened by hybridization with the fringed darter (Hansen et al. 2006). AFS (2008) lists the barrens darter as threatened because of "a narrowly restricted range." This species is threatened by pollution from agriculture and cattle grazing (Madison 1995, NatureServe 2008).

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Etheostoma maculatum
Common Name:
Spotted Darter

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	NT - Near threatened

Range:
The spotted darter is a small percid species that currently occurs in Indiana, Kentucky, New York, Ohio, Pennsylvania, and Virginia in two waters of the Allegheny River Drainage, eight waters of the Green River Drainage, one water of the Kanawha River Drainage, six waters of the Ohio River Drainage, and two waters of the Wabash River Drainage (Mayasich et al. 2004). Historically, the species also occurred in the Mahoning and Shonango Rivers, as well as presumably many other waters in the above drainages where the species is presently absent (Ibid.) For example, the species is absent from Big Walnut and Deer Creeks in the Ohio River drainage, portions of the Barrens River and a portion of the Elk River, all in places where they had previously been collected (Ibid.)

Habitat:
This species is found in small to medium-sized rivers in clear, high quality waters in habitat characterized by cobbles or boulders in rapidly flowing, deep riffles (Lee et al. 1980, Page and Burr 1991). Adults overwinter in deeper, slower waters (Kuehne and Barbour 1983).

Ecology:
This invertivorous species feeds primarily on caddisfly larvae and juvenile stoneflies, mayflies, beetles, and water mites (Page 1983). Spawning occurs between late May and July, and females may spawn several times in a season, laying eggs beneath stones in calm waters near their preferred riffle habitat (Page 1983). Males guard developing eggs, and are highly territorial (USFS 2005). Females become sexually mature at 2 years, and lifespan is estimated to be 4 years at most (Page 1983, Kuehne and Barbour 1983, Bart and Page 1992).

Populations:
The spotted darter is still found in French Creek in the Allegheny Drainage, the Walhonding, Olentangy, Blue, and Kokosing Rivers and Big Darby Creeks in the Ohio River, the Russell, Big Pitman, Little Barren, Barren, Gasper and Green River itself and Drakes and Meadow Creeks in the Green River Drainage, the Elk River in the Kanawha Drainage and the East Fork of the White and Tippecanoe River in the Wabash River Drainage (Mayasich et al. 2004, Simon 2005). The species is reported to be sporadic and uncommon throughout its range (Ibid.)

Population Trends:
The spotted darter is no longer found in a number of rivers and streams where it was formerly recorded, including the Mahoning River, Muskingum, Licking, lower Kanawha, Shenango, portions of the Barren and Scioto Rivers and Deer and Big Walnut creeks (Mayasich et al. 2004, Simon 2005). Although one population in Big Darby Creek appears to be expanding, the spotted darter is considered to be declining throughout its range (Simon 2005).

Status:
NatureServe (2008) reports that the spotted darter is critically imperiled in New York, Ohio, and West Virginia, and imperiled in Indiana, Pennsylvania, and Kentucky. It is listed as endangered in

Ohio, threatened in New York, Pennsylvania, and West Virginia, and is a species of special conservation concern in Indiana. Jelks et al. (2008) list the species as threatened and declining.

Habitat destruction:

As evidenced by the loss of many populations, the spotted darter is considered highly sensitive to habitat degradation from sedimentation, impoundment, and channelization (Mayasich et al. 2004, Simon 2005). Simon (2005), for example, concluded:

"The spotted darter occurs in moderate- to large rivers with coarse substrates such as gravel, cobble, and boulder habitats and is extremely sensitive to siltation, which results from watershed disturbance. The spotted darter is among the first darter species to disappear when siltation levels increase (T.P. Simon, unpublished data). The species utilizes interstitial pore spaces for reproduction around large cobble and boulders and seeks refuge from predators beneath rocks. As embeddedness increases from siltation, pore spaces would be unavailable if covered by high silt levels. Poor agricultural techniques, removal of riparian buffer strips along stream margins, and tributary channelization represent the greatest source of increased silt loads in rivers containing E. maculatum. Efforts to remove riffle, run, and pool habitats through activities aimed at improving watershed drainage (i.e., channelization) and the removal of bottom substrates by instream cobble and gravel mining could adversely affect the species. The species requires cobble and boulder substrates for refuge. Removal of such habitat components would significantly increase predation rates. Stream impoundment is another habitat alteration that represents a threat to the spotted darter."

Mayasich et al. (2004) report that "reservoir construction on the Barren River and Green River Lakes in Kentucky destroyed spotted darter habitat and fragmented populations in the Green River." They also identified a number of threats for each state in the range of the spotted darter, including impoundment and siltation in Kentucky, "siltation, pollution: animal waste, sewage plant failure, agricultural runoff (pesticides and fertilizers)" in New York, water quality in Ohio, "water quality, pollution: agricultural runoff" in Pennsylvania, and "siltation, pollution: domestic waste, mine drainage, industrial discharge, animal waste, low dissolved oxygen" in West Virgina.

Spotted darters in West Virginia are also threatened by the sedimentation and contamination caused by mountaintop removal, which is credited with the degradation and destruction of approximately 2000 miles of stream habitat in Appalachia to date (US EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Consistent with all of the above, Jelks et al. (2008) classified the spotted darter as threatened because of the present or threatened destruction, modification or reduction of habitat or range.

Disease or predation:

Impoundments alter habitat, and may make conditions more favorable for species that prey on the spotted darter, such as the blackbasses, Micropterus spp., temperate basses, Morone spp., pikes, Esox spp., sculpins, Cottus spp., and various minnow or sunfish species. If impoundments are large enough to support recreational fisheries, introduced game species may also be problematic (Simon 2005). Invasive species have already harmed darter populations in Eastern waterways; the introduction of the round goby, Neogobius melanostomus, to the Great Lakes has caused major reductions in native darter populations (USFS 2005).

Inadequacy of existing regulatory mechanisms:

A portion of spotted darter populations occur in streams on the Hoosier and Allegheny National Forests, where they are listed as sensitive species (Simon 2005). This designation, however, does not provide protection for the spotted darter's habitat. Instead, it requires the Forest Service to consider the impacts of their actions on the darter, but not to choose a benign alterantive or to stop a project because of impacts to the species. Likewise, the darter is listed as endangered or threatened in several states, but these designations do not provide regulatory protection for the darter's habitat.

Other factors:

Remaining populations of spotted darter are small and isolated and therefore vulnerable to stochastic extinction, inbreeding depression, and other perils that face small populations with low genetic diversity (NatureServe 2008).

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Scientific Name:
Etheostoma microlepidum
Common Name:
Smallscale Darter

G Rank:	**AFS Status:**
G2	Vulnerable

Range:
The smallscale darter is found in the lower Cumberland River from Stones River to Little River in Tennessee and Kentucky (Etnier and Williams 1989, NatureServe 2008).

Habitat:
The smallscale darter is typically found in fast riffles with gravel, boulder and rubble substrates in generally shallow water (Etnier and Starnes 1993).

Populations:
Populations are found in the Stones, Little, Harpeth and Red River systems (Hendricks and Timmons 2008, NatureServe 2008).

Population Trends:
There is no information available on population trends in smallscale darter.

Status:
NatureServe (2008) classifies the species as critically imperiled in Kentucky and imperiled in Tennessee. The smallscale darter has a small range in tributaries of the lower Cumberland River drainage, Tennessee and Kentucky, where urbanization and impoundments have impacted and threaten populations (NatureServe 2008, SFC and CBD 2010). Jelks et al. (2008) list as vulnerable. It is "deemed in need of management" in Tennessee and a "species of greatest conservation need" in Kentucky. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the smallscale darter should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
The smallscale darter is threatened by impoundment, urbanization and impaired water quality (NatureServe 2008, SFC and CBD 2010). Percey Priest Reservoir, for example, has reduced available habitat in the Stones River system and the Little River has undergone substantial urbanization in recent decades and is considered impaired (Etnier and Starnes 1993, Hendricks and Timmons 2008, SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:
There are currently no regulatory protections for the smallscale darters.

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Etheostoma osburni
Common Name:
Candy Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Vulnerable	NT - Near threatened

Range:
The candy darter occurs in the New River drainage in the Ridge and Valley province of Virginia and the Appalachian Plateaus of West Virginia (Jenkins and Burkhead 1994). In Virginia, it is generally distributed only in Big Stony Creek, and may only occur above the gypsum plant at Kimbalton. It has an extremely localized distribution in Laurel Fork of the Wolf Creek system, and a very limited range in the New River.This fish is also known from Reed, Big Walker, Little Stony, and Sinking creeks, and from Spruce and Pine runs, but there have been no recent detections in these streams (Burkhead and Jenkins 1991).

Habitat:
This darter occurs in swiftly flowing water over stone and boulder substrates in cool montane streams. It is associated with rocky, typically clear, cool to warm, small to large creeks. Adults typically occur in silt-free runs, riffles, and swift pockets of current in and around large rubble and boulders (Burkhead and Jenkins 1991). It is also known from fast rubble riffles of small to medium rivers (Page and Burr 1991). This darter may spawn in patches of sand in swift water (Burkhead and Jenkins 1991).

Populations:
Lee et al. (1980) mapped 29 collection sites for this species. Jenkins and Burkhead (1994) mapped 18 sites in Virginia, representing at least several distinct occurrences, but the candy darter may no longer be extant in some of those areas. The West Virginia Division of Natural Resources (WVDNR) (2002) report around 40 collection sites in the state, not all of which represent distinct occurrences. Total population size is unknown, but low numbers are estimated. This darter is described as rare in both Virginia and West Virginia (Jenkins and Burkhead 1994, WVDNR 2002, NatureServe 2008).

Population Trends:
The candy darter is declining in the short-term (decline of 10-30 percent) and has experienced a long-term decline of 25-75 percent (NatureServe 2008). Burkhead and Jenkins (1991) report that the darter is much reduced or absent in most tributaries in Virginia where it was detected from 1940-1970. Chipps et al. (1993) report concern about the darter's status in Deer Creek, Anthony Creek, and the Williams River, and report declines in several streams which supported populations in the late 1970s. Cincotta et al. (2000) report that this darter has been extirpated at some sites, occurs only in low numbers at others, and is declining at some historic locations.

Status:

This rare fish is declining within its limited range where it occurs at low abundance and faces several threats. It is critically imperiled in Virginia and imperiled in West Virginia (NatureServe 2008). It is a Species of Concern federally and in both states. It is categorized as vulnerable by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and narrow range. Jenkins and Burkhead (1994) stated that they previously (Burkhead and Jenkins 1991) may have underrated the jeopardy of this species in Virginia by recommending it for only special concern status; in 1994 they rated it as endangered or threatened in Virginia due to "localization or extirpation of most populations." At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the candy darter should be listed as theatened or potentially endangered (SFC and CBD 2010).

Habitat destruction:

Jelks et al. (2008) list habitat loss as a threat to this species. The candy darter is particularly vulnerable to habitat loss and degradation because it is sensitive to changes in water quality and temperature (West Virginia Division of Natural Resources (WVDNR) 2002). The primary threats to the candy darter are siltation and turbidity from a variety of anthropogenic activities (Berkman and Rabeni 1987, Burkhead and Jenkins 1991). Stream altering activities such as changes to the stream channel or bank from adding boulders or removing canopy which provide shade and bank stabilization severely negatively impact candy darters (WVDNR 2002). Chipps et al. (1993) report that the darter is absent or much diminished in areas with excessive siltation. The Virginia Dept. of Game and Inland Fisheries (2006) identifies siltation, mine wastes, industrial and municipal effluent pollution, and agricultural and urban runoff as threats to fish in Virginia's northern ridge and valley province. Recreational fishing potentially threatens the candy darter. Burkhead and Jenkins (1991) report that wading by anglers may negatively affect darter populations. The candy darter is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Disease or predation:

The candy darter may be particularly vulnerable to predation due to its bright colors (Page and Swofford 1984, Power 1987). Chipps et al. (1993) report that they did not detect the darter in pools or areas inhabited by large, piscivorous fish and suggest that predation is a limiting factor for this species. Trout stocking likely threatens the candy darter (Kuehne and Barbour 1983, Burkhead and Jenkins 1991, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect this species. It is a Species of Concern federally and in Virginia and West Virginia, but this designation does not confer any regulatory protection.

Other factors:

Other factors which threaten the candy darter include water pollution (Burkhead and Jenkins 1991, Chipps et al. 1993), introduction of predatory fishes (Kuehne and Barbour 1983), and hybridization with E. variatum, which has been introduced into the New River above Kanawha Falls (Switzer et al. 2008).

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Scientific Name:
Etheostoma pallididorsum
Common Name:
Paleback Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The paleback darter occurs in the Caddo River drainage in Arkansas. This fish is found upstream from the confluence of the South Fork Caddo River in the main stem of the Caddo and several tributaries including Five Mile Creek, though it has not been recently detected in Five Mile Creek (NatureServe 2008). It is also known from Mayberry Creek, a secondary tributary of the Ouachita River in west-central Arkansas (USFWS 1991).

Habitat:
The darter is associated with quiet shallow pools at the margins of gravel-bottomed, spring-fed streams and rivulets, and generally avoids swift riffles (Lee et al. 1980). It often occurs near vegetation over mud substrates (Robison and Allen 1995). Spawning occurs "in small seepage water in open pastures or wooded areas" (Robison and Allen 1995), usually in temporary water (USFWS 1991).

Populations:
NatureServe (2008) estimates that there are fewer than five populations of this species. Populations are not contiguous. There are seven sites where spawning has been confirmed, and it is thought that there are additional sites (USFWS 1991).

Population Trends:
Trend information is not available for this species.

Status:
The paleback darter has a very restricted range where it is threatened by habitat destruction and water pollution. It is ranked as imperiled by NatureServe (2008) and as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat degradation and narrow range.

Habitat destruction:
Within its very limited range, the paleback darter is threatened by habitat loss and degradation from several factors. The paleback darter is threatened by sand and gravel mining in the upper Caddo River and tributaries (FWS 1991). It is threatened by loss of habitat through channelization, which eliminates much of the shallow backwater areas which are preferred by the species (Robison 2004). It is also threatened by habitat fragmentation caused by road crossings, and destruction of spawning habitat as a result of municipal development (B. Crump, pers. comm., 1995 cited in NatureServe 2008). The Arkansas Game and Fish Commission (2005) lists threats to this species as resource extraction, dams, channel alteration, forestry, and road construction. Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Disease or predation:
The Arkansas Game and Fish Commission (2005) lists predation as a problem for this species, but does not provide any details.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect this species, and no occurrences are appropriately protected and managed.

Other factors:

The paleback darter is threatened by sedimentation from sand and gravel mining, forestry, and development, and by chemical pollution from resource extraction (Arkansas Game and Fish Commission 2005). It is also threatened by nutrient inputs from chicken and hog farms (B. Crump, pers. comm., 1995 cited in NatureServe 2008).

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Scientific Name:
Etheostoma pseudovulatum
Common Name:
Egg-mimic Darter

G Rank:	**AFS Status:**
G1	Threatened

Range:
The egg-mimic darter is known from five tributaries systems of the Duck River, Tennessee, including Piney River, Beaverdam Creek, Happy Hollow Creek, Only Creek, and Little Piney Creek (Ceas and Page 1995, NatureServe 2008).

Habitat:
Like other members of the lollypop darter group, the egg-mimic darter occurs in cool, clear, small to medium gravelly streams, typically beneath overhanging banks in low-gradient areas and often in areas with dense mats of vegetation or tree roots (Etnier and Starnes 1993, Ceas and Page 1995).

Populations:
Ceas and Page (1995) surveyed 43 sites, finding the species in 10 historic and seven new sites. Based on these surveys, they noted that populations in Only, Happy Hollow, and probably Little Piney Creeks "continue to survive on a year-to-year basis but are highly susceptible to extirpation," that the species was likely never abundant in Beaverdam Creek, and that the Piney River populations are the most secure in the long term. NatureServe (2008) cites Peggy Shute (pers. comm., 1998) as having recorded 18 occurrences with "an estimated condition of 20% excellent, 20% good, 40% fair, and 20% poor." In high quality habitat, the species can be common, but has a very restricted range and is found in low abundance in a several of the few systems in which it occurs (Ceas and Page 1995, NatureServe 2008).

Population Trends:
Trend information is not available for this species and there have not been rangewide status surveys since 1995.

Status:
Ceas and Page (1995) note that "since the entire range of the egg-mimic darter encompasses an extremely small area, continuing degradation of the headwater streams may eventually lead to the extirpation of the egg-mimic darter." NatureServe (2008) lists the species as critically imperiled, noting that "populations are highly vulnerable to extinction." AFS (Jelks et al. 2008) lists it as threatened because of present or threatened destruction, modification or reducton of habitat or range and because of a narrow restricted range.

Habitat destruction:
Speaking of the lollypop, crown and egg-mimic darters, Ceas and Page (1995) conclude that: "All have extremely small total ranges, and all inhabit headwater streams. Localized extirpations of populations from various streams may eventually lead to the widescale endangering of these species. Headwaters are continuously being altered by human activities, and all forms of habitat degradation and pollution are detrimental to the natural ecology of streams, especially to the benthic organisms such as darters." They go on to note that diversions, channelization, bedload removal, dams, destruction of riparian vegetation, point and non-point source pollution from domestic, municipal and industrial sources, agricultural pollution from pesticides, herbicides and animal wastes, livestock grazing, logging and other factors

threaten the habitat of the three darters and that specifically bedload removal for gravel is common in the Beaverdam Creek system, which is one of the five tributaries occupied by the egg-mimic darter.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) notes that none of the populations of egg-mimic darter are appropriately protected. It is listed in Tennessee, but this affords no protection to the species' habitat. Ceas and Page (1995) conclude that: "Additional protection could be gained by requiring federal, state, and local agencies to consult with the USFWS when projects they possess knowledge of, fund, carry out, or authorize may negatively affect these species," or in other words listing of the species under the Endangered Species Act.

Other factors:
Jelks et al. (2008) list this species as threatened in part because of a narrow restricted range. The egg-mimic darter is threatened by water pollution from a variety of sources (Ceas and Page 1995).

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Scientific Name:
Etheostoma striatulum
Common Name:
Striated Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Threatened	VU - Vulnerable

Range:
The striated darter is confined to tributaries of the Duck River in Bedford, Lewis, Marshall, and Maury counties, Tennessee (Burr et al. 1993, Etnier and Starnes 1993). A survey of 30 sites in 2006 failed to find the striated darter in four historic reaches, including the type locality (Abernathy and Mattingly 2007).

Habitat:
The striated darter occurs in slabrock pools in small to medium, low gradient creeks and shelters under rocks, undercut banks or tree roots (Page 1980, Etnier and Starnes 1993, NatureServe 2008). Males guard eggs, which are deposited on the underside of slabrocks (Page 1980).

Populations:
In total, the striated darter has been collected at 28 locations, but in the most recent surveys has only been found in a slightly more than a third as many sites (Burr et al. 1993, Abernathy and Mattingly 2007). Burr et al. (1993) only found the species at 10 sites. Abernathy and Mattingly (2007) found the species at six of these same sites, could not find the species at four sites, including the type locality, and identified five new reaches where the species was found.

Populations of the striated darter are very rare. Based on their 1996 survey, Abernathy and Mattingly concluded:

"This study reaffirmed that Etheostoma striatum is a rare species with a relatively small geographic range. Only 24 adults and 78 juveniles were seen in 11 sites in 2006 and only 26 individuals were seen in 10 sites in the previous (1992) survey."

Population Trends:
NatureServe (2008) concluded that short term trend is unknown, but that "habitat extent and quality probably are still declining," and that the species has experienced a substantial long term decline. In surveys in 1992, this species was detected at only one-third of historical locations (Burr et al. 1993) and in surveys in 2006, the species was not found at four of ten sites where it was previously found (Abernathy and Mattingly 2007).

Status:
Etnier and Starnes (1993) conclude that "although not currently protected by state or federal endangered species legislation, its occurrence in fewer than a dozen creeks in a four-county area makes it extremely vulnerable to significant depletion," further noting that "recent attempts to collect E. striatulum from four of these localities have met with no success, making its status very questionable." NatureServe (2008) lists the striated darter as critically imperiled, noting that it is "threatened by habitat degradation resulting from agricultural practices." Jelks et al. (2008) list it as threatened and declining. Abernathy and Mattingly (2007) concluded:

"The combination of low abundance, small geographic range, declining abundance at selected sites, and anecdotal evidence of degraded stream conditions warrants the attention of biologists and policymakers charged with resource conservation duties in the Tennessee Region. The striated darter should be considered for federal listing under the Endangered Species Act and its state status should be elevated if possible. Periodic monitoring of population trends and interim efforts to restore and protect stream habitat quality would be prudent conservation measures to encourage the persistence of this unique Duck River species."

At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the striated darter should be listed as endangered (SFC and CBD 2010).

Habitat destruction:
NatureServe (2008) concludes that "habitat degradation resulting from agricultural practices pose the greatest threat to this species," and more specifically that "cattle manure being dropped directly into streams is causing severe oxygen depletion," and that "siltation from nonpoint agricultural sources also is a problem." Jelks et al. (2008) list this species as threatened because of the present or threatened destruction, modification or reduction of habitat or range. Abernathy and Mattingly (2007) concluded: that "habitat degradation is occurring in striated darter streams and the species may be suffering as a result," noting that the "darter was not observed at four sites where it was seen in 1992, including the type locality which is in a degraded condition."

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) concludes that it is unknown whether any occurrences of the striated darter are appropriately protected. It is listed as threatened by the state of Tennessee, but this designation does not provide any protection for the species' habitat.

Other factors:
Jelks et al. (2008) list the striated darter as threatened because of a narrow, restricted range. Water pollution from agricultural sources also threatens this species. Finally, because the striated darter is an annual species, it is vulnerable to population extirpation caused by lapses in reproduction due to environmental or anthropogenic stochasticity, such as stream dewatering due to drought or withdrawal (Abernathy and Mattingly 2007).

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Etheostoma tecumsehi
Common Name:
Shawnee Darter

G Rank:	**AFS Status:**
G1	Threatened

Range:
This fish has one of the smallest known ranges for any darter and occurs only in upland tributaries of the upper Pond River in the Green River system in Christian, Todd, and extreme southeastern Hopkins counties in Kentucky. These headwaters originate on the Dripping Springs Escarpment of the Mammoth Cave Plateau and drain a small part of the Shawnee Hills section of the Interior Low Plateaus Province (Ceas and Page 1997).

Habitat:
The shawnee darter occurs in upland headwater creeks with sand-gravel or pebble-cobble substrates. It is found in riffles, glides, and pools (Burr et al. 2004).

Populations:
There are less than five populations of this fish. Within its single river basin, it is widely distributed and common. This species was detected at 24 of 30 sites sampled in 2002, but these represent a very small number of distinct occurrences (Cicerello and Butler 2007, NatureServe 2008).

Population Trends:
This fish has declined by 10-30 percent (NatureServe 2008).

Status:
This endemic fish is restricted to upland tributaries of a single river system. It is ranked as imperiled (G1S2) by NatureServe (2008) and as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and narrow range.

Habitat destruction:
The Shawnee darter is highly vulnerable to habitat degradation because the flow and water quality of headwater streams is tied more closely to local land use than in larger streams (Cicerello and Butler 2007). Within its extremely limited range, the darter faces threats from multiple land-uses. Agriculture is the primary land-use in the Pond River system, and extensive row crops and pasture fragment upland forests (Cicerello and Butler 2007). Clearing of upland and riparian forests negatively influences water quality and threatens this darter, particularly during drought years, by reducing ground water inflow and raising stream temperature (Ibid.). Cicerello and Butler (2007) state, "We observed several upper Pond River system streams that were reduced to isolated pools during the relatively dry summer of 2002. Some headwater streams normally cease flowing in summer, but conversion of forests to other uses could have increased the duration and extent of zero flow periods." Agricultural run-off, including sedimentation and pesticides, are known threats to sensitive fish. Ceas and Pages (1997) reported declines of this darter related to a tractor fuel spill and the construction of small impoundments. Many streams in the area are impounded for flood control, and others, such as Buck Fork Pond River and Jarrels Creek are channelized (Cicerello and Butler 2007). Impoundments cause increased siltation and population isolation and fragmentation. Numerous populations of this species have been isolated by flood control reservoirs, and movement and gene flow in many streams is precluded, which could

negatively influence the long-term viability of the species (Ibid.). Coal mining also threatens this fish. Broad areas in the region have been surface-mined for coal, leaving abandoned mine lands and highly degraded aquatic habitats. Many streams, including the entire mainstem Pond River, do not support or only partially support their designated uses because of contaminants and other factors such as low pH, PCBs, pathogens, chlorides, and silt (Ibid.). Coal mining occurs in the northern portion of the southern half of the system, and mining has occurred adjacent to lower McFarland and Jarrels creeks and near the confluence of the West and East Forks Pond rivers (Ibid.). Although this species is common within its lone river system, its habitat has been and continues to be degraded and this endemic fish could easily be extirpated by the cumulative impacts of agriculture, logging, coal mining, and impoundment. Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Disease or predation:

Cicerello and Butler (2007) report that migrating E. tecumsehi are threatened by stocked predatory game fishes (e.g.,Lepomis spp., Micropterus spp.).

Inadequacy of existing regulatory mechanisms:

There are no regulatory mechanisms which protect this fish or its habitat.

Other factors:

The Shawnee darter is threatened by pollution from agriculture and coal mining (Cicerello and Butler 2007).

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Scientific Name:
Etheostoma tippecanoe
Common Name:
Tippecanoe Darter

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
The Tippecanoe darter has a wide but sporadic distribution in the Ohio River basin, from the Allegheny River and French Creek drainages in western Pennsylvania, Muskingum and Scioto river drainages in Ohio, Tippecanoe River and East Fork White River drainages in Indiana, and the Little Kanawha and Elk rivers in West Virginia south to the Cumberland River drainage in Tennessee and Kentucky (Lee et al. 1980, Cooper 1983, Burr and Warren 1986, Etnier and Starnes 1993, Felbaum 1995, Stauffer et al. 1995, Skelton and Etnier 2000). In Tennessee, this darter occurs in short reaches of the Big South Fork Cumberland, Red, and Harpeth rivers (Skelton and Etnier 2000). Populations which have been reported from the upper Tennessee River drainage, Tennessee and Virginia, and the Duck and Buffalo rivers in the lower Tennessee River drainage, are now known to represent another species, E. denoncourti (Stauffer and van Snik 1997, Skelton and Etnier 2000, Kinziger et al. 2001).

Habitat:
This darter uses medium-sized upland rivers and large creeks with moderate gradient and warm water which is usually clear. Adults are found in both shallow and deep, moderate and swift runs and long shallow gravel/sand riffles (Trautman 1981, Burr and Warren 1986, Burkhead and Jenkins 1991). Spawning occurs in areas with gentle current at the heads or tails of clean-swept gravel and pebble riffles in water 8-46 centimeters deep (Lee et al. 1980, Page 1983, Burr and Warren 1986).

Ecology:
Population size of this species exhibits major annual fluctuations (see Burkhead and Jenkins 1991).

Populations:
Skelton and Etnier (2000) coarse-scale mapped approximately 40 collection sites for this species, which may represent more than 20 distinct occurrences. The number of locations (as defined by IUCN) exceeds 10. Total adult population size is unknown. In Kentucky, where most of the best remaining populations are known, Burr and Warren (1986) reported the darter as sporadic and generally uncommon in the Green river, the South and Middle Forks Kentucky river, and the Big South Fork Cumberland River, and as occasional and seasonally common in the middle to lower Licking River. NatureServe (2008) reports that subsequent surveys have found this species to be more common than previously known, though it has been extirpated from many areas.

Population Trends:
NatureServe (2008) reports that the Tippecanoe darter has experienced long-term decline of up to 50 percent, and that it is probably relatively stable to slowly declining in the short-term. It has been eliminated from many areas (Etnier and Starnes 1993).

Status:

NatureServe (2008) ranks the Tippecanoe darter as critically imperiled in Tennessee, imperiled in Ohio, West Virginia, and Pennsylvania, vulnerable in Indiana, and secure in Kentucky. The vulnerable ranking in Indiana may not accurately reflect its status in the state, where it is listed as threatened. This species is discontinuously distributed from the Ohio River basin to the Cumberland River drainage, and is regarded as endangered, threatened, or special concern in all states except Kentucky. Its habitat has declined due to impoundments, siltation, coal mining, and possibly agricultural contaminants. It is state-listed as threatened in Indiana, and Ohio, endangered in Pennsylvania, is a Virginia Species of Greatest Conservation Need, and a Tennessee species in need of management. It is ranked as vulnerable by the American Fisheries Society (Jelks et al. 2008).

Habitat destruction:

Habitat loss and degradation is the primary threat to this species (Jelks et al. 2008). Some populations have been extirpated by impoundments and siltation (Etnier and Starnes 1993). Agricultural runoff, including siltation and possibly contamination, is a chronic limiting factor in some areas (NatureServe 2008). The Tippecanoe darter is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which adequately protect this species. It is state-listed in Indiana, Pennsylvania, and Ohio, but these designations provide no regulatory protection for the species' habitat. It lacks protective status in Virginia, West Virginia, and Kentucky where it is threatened by pollution from mining and agriculture. NatureServe (2008) reports that at least a few occurrences appear to be adequately protected.

Other factors:

Water pollution is a dire threat to this species.

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Scientific Name:
Etheostoma trisella
Common Name:
Trispot Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
The trispot darter is found in portions of the upper Coosa River system in Alabama, Tennessee and Georgia, including the Conasauga River system above the Coosawatee River and eight of its tributaries, the Coosawatee River and three tributaries below Carters Reservoir, and in at least one tributary to the Oostanaula River system (Etnier and Starnes 1993, Boschung and Mayden 2004, Georgia DNR 2008). It was long believed extinct in Alabama, but was recently found on "protected forest land east of Gadsden, Alabama" (Freeman 2009).

Habitat:
The trispot darter utilizes two distinct habitats (Boschung and Mayden 2004). When not breeding, the darter occupies slack water in the Conasauga and its tributaries, Coahulla and Mill Creeks in association with detritus, logs, sticks and beds of water willow (Ibid.) For spawning, the darter migrates during flooding to seepage waters and small ditches in pastures adjacent to Mill Creek and floodplain forests adjacent to the Conasauga River (Etnier and Starnes 1993, Boschung and Mayden 2004). This requirement for two distinct, but interconnected habitats makes the species highly sensitive to habitat modification.

Populations:
Although populations of the trispot darter may have occurred throughout the Ridge and Valley corridor portion of the Conasauga River, populations are currently restricted to limited areas of a few mainstem rivers and a small number of tributaries (Etnier and Starnes 1993, Freeman 2009).

Population Trends:
The trispot darter is extirpated from portions of its historic range from impoundment and other factors, indicating long-term decline (Boschung and Mayden 2004, Freeman 2009).

Status:
The tripost darter was reclassified from threatened to endangered by Jelks et al. (2008) due to increasing threats to its survival. Boschung and Mayden (2004) conclude, "[b]ecause the trispot darter is so restricted in range, so few in numbers, and needs two distinctly different and interconnecting habitats, it is very vulnerable to any environmental insults that would disrupt its normal life cycle," adding that they "concur with Warren et al. (2000) in recommending endangered status for the trispot darter." NatureServe (2008) lists the species as extirpated in Alabama and critically imperiled in Georgia and Tennessee. At a meeting of the Southeastern Fishes Council and the Center for Biological Diversity, there was consensus that this species should be listed (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) cite the present or threatened destruction, modification, or reduction in habitat or range as a threat to the survival of this species. This fish is known to have been lost from portions of the mainstem Coosa River following impoundment (Etnier and Starnes 1993, Boschung and Mayden 2004, Georgia DNR 2008). Freeman (2009) concluded:

"The greatest threat to the trispot darter is habitat loss and degradation, including loss of access to spawning areas in seepage streams. Dams built on tributary streams and springs and dredging or filling in small seepage streams could eliminate spawning habitat for the trispot darter. Droughts or excessive water withdrawal which de-water spring runs could also lead to reproductive failure."

Although trispot darter have to date remained stable, conditions in the Conasauga River, where the largest population occurs, have declined with Freeman (2009) noting: "declines or apparent loss of some fish species (e.g., the Coosa chub (Macrhybopsis sp. cf. M. aestivalis and Coosa madtom (Noturus sp. cf. N. munitus)), decline in the aquatic macrophyte, riverweed, and an apparent increase in algal production."

Freeman (2009) states that this species' habitat needs to be protected from runoff from agriculture and development.

This species is also threatened by urban sprawl from Birmingham in the Little Canoe River area (SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected. Freeman (2009) highlights the need to "protect habitat quality in main channel and small tributary streams by eliminating sediment runoff from upland construction, maintaining or enhancing forested buffers along stream banks, eliminating inputs of contaminants, such as fertilizers or other nutrients and pesticides, and maintaining natural patterns of stream flow," but did not suggest any mechanisms for accomplishing these goals. Georgia lists the species as endangered and Tennessee as threatened. Alabama included the darter on its list of species of greatest conservation need, but as extinct. None of these designations provide substantial regulatory protections for the species.

Other factors:
Jelks et al. (2008) list the species as endangered because of a narrow, restricted range. This fish is also threatened by water pollution from agriculture and development (Freeman 2009).

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Etheostoma tuscumbia
Common Name:
Tuscumbia Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Tuscumbia darter occurs in springs and spring runs of the southern bend of the Tennessee River in northern Alabama and formerly Tennessee (Etnier and Starnes 1993, Boschung and Mayden 2004).

Habitat:
The Tuscumbia darter occurs in well vegetated springs with substrates of fine gravel, sand and silt with Boschung and Mayden (2004) concluding, "In degraded habitats, the substrate is silted, much of the vegetation has been lost and replaced with filamentous algae; and the water is often turbid. In healthy habitats, the darter usually occurs in large numbers amid thick mats of native vegetation."

Populations:
Of 26 known populations of the Tuscumbia darter, at least twelve have been lost to impoundments and other causes of habitat destruction and degradation (Etnier and Starnes 1993, Boschung and Mayden 2004, NatureServe 2008). In Tennesse, two known Tuscumbia darter sites were inundated by Pickwick Pool (Boshcung and Mayden 2004). In Alabama, 10 of 12 historic sites "are inundated by impoundments or otherwise detroyed or degraded to the point that they not longer support the darter" (Ibid.) Discovery of new sites has led to documentation of a total of 14 populations with Boschung and Mayden (2004) noting that "some springs appear to be in good and stable condition, but others (Tuscumbia and Bradham springs) are in poor condition and support only small populations." This species can be abundant in individual springs (SFC and CBD 2010).

Population Trends:
Many sites of this species have been lost or degraded to impoundment and other factors, indicaitng long-term decline (Etnier and Starnes 1993, Boschung and Mayden 2004, NatureServe 2008).

Status:
Jelks et al. (2008) list the Tuscumbia darter as threatened. NatureServe (2008) lists the darter as imperiled in Alabama and extirpated in Tennessee, noting that it is "extirpated from roughly half of known sites in Alabama," and that "populations are vulnerable to alteration of spring heads." Kuhajda (2004) concluded:

"Restricted to 14 springs and spring runs in five counties in Alabama, but most springs have some degradation, including removal of aquatic vegetation and water, excessive sedimentation, livestock entering spring, and small impoundments. Have dissapeared from almost half of historic springs; seven sites have been inundated by impoundment of Tennessee River, and have dissapeared from an additional five springs due to extensive habitat modification."

Habitat destruction:
At least 12 populations of the Tuscumbia darter have been lost to destruction of habitat from impoundments and other factors (Etnier and Starnes 1993, Boschung and Mayden 2004, Kuhajda

2004, NatureServe 2008). Boschung and Mayden (2004) conclude:

"Where spring habitsts persist and vegetation is maintained in the spring head area, the darter is able to maintain adequate population numbers. However, the species is extirpated in some springs because of gross habitat modification. Some springs have been converted into fishing ponds, and others have been completely denuded of vegetation by wholesale use of herbicides to 'clear out' the spring."

Jelks et al. (2008) identify the present or threatened destruction, modification or reduction of habitat or range as a reason for classifying the species as threatened.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) concludes that no occurrences of the Tuscumbia darter are appropriately protected or managed. Alabama considers the species a priority 2 species of greatest conservation need, but this designation does not provide any regulatory protection.

Other factors:
Jelks et al. (2008) identify a narrow, restricted range as a factor in this species being considered threatened.

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Eumeces egregius egregius
Common Name:
Florida Keys Mole Skink

G Rank:
T2

Range:
The Florida Keys Mole Skink has a restricted range in southern Florida. It is the southernmost of the mole skink subspecies. It occurs in Dry Tortugas and Lower Keys in Monroe County. It might occur in Upper and Middle Keys, and in Key West, Middle Torch Key, Key Vaca, Stock Island, Big Pine Key, Grassy Key, Upper Matecumbe, and Saddlebunch. Intergrade forms occur on Key Largo. It may no longer be extant on Indian Key (Lazell 1989, Christman 1992, NatureServe 2008).

Habitat:
The Florida Keys Mole Skink usually occurs near the shoreline in sandy areas where it burrows into soil. It likely requires fairly loose soil. It uses stones, debris, driftwood, and tidal wrack for cover (Christman 1992, Conant and Collins 1991).

Ecology:
Mole Skinks reach sexual maturity after one year. They mate in winter; after which the female lays three to seven eggs in spring in a shallow nest cavity less than 30 cm below the surface. The eggs incubate for 31 to 51 days, during which time the female tends the nest (http://www.redorbit.com/education/reference_library/reptiles/mole_skink/760/index.html).

Populations:
NatureServe (2008) estimates that there are from 6-20 populations of Florida Keys Mole Skink distributed on at least seven islands in the Florida Keys. Total population size is unknown. It was once thought to be locally common, but Lazell (1989) regarded this lizard as genuinely rare and probably endangered.

Population Trends:
The Florida Keys Mole Skink has experience a decline of 10-30 percent and elemental occurrences are probably decreasing (NatureServe 2008).

Status:
The Florida Keys Mole Skink is imperiled (T2S2) in Florida (NatureServe 2008). It is considered to be a Species of Special Concern by the State of Florida.

Habitat destruction:
NatureServe (2008) reports that habitat loss and degradation due to development is a major threat for the Florida Keys Mole Skink, and that it is "highly threatened by increasing development." The Florida Dept. of Environmental Protection reports that the Florida Keys has been a fast-growing area since the middle of the 20th Century and remains very vulnerable to habitat conversion for development (http://www.dep.state.fl.us/cmp/programs/files/final_proj_flkeys_08.pdf). The Florida Wildlife Conservation Commission reports that the transitional/disturbed habitat with which the species is associated is threatened by degradation, altered fire and hydrologic regime, pollution, fragmentation, development, conversion to agriculture, logging, mining, and recreation (myfwc.com/docs/WildlifeHabitats/Legacy_Disturbed.pdf). The pine rockland habitat with which this species is associated are highly threatened by habitat conversion, landscape alteration, altered

fire regime, roads, and development (http://myfwc.com/docs/WildlifeHabitats/Legacy_Pine_Rockland.pdf). This species' beach habitats are very highly threatened by disturbance, degradation, and recreation, and are highly threatened by erosion, altered soil structure, and sea level rise (http://myfwc.com/docs/WildlifeHabitats/Legacy_Beach.pdf).

Overutilization:
Overcollection by herpetological enthusiasts is a major threat to the Florida Keys Mole Skink (NatureServe 2008). Christman (1992) noted that amateur collecting on the National Key Deer Wildlife Refuge should be controlled. NatureServe (2008) notes that the state ban on collection except by scientific permit needs to be enforced.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this subspecies. The skink is a Species of Special Concern in Florida, but this designation does not convey regulatory protection. This lizard occurs at Fort Jefferson National Monument, at Bahia Honda SRA, and it might occur on Key Deer and Crocodile Lakes National Wildlife Refuges.

Other factors:
The Florida Center for Environmental Studies reports that the Florida Keys Mole Skink is in danger of extinction from sea level rise due to global climate change (http://www.ces.fau.edu/floc/presentations/presentations.php?id=14).

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Scientific Name:
Eupatorium paludicola
Common Name:
No common name

G Rank:
G2

Range:
Recently described (2007), this species is found along the Atlantic Coastal Plain of North and South Carolina. Natural heritage records exist for Onslow and Scotland Counties, North Carolina, and Marlboro County, South Carolina (NatureServe 2008).

Habitat:
This species occurs in isolated wet Coastal Plain depressions, including clay-based Carolina bays. Its habitat is typically inundated in the winter and spring, and drier in summer and fall, though sites may remain flooded throughout the growing season. This plant prefers habitat that is generally open, with no shrub layer and few trees, though it sometimes occurs with pond cypress, Taxodium ascendens (LeBlond et al. 2007).

Populations:
Eight occurrences of this plant are currently known: five in North Carolina, two in South Carolina, and one on the border between the states. Population sizes are not reported, and researchers do not anticipate that many new populations will be discovered since surveys throughout potential habitat have been extensive (LeBlond et al. 2007).

Population Trends:
Population trend has not been reported for this recently described species.

Status:
This recently described plant is known only from eight locations, has high habitat specificity, and is dependent on consistent hydroperiods. It is possibly threatened by hybridization with E. mohrii. NatureServe (2008) has not yet ranked this species.

Habitat destruction:
This plant is very sensitive to changes in hydrology (LeBlond et al. 2007).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

Other factors:
Hybridization with the widespread species Eupatorium mohrii has been observed at some locations, and may outnumber pure E. paludicola; such assimilation represents a major threat to this species' genetic integrity (LeBlond et al. 2007).

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Scientific Name:
Euphyes dukesi calhouni
Common Name:
Dukes' Skipper

G Rank:
T2

Range:
E. d. calhouni is known from at least seven counties in the northern Florida peninsula. NatureServe (2008) reports that this subspecies may become elevated to a full species. Should that occur, the Center hereby petitions for either the subspecies or the species.

Habitat:
The calhouni subspecies of E. dukesi inhabits sedge patches within swamps, which may be cypress, gum, red maple or mixed canopy (NatureServe 2008).

Populations:
There are seventeen known occurrences of this butterfly.

Population Trends:
According to Natureserve (2008), this species is declining by 10-30 percent in the short-term due to loss of habitat to urbanization and other uses.

Status:
NatureServe (2008) ranks Duke's skipper as an imperiled subspecies (T2).

Habitat destruction:
Duke's skipper is threatened by conversion of its wetland habitat to development and other uses (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. NatureServe (2008) reports that it is unknown if any occurrences are protected. Minno (1994 in Deyrup and Franz) specifically points out the inadequacy of wetland regulations for protecting specialized species such as this one.

Other factors:
This butterfly is threatened by chemicals sprayed in mosquito control efforts.

References:

Deyrup, Mark and Richard Franz. 1994. Rare and Endangered Biota of Florida, Vol. IV: Invertebrates. R. E. Ashton Jr. (series ed.). University of Florida Press, Gainesville, FL. 798 pp.

Shuey, John A., 1996. Another new EUPHYES from the southern United States Coastal Plain (Hesperiidae). Journal of the Lepidopterists' Society 50(1): 46-53.

Scientific Name:
Euphyes pilatka klotsi
Common Name:
Palatka Skipper

G Rank:
T1

Range:
This butterfly is known from the following Florida Keys: Big Pine, Big Torch, Cudjoe, No Name, Sugarloaf, Stock Island (NatureServe 2008). Its total range is less than 100-250 square km (less than about 40 to 100 square miles).

Habitat:
This species is found in tropical pinelands and sawgrass marshes at the edges of mangroves with substantial sawgrass (Minno, in Deyrup and Franz, 1994).

Populations:
Population information has not been quantified for this rare species. Marc Minno (pers. co, to D. Schweitzer, cited in NatureServe 2008) searched for it in the lower Keys nearly every month from August 2006 to January 2008 and only found nine adults and a few larvae.

Population Trends:
Less than 10 adults of this species have been recently detected.

Status:
In 1994 the Palatka skipper was already considered to be Threatened (Minno in Deyrup and Franz 1994) and it is much rarer now. Fewer than 10 adults of this species were detected from 2006-2008 (NatureServe 2008). It is critically imperiled, and is a Species of Greatest Conservation Need.

Habitat destruction:
This butterfly is threatened by habitat loss from development and succession (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
This butterfly is a Species of Greatest Conservation Need in Florida, but this confers no habitat protection. NatureServe (2008) reports that it is unknown if any occurrences are protected and states that any protection would have to include restrictions on biocide use as well as land preservation.

Other factors:
This butterfly is threatened by the spraying of biocides for mosquito control (NatureServe 2008).

References:

Deyrup, Mark and Richard Franz. 1994. Rare and Endangered Biota of Florida, Vol. IV: Invertebrates. R. E. Ashton Jr. (series ed.). University of Florida Press, Gainesville, FL. 798 pp.

Minno, Marc C., and Thomas C. Emmel. 1993. Butterflies of the Florida Keys. Scientific Publishers, Gainsville, FL. 168 pp.

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Scientific Name:
Eurybia saxicastellii
Common Name:
Rockcastle Wood-Aster

G Rank:
G1

Range:
This wood-aster is known from reaches of the Rockcastle River in Laurel, McCreary, and Pulaski Counties, Kentucky, and along the Big South Fork River in Scott County, Tennessee (NatureServe 2008, Bailey et al. 2000, USDA Plant Database 2009).

Habitat:
This plant occurs on sandstone boulder or cobble river bars that are flooded in spring, dry in summer, and exhibit a range of successional stages (FNA 2006, Bailey 2000). E. saxicastellii is found within the transitional zone between open grassy vegetation on river bars and upslope forests, and may be associated with hazel alder (Alnus serrulata), groundnut (Apios americana), blue wood aster (Aster cordifolius), black birch (Betula nigra), sweetgum (Liquidambar styraciflua), swamp tupelo (Nyssa sylvatica) and various ferns (Campbell and Medley 1989, Shea 1994).

Ecology:
The wood-aster is perennial and flowers August-October (Campbell and Medley 1989).

Populations:
This flower is known from approximately 16 occurrences each in Tennessee and Kentucky, all along the Rockcastle or Big South Fork Rivers. Population sizes are not reported (NatureServe 2008).

Population Trends:
NatureServe (2008) determined that this species is stable in the short term but threats to its habitat are widespread.

Status:
Known from an extremely restricted range, the long-term viability of this plant is threatened by various anthropogenic factors. NatureServe (2008) ranks this species as critically imperiled in both Tennessee and Kentucky. It is state-listed as threatened in Kentucky and endangered in Tennessee.

Habitat destruction:
The rockcastle wood-aster is threatened widely by anthropogenic alterations to regional or local hydrology, timber harvesting, agriculture, and other sediment-generating activities, and locally by road and trail construction and ATV use (KSNPC 2006, Southern Appalachian Species Viability Project 2002, Shea 1994). Habitat protections are vital to this species' conservation because its distribution is so limited.

Inadequacy of existing regulatory mechanisms:
Tennessee occurrences are found within the Big South Fork National River Recreation Area, which may provide minor protection from some threats but not all. Several Kentucky populations occur within the Big South Fork National River Recreation Area or Daniel Boone National Forest, but specific management for this species is likely limited. No existing regulatory mechanisms adequately protect this species or its habitat. This flower is state-listed in both Kentucky and Tennessee, but this

designation does not confer habitat protection.

Other factors:

Invasive exotic plants may threaten E. saxicastellii at some sites (NatureServe 2008).

References:

Bailey, C. 2000. Field survey for Aster saxicastellii (Rockcastle aster) and Calamovilfa arcuata (Cumberland sandgrass). Report submitted to the U.S. Fish and Wildlife Service by Tennessee Department of Environment and Conservation, Division of Natural Heritage.

Campbell, J.J.N., and M.E. Medley. 1989. Aster saxicastellii (Asteraceae), a new species from the Rockcastle River bars in southeastern Kentucky. Sida 13(3): 277-284.

Flora of North America Editorial Committee. 2006b. Flora of North America North of Mexico. Vol. 20. Magnoliophyta: Asteridae, part 7: Asteraceae, part 2. Oxford Univ. Press, New York. xxii + 666 pp.

Jones, R. L. 2005. Plant Life of Kentucky. The University Press of Kentucky. 834 pp.

Kentucky State Nature Preserves Commission (KSNPC). 2006. Kentucky Rare Plant Database. Available online:<< http://eppcapps.ky.gov/nprareplants/>> (accessed February 1 2010).

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 19, 2010).

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Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

USDA Plant Database. 2009. Eurybia saxicastellii. Accessed online February 1, 2010 <<http://plants.usda.gov/java/profile?symbol=EUSA15>>

Scientific Name:
Eurycea chamberlaini
Common Name:
Chamberlain's Dwarf Salamander

G Rank:
G5

IUCN Status:
DD - Data deficient

Range:
Chamberlain's Dwarf Salamander has been detected in the Piedmont region and central coastal plain of North Carolina, the Piedmont region and upper coastal plain of South Carolina, and also from Alabama, Georgia, and Florida (Harrison and Guttman 2003, NatureServe 2008). To further delineate the range, genetic study is needed on the differentiation of E. chamberlaini from E.quadridigitata.

Habitat:
Chamberlain's Dwarf Salamander is a semi-terrestrial species that occurs in a variety of habitats but generally occurs in seepage areas near ponds and streams, particulary in upper coastal plain and Piedmont areas (Harrison and Guttman 2003, NatureServe 2008, AmphibiaWeb 2009). Information from 33 records in the files of the North Carolina State Museum of Natural History indicates that they normally occupy the margins of streams or seepages (70 percent) or floodplain or pond sites (30 percent) (A. Braswell, personal communication in AmphibiaWeb 2009).

Ecology:
Chamberlain's Dwarf Salamanders have a biphasic life cycle wiith semi-terrestrial adults and aquatic eggs and larvae. This species breeds in the winter in North Carolina, but in the fall in South Carolina (AmphibiaWeb 2009). Salamanders might have limited dispersal from upland areas to wetlands for breeding. Brimley (1923) reported that eggs are deposited singly or in groups of 3-6 among downed leaves in seepages and spring areas, and most hatching takes place in March with transformation 2-3 mo later (AmphibiaWeb 2009). Clutch size is likely 35-64 (Harrison and Guttman 2003). It is thought that this species preys on amphipods, ostracods, cladocerans, chironomid larvae, earthworms, several kinds of insects, spiders, pseudoscorpions, mites, ticks, and millipedes (Carr 1940; McMillan and Semlitsch, 1980; Powders and Cate, 1980 in AmphibiaWeb 2009). This salamander has a highly projectile tongue, and is likely a sit-and-wait predator. This species is likely preyed upon by crayfish, predaceous insects, large spiders, small snakes, and birds.

Populations:
There are 21 known sites for this species in North and South Carolina (Harrison and Guttman 2003). Overall population size is unknown.

Population Trends:
The long-term population trend for Chamberlain's Dwarf Salamander is moderately declining to relatively stable (NatureServe 2008).

Status:
Chamberlain's Dwarf Salamander is critically imperiled (S1) in Georgia, vulnerable in North Carolina (S3), and not ranked in Florida and South Carolina (NatureServe 2008). It lacks legal protective status.

Habitat destruction:

The Florida Fish and Wildlife Conservation Commission reports that the seep habitats on which this salamander depends are highly threatened by altered hydrologic regime (myfwc.com/docs/WildlifeHabitats/Legacy_Seepage.pdf, p. 311) and that forested habitats which support this salamander face numerous threats including altered fire regime and community structure, fragmentation, degradation, and conversion (http://myfwc.com/docs/WildlifeHabitats/Legacy_Mixed_Hardwood_Pine.pdf, p. 263).

Florida's Comprehensive Wildlife Conservation Strategy states that this species' habitat is threatened by agricultural conversion, groundwater withdrawal, development, and forestry (www.masgc.org/gmrp/plans/FL%20FWCII.pdf, p. 231).

This salamander is potentially threatened by habitat degradation due to new construction at the Dept. of Energy Savannah River Site (U.S. DOE 2005, http://www.srs.gov/general/pubs/envbul/ea-1538_12-08-05.pdf).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous” (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: “There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations” (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: “Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species” (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007).
Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: "Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:
This salamander is potentially threatened by overcollection. Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:
New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, see http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on

amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and thus potentially threatens this species. In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002).

Inadequacy of existing regulatory mechanisms:
Chamberlain's Dwarf Salamander has no legal protective status (AmphibiaWeb 2009).

Other factors:
This salamander is also threatened by pollution, acidification, climate change, invasive species, and synergies between multiple threats. On threats to cave-dwelling organisms, Scott (2004) states: "Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers. Humans have slaughtered entire bat colonies in some caves and caused partial or total abandonment of others, depleting the guano that supplies important nourishment for many cave invertebrates. Degradation of surface habitats may also threaten cave fauna" (p. 77).

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations” (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians.
Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets “may exact a substantial toll on amphibian populations” (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: “Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast” (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians.

Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

References:

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Scientific Name:
Eurycea tynerensis
Common Name:
Oklahoma Salamander

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The range of the Oklahoma Salamander is poorly understood and needs further research. AmphibiaWeb (2009) states that the distribution of known localities appears to be considerably smaller than the proposed range. This species might be restricted to a small area in eastern Oklahoma, because previously identified populations in Missouri and Arkansas could be a different species (NatureServe 2008).

NatureServe (2008) states: "According to Bury et al. (1980), range includes the drainages of the Neosho and Illinois rivers, Springfield Plateau section of Ozark plateaus of southwestern Missouri (McDonald County), northwestern Arkansas (Benton, Washington, and Carroll counties), and northeastern Oklahoma (Adair, Cherokee, Delaware, Mayes, and Ottawa counties). Petranka (1998) also indicated that the range includes eastern Oklahoma, southwestern Missouri, and northwestern Arkansas. However, preliminary electrophoretic data indicate that E. Tynerensis is restricted to a few counties in eastern Oklahoma; populations in Arkansas and Missouri are not genetically distinct from E. multiplicata griseogaster (Wilkinson, in Figg 1991). Johnson (2000) accordingly did not recognize E. Tynerenis as a member of the Missouri herpetofauna."

Habitat:
Oklahoma Salamanders are found in shallow streams with slow current and medium-sized, partially embedded rocks, and also in small springs and seeps with leaf litter and mud and detritus substrate. They are most abundant in areas with high densities of invertebrates (Tumlison et al. 1990, Tumlison and Cline 1997, in AmphibiaWeb 2009). NatureServe (2008) describes their habitat as small, clear, spring-fed streams with temperatures generally below 24 C, at elevations below 305 m, with coarse sand, gravel, or bedrock substrate (Bury et al. 1980). The species is commonly found in gravelly (primarily chert) substrates, in spaces between stones and pebbles in loose, coarse sand under cold swift shallow water. During drought, the salamander seeks refuge below the substrate (references cited by Tumlison et al. 1990).This salamander is associated with Ordovician-Silurian strata (Tumlison and Cline 2003), and may use karst passages to move within or between stream systems (Tumlison et al. 1990).

Ecology:

The Oklahoma Salamander is neotenic, meaning it is an aquatic obligate that reaches sexual maturity while retaining juvenile body form (Conant and Collins 1998). Populations thus consist of permanently aquatic, non-transforming individuals (Petranka 1998). Eggs are laid on the undersides of rocks, and clutch size is estimated at 1-11. Gravid females have been detected in May and November (Moore and Hughes 1939, Trauth et al. 1990, AmphibiaWeb 2009). Oklahoma Salamanders reach sexual maturity in 2–3 yr (Dundee, 1958) at approximately 26 mm SVL (Dundee, 1965b) (AmphibiaWeb 2009). This species might undergo seasonal migrations. AmphibiaWeb (2009) states: "The discovery of subterranean isopods (Caecidotea sp.) in the stomachs of two specimens and the location of many individuals in small, isolated springs distant from a main stream course led Tumlison and Cline (1997) to propose that Oklahoma salamanders may be migrating along subterranean corridors to reach resource-rich habitats on the surface. However, high densities of Oklahoma salamanders in rather atypical habitats might also be interpreted as a sequestering of all individuals into the last remaining moist habitats to survive drought conditions." Oklahoma salamanders are sympatric with cave salamanders (E. lucifuga), dark-sided salamanders (E. longicauda melanopleura), gray-bellied salamanders (E. m. griseogaster), and grotto salamanders (Typhlotriton spelaeus). This species preys on dipterans, ephemeropterans, plecopterans, coleopterans, trichopterans, hymenopterans, thysanopterans, odonates, ostracods, isopods, amphipods, decapods, hydracarians, and pulmonates (Tumlison et al. 1990, AmphibiaWeb 2009).

Populations:
Both number of populations and total population size of the Oklahoma Salamander are currently unknown and in need of genetic research. The species was presumably detected at 50 of 213 sites examined in three states (Tumlison and Cline 2003), but there is genetic uncertainty regarding the distribution of this salamander, and it may only occur in Oklahoma (NatureServe 2008).

Population Trends:
NatureServe (2008) states that this salamander is probably stable to slightly declining in population size, area of occupancy, and number/condition of occurrences over the short term, with unknown trend over the long term. Cline and Tumlison (2001) found this species at 50 percent of historic sites in Oklahoma, and reported declines or extirpations from several

Status:
The Oklahoma Salamander is vulnerable in Arkansas and Oklahoma (S3) (NatureServe 2008). It is classified as Near Threatened by the IUCN. It lacks legal protective status.

Habitat destruction:

Dodd (1997) reports that the Oklahoma Salamander is threatened by habitat alteration. NatureServe (2008) states that it is threatened by direct habitat destruction (e.g., flooding by impoundments), and by activities (agriculture, urbanization, stream channelization, gravel removal) that result in silting or pollution of aquatic habitat (Bury et al. 1980). Bury et al. (1980) state: "Individuals are common where there is suitable habitat, but such areas are rapidly being destroyed by construction projects. Other threats are agricultural use, urbanization, and manipulation of the aquatic habitat" (p. 24). Cliine and Tumlison (2001) report that this salamander is threatened by graveling operations, siltation from livestock grazing, permanent flooding from damming of streams, and water diversion for livestock and recreation. The State of Arkansas (2008) reports that the species is threatened by nutrient loading from confined animal feeding operations, and by grazing, sedimentation, contaminants, and urban development (http://www.wildlifearkansas.com/materials/updates/04a_amphibian.pdf).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: "Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:

Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, see http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and it is imperative that equipment be disinfected so that research efforts to protect species do not inadvertently introduce this fungus or other pathogens to imperiled amphibian populations. In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002).

Inadequacy of existing regulatory mechanisms:

There are no regulatory mechanisms that protect the Oklahoma Salamander. It was previously listed as Rare in Missouri, but is no longer considered a valid taxon in that state. It is a species of special concern in Arkansas and Oklahoma, but this designation does not provide any protection. NatureServe (2008) reports that one site where this species occurs is at a church camp, which might provide some habitat protection, but not necessarily.

Other factors:

The Oklahoma salamander is threatened by water pollution and may be threatened by other factors which widely threaten southeastern amphibians.

This salamander sometimes uses karst passages. On threats to cave-dwelling organisms, Scott (2004) states: "Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers. Humans have slaughtered entire bat colonies in some caves and caused partial or total abandonment of others, depleting the guano that supplies important nourishment for many cave invertebrates. Degradation of surface habitats may also threaten cave fauna" (p. 77).

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats. NatureServe (2008) states that "being permanently aquatic leaves the Oklahoma Salamander particularly vulnerable to alterations in water quality and pollutants."

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: "Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis" (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: "If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations" (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians. Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: "Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Fallicambarus burrisi
Common Name:
Burrowing Bog Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	VU - Vulnerable

Range:
The Burrowing Bog crayfish is currently known from the Escambia River drainage in Washington County, Alabama, Jackson County, Mississippi and the Chickawawhay River drainage in Green County, Mississippi (NatureServe 2008). In Alabama, the species is known from only two database records from the Escatawpa River system in southwestern Alabama (Mirarchi et al., 2004).

Habitat:
According to Fitzpatrick (1987), F. burrisis burrows in saturated sandy soils of hillside Sarracenia bogs. All specimens were found in pitcher plant bogs in the Chichasawhay and Escatawpa drainages of Alabama and Mississippi. It is always burrowing, usually into sandy clay substrate. The burrows exhibit complex branching patterns, and there is usually water running through habitat (except in midsummer). Johnson and Fiegiel (1995) report that this species' bog habitat is turning into a terrestrial environment. The species can be found in ditches and seeps, so it might not be confined to pitcher plant bogs.

Populations:
In Alabama, this species known from only two database records from the Escatawpa River system in southwestern Alabama (in Mobile Bay and Pascagoula drainages) (Mirarchi et al., 2004; appendix 1.2; Schuster and Taylor, 2004; Schuster et al., 2008). There are estimated to be between 6 and 20 total populations (NatureServe 2008) with 100-2500 total individuals.

Status:
NatureServe (2008) ranks this species as imperiled in Mississippi and vulnerable in Alabama. It was a C2 Candidate species under the federal ESA before that list was abolished. It is ranked as threatened by the American Fisheries Society and as vulnerable by the IUCN. Guiasu (2007) states that F. burrisi and F. gordoni "have not only small ranges, but also apparently very specific and narrow habitat requirements. Both species seem to be found only in pitcher plant bogs." Therefore, "they require special attention from a conservation standpoint."

Habitat destruction:
NatureServe (2008) suggests that removal of pitcher plant bogs is long-term threat. The U.S. Forest Service (2008) reports that in the range of Fallicambarus burrisi, "the viability of many of the rare crustaceans is most threatened because of their small ranges. Impacts to habitats that would reduce or extirpate local populations of other taxonomic groups might result in extinction of some crustaceans. Crayfish are somewhat tolerant of desiccation, but permanent conversion of wetlands to pasture or urban uses could eliminate populations and lead to extinctions."

Inadequacy of existing regulatory mechanisms:
Part of the range of this species includes the DeSoto National Forest in Mississippi. No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Fallicambarus danielae
Common Name:
Speckled Burrowing Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	VU - Vulnerable

Range:
The Speckled Burrowing crayfish occurs spottily in Mobile County, Alabama, and Marrison, Jackson, Scott and Stone counties, Mississippi. The exact range and relationships of several populations of this species, and the closely related and environmentally equavilent F. burris and F. byersi need to be determined (NatureServe 2008).

Habitat:
F. danielae is found almost exclusively in pitcher plant bogs or on the edges of such as a primary burrower (NatureServe 2008). The dominant vegetation in its habitat is Sarracenia spp., Drosera spp. and other bog species.

Populations:
In Alabama, this species is known from four records from the Mobile and Pascagoula River systems (AL NHP; Mirarchi et al., 2004, appendix 1.2 pub. separately; Schuster and Taylor, 2004; Schuster et al., 2008). Information on population size and trend is not available.

Status:
NatureServe (2008) ranks this species as critically imperiled in Alabama and imperiled in Mississippi. The State of Alabama lists it as a Priority 2 Species of Greatest Conservation Need, while Mississippi considers it a Tier 2 SGCN. It was a Federal C-2 Candidate Species until that list was abolished. It is ranked as vulnerable by the IUCN and as Threatened by the American Fisheries Society.

Habitat destruction:
NatureServe (2010) states that it is likely that this species is undergoing localized declines in areas of urbanization or in areas where there are alterations to the hydrological regime or water pollution. The pitcher plant habitats on which this species depends are apparently being drained for development even when no immediate alternate use is in sight. This species apparently does not survive the destruction/draining of its habitat and is unable to adjust to a modified environment.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected and managed

This species occurs on the DeSoto National Forest in Mississippi, where it is considered a Forest Service Sensitive Species, but this designation confers only discretionary protection.

Other factors:
Guiasu (2007) reports that Fallicambarus species have fairly limited to very limited distributions and are particularly vulnerable intrinsically to decline and extirpation.

NatureServe (2008) reports that Fallicambarus species are imperiled by pollution, "including air, water and soil pollution as these species spend time burrowing and in temporary waters."

This crayfish may also be threatened by global climate change. NatureServe (2008) states: "Because burrowing crayfish tend to prefer warmer climates and the milder and shorter winters currently found in southeastern areas of the U.S. and because they live in semi-terrestrial habitats sometimes far removed from permanent water todies, they are often prevented from expanding their ranges and, theoretically may be susceptible to the effects of global warming."

Competition from introduced crayfish species (Orconectes rusticus, Procambarus clarkii, Cambarus robustus) is considered a threat to the species in this genus (Guiasu 2007).

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Scientific Name:
Fallicambarus gilpini
Common Name:
Jefferson County Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	VU - Vulnerable

Range:
NatureServe (2008) reports that the total range of F. gilipini is less than 100-250 square km (less than about 40 to 100 square miles). It is currently known only from the type locality in Jefferson County, Arkansas (Robison and Allen 1995).

Habitat:
Fallicambarus gilpini digs complex burrows on slopes in seepage areas (NatureServe 2008). The species may prefer flowing groundwater rather than static (Robison and Allen 1995).

Populations:
This species has been collected only once from one location, with three females and no males captured (NatureServe 2008).

Population Trends:
Trend information is not available for this very rare species.

Status:
Fallicambarus gilpini is extremely rare, being known only from the type locality and three specimens (NatureServe 2008). Within Arkansas and globally its status is critically imperiled (NatureServe 2008). It was a Federal C2 candidate species until that list was abolished. It is ranked as vulnerable by the IUCN and as endangered by the American Fisheries Society.

Habitat destruction:
The Arkansas Wildlife Action Plan (2008) reports that this species' habitat is threatened by road construction and hydrological alteration from forestry.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this rare species.

Other factors:
This species is threatened by water pollution from logging activities including herbicides and sedimentation (Arkansas Wildlife Action Plan 2008).

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Scientific Name:
Fallicambarus harpi
Common Name:
Ouachita Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	EN - Endangered

Range:
NatureServe (2008) estimates the range of Fallicambarus harpi to be 100-250 square km (about 40-100 square miles). This crayfish is endemic to the southern Ouachitas and is known from 12 sites in Garland, Hot Spring, Montgomery, and Pike counties, Arkansas (Robison and Crump 2004).

Habitat:
The Ouachita Burrowing crayfish digs burrows in grassy areas with a high water table. It is associated with Pinus, Quercus, and Cornus florida at the type locality (Robison and Allen 1995).

Populations:
NatureServe (2008) estimates that F. harpi has 6 - 20 populations with less than 1000 total individuals. It was initially known from only two sites in Pike County, Arkansas (Hobbs and Robison, 1985; Robison and Allen, 1995). The two known localities are within 0.1 miles of each other. It is now known from 12 sites in Garland, Hot Spring, Montgomery, and Pike Counties, Arkansas (Robison and Crump, 2004). Population size is unknown.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as critically imperiled. AFS now lists it as threatened (Taylor et al 2007) rather than endangered. It was also a Federal C-2 Candidate species until that list was abolished. It is classifed as endangered by the IUCN.

Habitat destruction:
According to the Arkansas Wildlife Action Plan (2008), this species faces threats from road construction, which involves habitat destruction and toxic contamination, and recommends that this species be protected from construction activities and herbicide applications.

NatureServe (2008) reports that species in this genus are threatened by habitat destruction and degradation due to habitat modification for agriculture and wetland destruction.

Inadequacy of existing regulatory mechanisms:
This species occurs on the Ouchita National Forest, where it is a Species of Viability Concern (USFS 2005) but this designation provides no regulatory protection. NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected and managed.

Other factors:
NatureServe (2008) reports that Fallicambarus species are widely threatened by pollution, "including air, water and soil pollution as these species spend time burrowing and in temporary waters."

This species may be threatened by global climate change, "because burrowing crayfish tend to prefer warmer climates and the milder and shorter winters currently found in southeastern areas of the U.S. and because they live in semi-terrestrial habitats sometimes far removed from permanent water todies, they are often prevented from expanding their ranges and, theoretically may be susceptible to the effects of global warming" (NatureServe 2008).

This species may also be threatened by competition from introduced crayfish species (Orconectes rusticus, Procambarus clarkii, Cambarus robustus) (Guiasu 2007).

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Scientific Name:
Fallicambarus hortoni
Common Name:
Hatchie Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
F. hortoni is known only from immediate vicinity of the type-locality in McNaivy County, Tennessee (Hobbs 1989).

Habitat:
The Hatchie Burrowing crayfish digs simple shallow burrows in sandy soil (NatureServe 2008). F. hortoni is found in sandy soil with only short herbaceous flora, and small Salix nigra at the water's edge (NatureServe 2008).

Populations:
The only known colony of this species probably does not exceed 100 adults (NatureServe 2008).

Population Trends:
Trend information is not available for this rare species.

Status:
Due to its restricted range and small population, the status of Fallicambarus hortoni is critically imperiled (NatureServe 2008). The State of Tennessee, the American Fisheries Society, and the IUCN list it as Endangered.

Habitat destruction:
Habitat destruction and degradation from agriculture and pollution are the main threats to all Fallicambarus crayfishes, including the Hatchie burrowing crayfish (NatureServe 2008).

Fallicambarus hortoni occurs in the same area in Tennessee as a proposed National Park Service expansion of the Corinth Civil War Battlefield (National Park Service 2004). Increased development and visitation could negatively impact this species' habitat

Inadequacy of existing regulatory mechanisms:
This species is listed as endangered by the state of Tennessee, but this designation provides no regulatory protection for the species' habitat.

Other factors:
This species is potentially threatened by global climate change. NatureServe (2008) states: "Because burrowing crayfish tend to prefer warmer climates and the milder and shorter winters currently found in southeastern areas of the U.S. and because they live in semi-terrestrial habitats sometimes far removed from permanent water bodies, they are often prevented from expanding their ranges and, theoretically may be susceptible to the effects of global warming."

This species is also potentially threatened by competition from introduced crayfish species (Orconectes rusticus, Procambarus clarkii, Cambarus robustus) (Guiasu 2007).

Because of its very limited distribution, this species is particularly vulnerable intrinsically to decline and extirpation (Guiasu 2007).

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Scientific Name:
Fallicambarus petilicarpus
Common Name:
Slenderwrist Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	CR - Critically endangered

Range:
NatureServe (2008) states that the range of Fallicambarus petilicarpus is less than 100-250 square km (less than about 40 to 100 square miles). It is known only from the type locality in Union County, Arkansas (Robison and Allen 1995).

Habitat:
This species forms complex burrows in seepage areas (NatureServe 2008).

Populations:
There is only one known site for this species, which is known from only 18 specimens collected on two dates (NatureServe 2008). It is "always rare and never abundant locally."

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of Arkansas classifies it as a Species of Greatest Conservation Need. It was a Federal C-2 Candidate Species before that list was abolished. It is ranked as endangered by the AFS and as critically endangered by the IUCN.

Habitat destruction:
The Arkansas Wildlife Action Plan (2008) reports that the habitat of this species is threatened by habitat disturbance due to road construction, and toxins and contaminants from road construction. The Plan recommends protecting known occurrences from construction activities and herbicide applications.

NatureServe (2008) reports that habitat destruction and degradation are the main threats to all Fallicambarus crayfishes, primarily habitat modification for agriculture and wetland draining and destruction.

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that no occurrences are appropriately protected and managed.

Other factors:
NatureServe (2008) reports that Fallicambarus species are imperiled by pollution, "including air, water and soil pollution as these species spend time burrowing and in temporary waters."

This crayfish may also be threatened by global climate change. NatureServe (2008) states: "Because burrowing crayfish tend to prefer warmer climates and the milder and shorter winters currently found in southeastern areas of the U.S. and because they live in semi-terrestrial habitats sometimes far removed from permanent water todies, they are often prevented from expanding their ranges and, theoretically may be susceptible to the effects of global warming."

Competition from introduced crayfish species (Orconectes rusticus, Procambarus clarkii, Cambarus robustus) is considered a threat to the species in this genus (Guiasu 2007).

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Scientific Name:
Fallicambarus strawni
Common Name:
Saline Burrowing Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Threatened	VU - Vulnerable

Range:
The Saline Burrowing crayfish is known from small portions of the Red and Ouachita River drainages in Howard, Pike, and Sevier counties, Arkansas.

Habitat:
Fallicambarus strawni inhabits seeps in elevated areas in pine woods, and digs complex but shallow burrows in saturated sand-clay soils (NatureServe 2008).

Ecology:
According to NatureServe (2008) this species is a primary burrower.

Populations:
This species is known from 13 locations. Total population is estimated at 1000-2500 individuals (NatureServe 2008).

Population Trends:
Trend is unknown.

Status:
The State of Arkansas classifies this crayfish as a Species of Greatest Conservation Need. It is ranked as critically imperiled by NatureServe (2008) and as vulnerable by the IUCN. The American Fisheries Society classifies this species as threatened.

Habitat destruction:
According to the Arkansas Wildlife Action Plan (2008), F. strawni is threatened by habitat destruction due to road construction. The plan recommends protecting known occurrences from construction activities.

NatureServe (2008) reports that habitat destruction and degradation are the main threats to all Fallicambarus crayfishes, primarily habitat modification for agriculture and wetland draining and destruction.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

Other factors:
According to the Arkansas Wildlife Action Plan (2008), F. strawni is threatened by exposure to toxics from efforts to control other species' populations.

NatureServe (2008) reports that Fallicambarus species are imperiled by pollution, "including air, water and soil pollution as these species spend time burrowing and in temporary waters."

This crayfish may also be threatened by global climate change. NatureServe (2008) states:

"Because burrowing crayfish tend to prefer warmer climates and the milder and shorter winters currently found in southeastern areas of the U.S. and because they live in semi-terrestrial habitats sometimes far removed from permanent water todies, they are often prevented from expanding their ranges and, theoretically may be susceptible to the effects of global warming."

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Scientific Name:
Farancia erytrogramma seminola
Common Name:
South Florida Rainbow Snake

G Rank:
T1

Range:
The South Florida Rainbow Snake is known only from a single population in Fish Eating Creek, flowing into the west side of Lake Okeechobee, in the southern peninsula of Florida (NatureServe 2008).

Habitat:
This is an aquatic snake that has only been found in a freshwater stream with substantial aquatic vegetation. Fisheating Creek , its only known location, is a sluggish, small to moderate sized stream flowing through a cypress stand. During drought Fisheating Creek is reduced to a series of disconnected lakes (Moler 1992). Though the South Florida Rainbow Snake has has only been found in creeks, it could possibly inhabit areas similar to other rainbow snakes (Florida Museum of Natural History 2000).

Populations:
There is only one known population of the South Florida Rainbow Snake, and only three invididuals have ever been detected, one from 1949, and two from 1952 (NatureServe 2008). The Florida Museum of Natural History reports that several unsuccessful searches have been conducted for this snake since the 1950s (Florida Museum of Natural History 2000).

Population Trends:
No population trend data are available for this subspecies, as it is known only from three individuals, the last of which was detected in 1952 (NatureServe 2008).

Status:
The South Florida Rainbow Snake is critically imperiled (T1S1) (NatureServe 2008).

Habitat destruction:
The South Florida Rainbow Snake is known only from a single creek, making it extremely vulnerable to habitat degradation. The creek where this species occurs is vulnerable to degradation from channelization or pollution, especially agricultural runoff (NatureServe 2008). During periods of drought, Fisheating Creek is reduced to a series of disconnected lakes (Moler 1992), making drought a threat for this aquatic snake.

Overutilization:
Because of the South Florida Rainbow Snake's extreme rarity, any level of collection poses a threat to its survival. Only three individuals of this subspecies have ever been detected (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the South Florida Rainbow Snake, and the single known population is not appropriately protected and managed (NatureServe 2008).

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Scientific Name:
Fimbristylis perpusilla
Common Name:
Harper's Fimbristylis

G Rank:
G2

Range:
This small annual sedge species is endemic to the southern Coastal Plain from Delaware to Georgia, occurring in Delaware, Georgia, Maryland, North Carolina, South Carolina, Tennessee, and Virginia (NatureServe 2008). The Tennessee population is entirely disjunct from the Coastal Plain population and is found exclusively in the Cumberland Plateau (Wofford and Jones 1988). Natural heritage records indicate that this species is currently known in Kent and New Castle Counties in Delaware, Baker, Seminole, and Sumter Counties in Georgia, in Caroline, Kent, and Queen Anne's Counties in Maryland, in Brunswick and Columbus Counties in North Carolina, in Horry County in South Carolina, and in Franklin and York Counties in Tennessee (NatureServe 2008). Within this range, occurrences are patchy and local abundance is highly variable across years, largely because this species has very precise ecological preferences and can only become established under certain environmental conditions.

Habitat:
Harper's fimbristylis occurs in areas that are exposed but not entirely desiccated during seasonal dry periods. It inhabits the mud or silt margins of ponds and blackwater rivers, mudflats, river shores, sloughs, sandbars, and depressions in low woodlands (NatureServe 2008). This species germinates only in years or locations with adequate seasonal inundation and exposure cycles; the conservation of natural hydrological patterns is therefore essential to its survival (NatureServe 2008, Kral 1971). It is thought that this species' seeds may lie dormant in substrate until suitable hydrological conditions develop (Kral 1971, NatureServe 2008).

Ecology:
Very little is known about this plant's ecology beyond its specific habitat and hydrological requirements (NatureServe 2008); means of dispersal is not fully understood (Wofford and Jones 1988).

Populations:
There are 55 known extant occurrences for this plant, though only half of these have been confirmed in the past 24 years; the temporally sporadic abundance of this species makes censusing difficult. NatureServe (2008) reports that only a few occurrences consist of substantial population sizes (more than 1,000 individuals) have been recently documented. It is estimated that the abundance of this species has declined more than 70 percent in comparison to its historical abundance (NatureServe 2008). Several populations have disappeared in recent years, and numerous known sites have been destroyed.

Population Trends:
NatureServe (2008) reports that the Harper's fimbristylis has experienced major declines in recent decades (up to 90 percent) and that populations continue to decline rapidly.

Status:
NatureServe (2008) reports that the Harper's fimbristylis is critically imperiled in Delaware, Georgia, North Carolina, Tennessee, and Virginia, and imperiled in Maryland and South Carolina.

It is state-listed as endangered in Georgia, Maryland, Tennessee, and Virginia, and threatened in North Carolina. Most populations are isolated and/or in decline.

Habitat destruction:

Anthropogenic alteration of local hydrology by any means is highly detrimental to this species as it is so particular in its moisture preferences. Logging, forest clearing, and drainage for agriculture are among the top recognized contributors to the decline of the Harper's fimbristylis, and residential and agricultural development play an increasingly significant role, both by causing habitat loss and increasing water demand (NatureServe 2008). Alterations to patterns of natural succession are also of concern because changes in vegetation structure may exclude this shade-intolerant plant. Trampling by livestock, humans, and off-road vehicles is also a localized threat in some areas (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

Though it is listed as endangered in Georgia, Maryland, Tennessee, and Virginia, and threatened in North Carolina, these designations afford the Harper's fimbristylis no significant regulatory protection. Therefore, no existing regulatory mechanisms adequately protect this species from the threats it faces.

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Scientific Name:
Fissidens appalachensis
Common Name:
Appalachian Fissidens Moss

G Rank:
G2

Range:
This species is limited to a few counties in North Carolina and Tennessee: records indicate it is or was present in Caldwell, Macon, MacDowell, Munroe and Watauga Counties, North Carolina, and Carter County, Tennessee, though more recent confirmation of this range is unavailable (Crum and Anderson 1981, USFS 2003, NC NHP 2004).

Habitat:
This moss is found submerged in rock crevices in shallow, fast-running waters, and is characterized as a riparian-dependent species (Crum and Anderson 1981). It is often found at high elevations in montane streams (USFS 2009).

Ecology:
This species' dark green or black foliage forms fan-shaped clumps within crevice habitat, and individuals are typically dioecious though synoecious populations have been found (Crum and Anderson 1981).

Populations:
It is not known how many populations of this species occur.

Population Trends:
Total global population size is not known, nor are population trends reported. Based on the various threats to its habitat, though, populations are likely in decline (NatureServe 2008).

Status:
It is considered a sensitive species in many National Forests. NatureServe (2008) ranks the Appalachian fissidens moss as critically imperiled in Tennessee, and imperiled in North Carolina.

Habitat destruction:
This species is threatened by changes in regional hydrological patterns as a result of dams, diversions, or other anthropogenic activities, and siltation or pollution by industry or upstream residential or commercial development.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Appalachian fissidens moss: though many remaining populations occur on National Forest lands, and the species is listed as sensitive within these jurisdictions, this designation offers no substantial regulatory protections.

Other factors:
This species is imperiled by its small range, which makes it highly vulnerable to any further habitat loss or other local threats (Southern Appalachian Species Viability Project 2002).

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Scientific Name:
Fissidens hallii
Common Name:
Hall's Pocket Moss

G Rank:
G2

Range:
An extremely rare species throughout its range, F. hallii is known from Florida, Louisiana, North Carolina, and Texas (Crum and Anderson 1981).

Habitat:
This moss is found on decaying wood or bark, most often in cypress swamps, and also grows on clay soil in swamp habitat (Crum and Anderson 1981).

Ecology:
This moss is small and dioecious.

Populations:
The North Carolina Natural Heritage Program (2008) describes this species as significantly rare throughout its range with fewer than 100 populations total, but more precise estimates of the number of occurrences or total population size are unavailable.

Population Trends:
Trend information is not available for this species.

Status:
NatureServe (2008) reports that this species is critically imperiled in North Carolina, but rankings are not available for the rest of the range of this extremely rare moss.

Habitat destruction:
This moss' habitat is threatened by anthropogenic alteration of regional hydrology, outright conversion to agriculture, residential, or silvicultural uses, and pollution or siltation generated by these land uses in adjacent areas.

Inadequacy of existing regulatory mechanisms:
F. hallii is listed as a Regional Forester's Sensitive Species in North Carolina, but this designation offers it no substantial regulatory protection; no existing regulatory mechanisms adequately protect this species.

Other factors:
This species is particularly vulnerable to extirpation due to its rarity and limited distribution (Southern Appalachian Species Viability Project 2002).

References:

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Scientific Name:
Floridobia mica
Common Name:
Ichetucknee Siltsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The known range of this snail is approximately 10 square yards at Ichetucknee Springs State Park in Florida (Florida Dept. of Environmental Protection 2000). It occurs only at Coffee Spring along the west bank of the Ichetucknee River (Thompson 1968, 1999).

Habitat:
This snail occurs on submerged mosses and cypress rootlets in sand and gravel-bottomed karst spring pools (Thompson 1968). Its spring issues from two sources beneath a sandstone outcropping before forming a large circular pool that is 40 feet wide and 1-2 feet deep with sand-gravel-silt substrate. The pool is open and continuous with the Ichetucknee River, and has large patches of submerged bryophytes covering sticks and rocks (Thompson 1968).

Populations:
There is only one population of this snail and total population size is unknown (NatureServe 2008).

Population Trends:
Trend information is not available for this species.

Status:
The Ichetucknee Siltsnail is critically imperiled (G1S1, NatureServe 2008). It is categorized as vulnerable by the IUCN.

Habitat destruction:
This snail's extremely limited habitat occurs in a state park which is heavily used for recreation, particularly "tubing," diving, and canoeing (NatureServe 2008). The spring where this snail occurs is continuous with the river, and the spring may be subject to unintentional degradation through recreational activities. The state park management plan states that extinction of the species could occur if the the spring is disturbed, and staff erected a fence across the mouth of the spring (Florida Dept. of Environmental Protection 2000). The species is vulnerable to habitat loss from water quality degradation from recreational activities. Florida's spring karst habitats are also threatened by a variety of factors including groundwater contamination, aquifer withdrawals, and saltwater intrusion (Walsh 2001).

Inadequacy of existing regulatory mechanisms:
There are no regulatory mechanisms in place to protect this snail.

Other factors:
This species is threatened by water pollution from recreation and from activities outside the park where it occurs.

References:

Florida Dept. of Environmental Protection. 2000. Ichetucknee Springs State Park Approved Unit Management Plan. Division of Recreation and Parks. http://www.dep.state.fl.us/parks/planning/parkplans/IchetuckneeSpringsStatePark.pdf Last accessed Jan. 11, 2010.

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Walsh, S.J. 2001. Freshwater Macrofauna of Florida Karst Habitats. In Eve L. Kuniansky, editor, 2001, U.S. Geological Survey Karst Interest Group
Proceedings, Water-Resources Investigations Report 01-4011, p. 78-88

Scientific Name:
Floridobia monroensis
Common Name:
Enterprise Siltsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
This snail is restricted to a single site in Volusia County, Florida, with a total extant range of less than 0.4 square km (Franz 1982, Thompson 1968, 1999; Watson 2000). Despite extensive surveys, this snail is known only from its type locality.

Habitat:
This snail occurs on leaf detritus on the edge and bottom of a seepage run (Franz 1982). The seepage is a few cm deep with mud and silt substrate, slow current, and leaf litter, woody debris, and orange flocculent matter (Watson 2000).

Populations:
This snail is only known from one occurrence, and total population size is unknown (NatureServe 2008).

Population Trends:
The population trend for this snail is thought to be stable to relatively stable, though available habitat has been reduced by alterations at the spring where it occurs (Watson 2000, NatureServe 2008).

Status:
NatureServe (2008) ranks the Enterprise Siltsnail as critically imperiled. It is categorized as vulnerable by the IUCN.

Habitat destruction:
With a total extant range of less than one square kilometer, the Enterprise Siltsnail is exceedingly vulnerable to habitat loss and degradation. This species' limited habitat has already been drastically reduced by alteration of the spring where it occurs (NatureServe 2008). Benson's Mineral spring was once a broad stream that formerly flowed into Lake Monroe (Johnson 1973). The spring is now capped, and most of its waters have been divested for human use. NatureServe (2008) reports that the snail "is still holding on in seeps associated with the original spring." This species is threatened because the remaining seepage is highly vulnerable to water table decline resulting from drought or human consumption. Walsh (2001) reports that hydroelectric development at the spring is a severe threat that could extirpate this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Enterprise Siltsnail. NatureServe (2008) reports that the lone occurrence of this species is not appropriately protected and managed.

References:

Franz, R. (ed.) 1982. Rare and Endangered Biota of Florida: Volume Six: Invertebrates. University Press of Florida: Gainesville, Florida. 131 pp.

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Watson, C.N., Jr. 2000. Results of a survey for selected species of Hydrobiidae (Gastropoda) in Georgia and Florida. Pages 233-244 in R.A. Tankersley, D.I. Warmolts, G.T. Watters, B.J. Armitage, P.D. Johnson, and R.S. Butler (eds.). Freshwater Mollusk Symposia Proceedings. Ohio Biological Survey, Columbus, Ohio. 274 pp.

Scientific Name:
Floridobia parva
Common Name:
Pygmy Siltsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The Pygmy Siltsnail is endemic to the upper part of Blue Springs in Volusia County, Florida, with a total range of far less than 100 square km (Johnson 1973, Thompson 1968, 1999, NatureServe 2008).

Habitat:
This snail occurs on vegetation, gravel, and debris in a freshwater karst spring run. The springs form a 50-ft wide circular pool that issues from a large central boil and several smaller boils. The spring run varies in depth from 5-15 ft and is approximately 30 yards wide. The water is clear and supports thick aquatic vegetation. The substrate is silty-sand and gravel over soft limestone. The spring run is approximately one-quarter mile long before entering the St. John's River (Thompson 1968).

Populations:
There is one population of this snail and population size is unknown.

Population Trends:
Bleasdale et al. (2009) and Jnbaptiste et al. (2009) report that this snail is declining and is now present in lower densities than in 1992-1993.

Status:
The Pygmy Siltsnail is critically imperiled (G1S1) (NatureServe 2008). It is categorized as vulnerable by the IUCN.

Habitat destruction:
The lone population of this snail is in a recreational area, making recreational impacts a threat to its survival. There is a developed swimming area in part of the spring (Moss et al. 2009). The park management plan states that the spring has suffered from erosion due to people climbing on the spring banks (Florida Division of Recreation and Parks 1999). The Siltsnail is also threatened by logging, as the park management plan allows for timbering operations within park boundaries (Florida Division of Recreation and Parks 1999). Invasive tilapia (Tilapia aurea) are causing habitat degradation at Blue Spring. Tilapia make deep spawning beds in the sand bottom which can undermine bank stability (Florida Division of Recreation and Parks 1999).

Deteriorating water quality also threatens this species. The Florida Wildlife Conservation Commission (2009) reports that spring habitats in the state are very highly threatened by nutrient loading from agricultural and urban runoff, and by invasive plants and animals. Bleasdale et al. (2009) report that "there is evidence suggesting chemical changes to the waters of Blue Spring and the St. John's River from direct spilling or dumping, runoff and flow rate changes from land use in the recharge basin, and/or seepage of chemicals into the groundwater source for Blue Spring." They also report that this species' habitat is threatened by the introduction of exotic species such as the Vermiculated Sailfin Catfish (Pterygoplichthys disjunctivus), which uses the long algal filaments that are a habitat component for the snail as a food source. Jnbaptiste et al. (2009) also report recent declines in water quality and outflow at the spring.

Inadequacy of existing regulatory mechanisms:
There are no regulatory mechanisms that currently protect this species.

References:

Bleasdale, C.J., M.A. Reiter, and A.J. Brooks-Walter. 2009. Potential drivers impacting the endemic snail populations of Blue Spring, Volusia County FL. Abstracts of the 73rd Annual Meeting of the Florida Academy of Sciences, in conjunction with the Tampa Bay Section of the American Chemical Society. Saint Leo University, Saint Leo, Florida
20-21 March 2009.

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http://edocs.dlis.state.fl.us/fldocs/dep/parks/unitmanplan/1999/BlueSpringStatePark.pdf Last accessed Jan. 6, 2010.

Florida Wildlife Conservation Commission. 2009. Wildlife Habitats: Legacy Springs. http://www.fwc.state.fl.us/docs/WildlifeHabitats/Legacy_Spring.pdf.

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Scientific Name:
Floridobia ponderosa
Common Name:
Ponderous Siltsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Ponderous Siltsnail is approximately 200 acres in Seminole County, Florida (Florida Dept. of Environmental Protection 2003). It is known only from Sanlando Springs in the Middle St. John's watershed (Burgess and Franz 1978, Johnson 1973, Thompson 1968, 1999).

Habitat:
The spring where this snail occurs issues from a large limestone cavern 15 feet below the water surface, and forms a pool 50 feet across at the base of low rolling hills in a semi-wooded area along the east bank of the Little Wekiva River. The spring has been been dammed below the pool and modified into a recreation area. Two runs flow from opposite ends of the pool and enter the river about 200 yards apart. Snails are abundant in the spring and in the Little Wekiva River to about 500 yards below the spring runs, but do not occur beyond this point. Snails are found on vegetation and on sand and gravel substrates (Thompson 1968).

Populations:
There is only one population of this species and population size is unknown.

Population Trends:
Trend information is not available for the lone population of this snail.

Status:
The Ponderous Siltsnail is critically imperiled (G1S1). It is classified as vulnerable by the IUCN.

Habitat destruction:
This species has only 200 total habitat acres, none of which are protected, making it very vulnerable to habitat degradation (FDEP 2003). The single spring where this snail occurs has been modified by damming to create a swimming pool, making recreational and water quality impacts a threat to its survival. The spring is surrounded by development, which further threatens water quality (NatureServe 2008). The Little Wekiva watershed has undergone "intense development" and rapid and extensive urbanization which has caused water quality problems and loss of native species (FDEP 2003). Spring habitats in Florida are also threatened by groundwater contamination, aquifer withdrawals, and saltwater intrusion (Walsh 2001).

Inadequacy of existing regulatory mechanisms:
There are no regulatory mechanisms that currently protect this species which occurs in a single population on private land.

Other factors:
This snail is threatened by pollution from recreation and development.

References:

Burgess, G.H. and R. Franz. 1978. Zoogeography of the aquatic fauna of the St. Johns River system with comments on adjacent peninsular faunas. The American Midland Naturalist, 100(1): 160-170.

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Scientific Name:
Floridobia wekiwae
Common Name:
Wekiwa Siltsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Wekiwa Siltsnail iis less than 100 square km in the St. John's River System in Orange County, Florida, where it is restricted to Wekiwa Springs and spring run (Burgess and Franz 1978; Johnson 1973, Thompson 1999). The area of occupancy of this species is less than 0.4 square km (NatureServe 2008).

Habitat:
This snail occurs in a freshwater karst spring that issues from five submerged horizontal caverns before forming a pool about 120 feet across. The snails are found in the spring pool and run for a short distance below the pool. The pool has fine sand substrate and the spring run has thick mats of submerged vegetation. The spring run is approximately 75 feet wide and 3 feet deep (Thompson 1968).

Populations:
There is one population of this snail and population size is unknown (NatureServe 2008).

Population Trends:
Trend information is not available for this species (NatureServe 2008).

Status:
This snail is critically imperiled (G1S1). It is categorized as vulnerable by the IUCN.

Habitat destruction:
The Wekiwa Siltsnail is exceptionally vulnerable to habitat loss and degradation because the lone population of this species occurs in a heavily used state park recreation area. Recreational impacts could cause water pollution, increased siltation, decreased aquatic vegetation, and direct crushing and displacement of snails (NatureServe 2008, Reiter 1992). Decreasing water quality or quantity threaten this species, as do external sources of pollution and groundwater decline resulting from urbanization (Walsh 2001).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechansims to protect this species.

References:

Burgess, G.H. and R. Franz. 1978. Zoogeography of the aquatic fauna of the St. Johns River system with comments on adjacent peninsular faunas. The American Midland Naturalist, 100(1): 160-170.

Johnson, R.I. 1973. Distribution of Hydrobiidae, a family of fresh and brackish water gastropods, in peninsular Florida. Occasional Papers on Mollusks, 3(46): 281-303.

Thompson, Dr. Fred G., Curator of Malacology, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611. ALAC. 352/392-1721. SUNCOM: 622-1721.

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Proceedings, Water-Resources Investigations Report 01-4011, p. 78-88

Scientific Name:
Forestiera godfreyi
Common Name:
Godfrey's Privet

G Rank:
G2

Range:
Godfrey's privet is known from a limited range. This species is present in nine counties in northern Florida, southeastern Georgia, and southeastern South Carolina (Anderson 1985, Weakley 1996, Kartesz 1998). Most occurrences are found in Florida. Population size and density are variable across its range. Natural heritage records show this species is present in Alachua, Dixie, Duval, Gadsden, Jackson, Jefferson, Liberty, and Marion Counties, Florida, Camden County, Georgia, and in Beaufort, Charleston, and Colleton Counties, South Carolina (NatureServe 2008).

Habitat:
The privet is found on forested slopes along lake or river bluffs, in rocky woodlands and hardwood hammocks, and often occurs on limestone outcroppings (Anderson 1985, FNAI 2000).

Ecology:
The privet is a deciduous shrub which flowers mid-January to mid-February and fruits through May (FNA 2000).

Populations:
This species is rare across its range (Anderson 1985): one occurrence is known in South Carolina, one in Georgia, and approximately 15 in Florida (Weakley, 1996, Chafin 1999). Several historical occurrences have been extirpated in recent decades (NatureServe 2008). Populations are dense at some sites and sparse at others. Total population size is not known, and estimation is difficult because the species forms dense thickets.

Population Trends:
NatureServe (2008) reports that the Godfrey's privet has experienced substantial declines (up to 75 percent in recent decades), and that populations continue to decline precipitously.

Status:
This species is known from a limited range across which it is already rare and in continuing decline. NatureServe (2008) ranks F. godfreyi as critically imperiled in Georgia and South Carolina, and imperiled in Florida.

Habitat destruction:
The habitat of Godfrey's privet is threatened by logging, establishment of tree plantations, and conversion to residential development (NatureServe 2008, FNAI 2000).

Inadequacy of existing regulatory mechanisms:
Several occurrences of this plant are found on protected parks or reserves; at some of these sites competition with invasive exotics still imperils the species (Chafin 1999, NatureServe 2008). Though it is listed as endangered in Florida, this designation affords no substantial protection, and no existing regulatory mechanisms adequately protect the Godfrey's privet or its habitat.

Other factors:

Competition with invasive exotic species, particularly Chinese privet (Ligustrem sinsense) and heavenly bamboo (Nandina domestica), threatens this species in certain parts of its range (FNAI 2000).

References:

Anderson, L. C. 1985. Forestiera Godfreyi (Oleaceae): A new species from Florida and South Carolina. SIDA. 11(1):1- 5.

Florida Natural Areas Inventory (FNAI). 2000. Godfrey's privet, Forestiera godfreyi. Accessed online December 15, 2009 <<http://www.google.com/search?q=godfrey%27s+privet&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:official&client=firefox-a>>.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life. Available at: http://www.natureserve.org/explorer. Accessed December 3, 2009.

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Weakley, A.S. 1996. Flora of the Carolinas and Virginia: working draft of 23 May 1996. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Dept., Chapel Hill, North Carolina. Unpaginated.

Scientific Name:
Fundulus julisia
Common Name:
Barrens Topminnow

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
Historically, the barrens topminnow was found in the headwaters of the Duck and Elk Rivers and the Caney Fork River system of the Cumberland drainage (Etnier and Starnes 1993). It is apparently extirpated from the Duck River where it was last collected in 1964 (Ibid.)

Habitat:
The barrens topminnow occupies heavily vegetated pools in springs and slow moving streams and appears to prefer areas with filamentous algae and watercress (Etnier and Starnes 1993).

Populations:
The barrens topminnow is a critcally endangered species that is currently limited to four localities with perhaps a few hundred fish (Rakes 1996, Winford 2002, Goldsworthy and Bettoli 2005). The topminnow has been stocked into additional sites, but in most cases reproduction has not occccurred and populations have not been established likely because of introduced mosquitofish (Goldsworthy and Bettoli 2005).

Population Trends:
The barrens topminnow has experienced rapid and substantial population declines (Rakes 1996, Goldsworthy and Bettoli 2005, NatureServe 2008). Surveys in 1983 identified the species at 14 sites with 4500-5000 adults (Rakes 1996, Goldsworthy and Bettoli 2005). By 1994, there were only seven sites with a few hundred adults and by 2004, there were only four sites, all of which are of questionable viability (Ibid.)

Status:
The barrens topminnow is listed as critically imperiled by NatureServe (2008), as endangered and declining by AFS (2008) and as endangered by the state of Tennessee. It is threatened by habitat degradation related to livestock grazing and agriculture, drought and introduced mosquitofish (Goldsworthy and Bettoli 2005, NatureServe 2008). Mosquitofish are present at two of the remaining four sites with wild populations and a third has recently been threatened by drought (Goldsworthy and Bettoli 2005). Etnier and Starnes (1993) concluded that the "species has to be considered in jeopardy." At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the barrens topminnow should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
Habitat for the barrens topminnow faces a multitude of threats, including impoundment, stream diversions and irrigation withdrawals associated with agricultural, pollution silt, petroleum products, and pesticides, and degradation by livestock, draining, bulldozing and dredging (Rakes 1996, Goldsworthy and Bettoli 2005, NatureServe 2008). Of the four remaining wild populations, for example, Goldsworthy and Bettoli (2005) report that "the stability of these populations was questionable" because "one site occurred behind a new housing subdivision and the other occurred on an active cattle farm adjacent to a major highway."

Disease or predation:
This fish is threatened by predation from introduced mosquitofish (Goldsworthy and Bettoli 2005).

Inadequacy of existing regulatory mechanisms:
The barrens topminnow was first proposed for listing in 1977 along with four other species of fish (Federal Register 42: 65209, December 30, 1977). This proposal was withdrawn along with proposals for roughly 2,000 species in 1979 after FWS failed to finalize these proposals prior to a one year deadline established by Congress in a 1978 amendment that added new requirements for public comment and designation of critical habitat (Federal Register 44, March 6, 1979). In the thrity-one years that have followed this failure, the barrens topminnow has continued to decline and threats have increased.

A number of voluntary efforts have been established in an attempt to recover the topminnow. In particular, a "Barrens Topminnow Working Group" was established in 2001, including the FWS, Nature Conservancy, two major universities, Tennessee Wildlife Resources Agency and others. The working group has been engaged in individual habitat restoration projects, such as constructing fencing to exclude livestock, and artificial propagation and stocking into springs within the species historic range. Although admirable, these efforts have not successfully recovered the barrens topminnow. To date, efforts to establish new populations through artificial propogation have not been succesful with Goldsworthy and Bettoli (2005) concluding:

"Barrens topminnow Fundulus julisia populations have declined precipitously since the species was described in 1982. Propagation and reintroductions have been the primary means of recovery since 2001, but the reintroductions have been generally unsuccessful in creating self-sustaining populations."

NatureServe (2008) report that "all known extant populations are on private property." In most cases, these populations are receiving little protection and as noted in the section on destruction of habitat, two of the remaining four wild populations are actively threatened by livestock grazing and urban sprawl (Goldsworthy and Bettoli 2005). The type locality of the species, which is a spring tributary to West Fork Hickory Creek, is afforded some protection by a cooperative agreement with the owner and the Nature Conservancy. Despite this protection, the population was almost lost to drought in the early 1980s (Rakes 1996).

The species is listed as threatened by the state of Tennessee, but this designation affords the species no regulatory protection.

Other factors:
The barrens topminnow is severely threatened by the introduction and spread of the mosquitofish (Gambusia affinis). NatureServe (2008) reports that "mosquitofish populations are becoming more widespread and abundant in the range of F. julisia and appear to be replacing F. juliasia." Goldsworthy and Bettoli (2005) determined that mosquitofish were likely the biggest factor in lack of recruitment for reintroduced populations. Mosquitofish are sympatric with at least two of the four remaining wild populations.

Barrens topminnow is also threatened by climate change, which will increase temperatures and reduce water availability and thereby increase drought (Karl et al. 2009). Drought is already known to be threat for the species with the type locality having to be rescued from drying habitat in the early 1980s.

Barrens topminnow is threatened by pollution from a variety of sources (Goldsworthy and Bettoli 2005).

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Scientific Name:
Pleuronaia barnesiana
Common Name:
Tennessee Pigtoe

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	NT - Near threatened

Range:
This mussel, formerly known as Fusconaia barnesiana, occurs in Alabama, Georgia, Mississippi, North Carolina, Tennessee, and Virginia. This mussel is restricted to the Cumberlandian regions of the Tennessee River drainage in Tennessee, Alabama, and Virginia (Simpson 1914, Parmalee and Bogan 1998). There are also recent records for two counties in North Carolina (LeGrand et al. 2006). Many populations persist as small, isolated remnants with diminished numbers in fragmented reaches of the Clinch, Powell, Holston, Nolichucky, Little Pigeon, Paint Rock, Elk, and Duck river systems (NatureServe 2008). This mussel is found in many small to medium-sized rivers in East and Middle Tennessee (Parmalee and Bogan 1998). This mussel also occurs in the Tennessee River drainage in Mississippi (Jones et al. 2005). This mussel may no longer be extant in Georgia, but might occur in the state in the Tennessee River basin (J. Wisniewski, GA NHP, pers. comm., January 2007 cited in NatureServe 2008).

Habitat:
This mussel inhabits riffle and shoal areas with moderate to swift current, and is rarely encountered in pools, slackwater areas, or depths exceeding one meter (Ahlstedt 1984). Preferred substrates range from cracks in bedrock to mixtures of coarse sand, gravel, cobble, and boulder-sized particles. Mirarchi et al. (2004) provided the following description of this species' habitat: "Varies from small streams to medium-sized rivers. However, historically occurred in Tennessee River at Muscle Shoals, but was extirpated when river was impounded (Garner and McGregor 2001). Appears to prefer shallow water with moderate current and a substratum of coarse sand, silt, and gravel (Parmalee and Bogan 1998)."

Ecology:
Mirarchi et al. (2004) state this species is presumably a short-term brooder that is gravid from spring through mid-summer.

Populations:
NatureServe (2008) roughly estimates that there are from 6-80 populations of Tennessee Pigtoe. This mussel's historical distribution has been severely fragmented, and it is now distributed sporadically throughout its former range at very low population densities. In North Carolina this mussel is only known from Macon and Swain counties in the Hiwassee and Little Tennessee River basins (Bogan 2002, LeGrand et al. 2006). In Alabama it is extant only in the Paint Rock River system and in a few tributaries to the Tennessee River, including Limestone and Round Island Creeks (Mirarchi et al. 2004). In Tennessee, it is extant in many small to medium-sized rivers in the east and center of the state including the upper Clinch and Powell, Little Pigeon, Nolichucky, Little, Elk, Duck, Buffalo, and Hiwassee (Parmalee and Bogan 1998). Johnson et al. (2005) report this mussel from the Hiwassee River inside and adjacent to Cherokee National Forest in Polk County, Tennessee. Jones et al. (2005) report this species from the Tennessee River drainage in Mississippi. In Georgia, this species might still occur in the Tennessee basin, but could be extirpated (J. Wisniewski, GA NHP, pers. comm., January 2007 cited in NatureServe 2008). In Virginia, this mussel occurs in the Powell, Clinch, North and South Fork Holston

rivers, and in Copper Creek (Jones et al. 2001, Fraley and Ahlstedt 2000, VA NHP, pers. comm. 2007 cited in NatureServe 2008). Jones and Neves (2007) describe the distribution in the upper North Fork Holston River in Smyth and Bland counties, Virginia as rkm 142.7 to 199.6.

Most extant populations exist at very low densities but the species persists in considerable numbers in several tributary systems of the Tennessee (Little Pigeon and Hiwassee) (NatureServe 2008).

Population Trends:

The Tennessee Pigtoe is very rapidly to rapidly declining (decline of 30-70 percent) in the short term and moderately declining (decline of 25 - 50 percent) in the long term. NatureServe (2008) states: "Populations continue to be lost at a high rate. TVA data indicates a sharp drop in occurrence in the Clinch River over the last 10 years. In Tennessee, it was known from the Emory, Watauga, French Broad, Holston, Sequatchie, and Tennessee Rivers but only prior to 1960 (Parmalee and Bogan, 1998). It is questionable as to whether this species still occurs in Georgia but it may still be surviving in the Tennessee River basin somewhere (J. Wisniewski, GA NHP, pers. comm., January 2007)." This species was extirpated from the mainstem of the Tennessee River by impoundments, but there are extant populations in many of the small to medium-sized rivers in east and middle Tennessee, though current populations are now reduced and localized (Parmalee and Bogan, 1998, NatureServe 2008).

Status:

NatureServe (2008) ranks the Tennessee Pigtoe as critically imperiled in Alabama, Mississippi, and North Carolina, imperiled in Tennessee and Virginia, and not ranked in Georgia. It is classified as Near Threatened by the IUCN. The range has been markedly reduced and the species is declining. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

Habitat alteration is the greatest threat to freshwater mussels in the southeastern U.S. (Neves et al. 1997). The habitat of the Tennessee Pigtoe has been severely impacted by alteration and inundation of river channels, siltation from agriculture and clear-cutting, and toxic run-off from coal mines (NatureServe 2008). Mussels in the Clinch and Powell watershed are threatened by coal mining and agricultural practices (U.S. EPA 2002). This species is also threatened by mountaintop removal coal mining in particular (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009). Virginia's Comprehensive Wildlife Conservation Strategy (2006) cites siltation, dredging, pollution, mining, water withdrawal, and impoundment as threats to aquatic species in the Southern Cumberlands. The North Carolina Wildlife Resources Commission (2010) reports that aquatic species in the Hiwassee River and Little Teneessee River basin, including the Tennessee Pigtoe, are threatened by erosion, sedimentation, impoundment, and increasing development. Mississippi's Comprehensive Wildlife Conservation Strategy (2009) reports that aquatic species in the Northeast Hills of the Tennessee River drainage, including this mussel, are highly threatened by agriculture, forestry, poor water quality, and operation of dams. The Alabama Dept. of Environmental Management (2003) reports that the Tennessee River basin has been widely degraded by nonpoint source pollution from many sources, particularly agriculture, urban development, logging, and surface coal mining (ADEM 2003). There are more than 130 confined animal feeding operations in the Tennessee River basin (ADEM 2003). Aquatic habitats in the basin are also degraded by water-related recreational activities and nonpoint source pollution from onsite residential sewage systems (ADEM 2003).

Disease or predation:

Neves and Odom (1989) cite muskrat predation as a threat to imperiled mussels in the North Fork of the Holston in Virginia, noting specific predation on the Tennessee Pigtoe.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechansims that adequately protect the Tennessee Pigtoe, and few occurrences of this mussel are appropriately protected and managed (NatureServe 2008). It is listed as Endangered by the State of North Carolina, and as a Species of Greatest Conservation Need in Alabama and Mississippi, and is a species of Special Concern in Virginia, but these designations do not provide the species with any substantial regulatory protection. It has no state status in Georgia or Tennessee. This species occurs on The Nature Conservancy's Pendleton Island Preserve, but the degree of habitat protection for this species at this site is "limited by inadequate protection from potential catastrophic threats within the watershed from upstream" (NatureServe 2008). It is unknown whether other populations occur within protected areas. ohnson et al. (2005) reported this mussel from the Hiwassee River inside and adjacent to Cherokee National Forest, Polk Co., Tennessee, but this confers little habitat protection. NatureServe (2008) provides the following management recommendations for this species: "All populations should receive protection through acquisition, easement, registry, and working with local, state, and federal government agencies on issues relating to development, water quality, river designation, etc. Management plans to control siltation and acid coal mine run-off are essential."

Other factors:

Any factor which degrades water qualilty is a threat to the Tennessee Pigtoe. NatureServe (2008) states that chemical and organic pollution have severely impacted this species, stating that management is necessary to protect water quality and to control siltation and acid coal mine run-off. Population isolation and low abundance of some populations heighten the susceptibility of this species to extirpation. The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996). Invasive species also threaten this mussel and its host fish. Several invasive species are known to be present in this mussel's habitat including blueback herring, Asian clam, striped bass, snail bullhead, rainbow trout, and brown trout (North Carolina Wildlife Resources Commission 2010).

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Scientific Name:
Fusconaia escambia
Common Name:
Narrow Pigtoe

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	EN - Endangered

Range:
The range of the Narrow Pigtoe encompasses 250-1000 square km in the Escambia River drainage in Alabama and Florida and the Yellow River drainage in Florida (Williams and Butler 1994, NatureServe 2008). Its historical distribution included the main channel of the Escambia River, in Escambia and Santa Rosa Counties in Florida, the Conecuh River in Escambia, Covington, Crenshaw, and Pike Counties in Alabama, and Murder Creek in Conecuh County, Alabama. This bivalve is known from the main channel of the Yellow River in Okaloosa County, Florida (Williams et al. 2000), but may be extirpated in the Yellow River system. The known range in the Escambia drainage was recently expanded based on surveys in which either live individuals or shell materials were encountered, and now includes Patsaliga Creek in Covington and Crenshaw Counties, Bottle Creek in Conecuh County, and Panther and Three Runs Creeks in Butler County, Alabama, all within the Escambia River drainage (FWS 2003).

Habitat:
This species is found primarily in the channels of small to medium-sized streams and rivers in sand, silty sand, gravel, or sandy gravel substrate in slow to moderate currents (Heard 1979, Deyrup and Franz 1994, Mirarchi et al. 2004). At least one population is known from a silty backwater area, and this species may occur in sloughs and river oxbows (NatureServe 2008).

Ecology:
The Narrow Pigtoe is a short-term brooder. Females are gravid in June and eggs and glochidia are red. Host fish species are unknown (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 6-80 populations of Narrow Pigtoe. There are 21-22 extant populations in the Escambia River drainage, and the species may be extirpated in the Yellow River drainage (Mirarchi et al. 2004, Williams et al. 2000, NatureServe 2008). All remaining populations of this species have low numbers of individuals, with an average of 3 surviving individuals per site (Williams et al. 2000). This species has questionable long-term viability, and it is unknown whether recruitment is occuring. If recruitment is occurring, it is likely low (USFWS 2003). Pilarczyk et al. (2006) reported newly detected populations of this species in the Choctawhatchee River drainage in southern Alabama (NatureServe 2008).

NatureServe (2008) estimates the total population size of Narrow Pigtoe to be 2500 - 10,000 individuals, but this is likely an overestimate. Williams et al. (2000) reported 65 individuals from 179 sites. Pilarczyk et al. (2006) reported two live individuals from Patsaliga Creek in the Choctawhatchee River drainage.

Population Trends:
The Narrow Pigtoe is declining in the short term and moderately declining in the long term (25-50 percent). Recent surveys show a 24 percent decline in historic range (29 historical sites), but this number does not reflect the loss of the species in an entire river basin. Within its limited range, this

species occurs in low abundance. This mussel is extirpated from the Yellow River drainage and is declining in the Choctawhatchee River drainage in Alabama and Florida (Pilarczyk et al. 2006, NatureServe 2008).

Status:

The Narrow Pigtoe is critically imperiled in Florida, and imperiled in Alabama (NatureServe 2008). It is listed as endangered by the IUCN. It is a federal Candidate species. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

NatureServe (2008) lists habitat loss and degradation as the most significant threat to the Narrow Pigtoe. Many land-use activities threaten the integrity of stream and river habitats by contributing to sedimentation and water quality degradation including highway and reservoir construction, improper forestry practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing. Sedimentation can kill mussels by deposition and suffocation (Ellis 1936, Brim Box and Mossa 1999) and can prevent or decrease the recruitment of juvenile mussels (Negus 1966, Brim Box and Mossa 1999). Suspended sediment interferes with feeding (Dennis 1984). Many of the confirmed extant populations of Narrow Pigtoe are near highway and unpaved road crossings. Highway and bridge construction and maintenance could negatively affect populations of Narrow Pigtoe due to erosion and sedimentation. Reservoir construction and the resultant habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can negatively impact mussel populations (Neves et al. 1997). This mussel's habitat is also degraded by nutrient input such as phosphorus and nitrogen emanating from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Narrow Pigtoe. This mussel is currently a Federal Candidate species in dire need of Endangered Species Act protection. It is a Priority 1 Species of Greatest Conservation Need in Alabama, but this designation provides no regulatory protection. It is not listed by the state of Florida. NatureServe (2008) states that few (1-3) occurrences are appropriately protected, noting that at least one occurrence may border the Conecuh River in Alabama, but the sites are largely unprotected. NatureServe (2008) also notes the inadequacy of existing regulatory mechanisms to reduce non-point source pollution impacts, particularly in terms of sedimentation in small stream drainages. Some efforts have been made to work with private landowners to encourage the use of Best Management Practices to protect water quality (FWS 2003, NatureServe 2008).

In addition to consideration of federal listing, NatureServe (2008) provides the following management recommendations for this species: "Protect populations through acquisitions and easements by working with government agencies and conservation organizations; establish buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; maintain high water and benthic habitat quality; consider propagation and reintroduction of cultured stock."

Other factors:

Several other factors imperil the Narrow Pigtoe. This species is particularly vulnerable to catastrophic events because populations are generally small and geographically isolated. Any factor which negatively affects host fish populations is detrimental for the Narrow Pigtoe. This species is potentially negatively affected by invasive species such as the Asiatic clam, zebra mussel, and black carp (USFWS 2003, NatureServe 2008). In addition, this mussel is threatened because some populations may be below the effective population size to maintain long-term viability (NatureServe 2008).

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Scientific Name:
Fusconaia masoni
Common Name:
Atlantic Pigtoe

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	EN - Endangered

Range:
The range of the Atlantic Pigtoe is now highly reduced as the majority of populations in large river mainstreams have been extirpated, and the mussel is now limited to headwater areas in the drainages where it still exists (NatureServe 2008).

This species once ranged from the Ogeechee drainage in Georgia north to the James River drainage in Virginia (Bogan 2002). In Georgia, populations in the Ogeechee system have been reduced to Jefferson and Jenkins counties, and these populations are likely not viable (Sukkestad et al. 2006, NatureServe 2008). In South Carolina, the species has not been detected in the Savannah drainage in over a century, and its status in the Pee Dee drainage in South Carolina is unknown (Bogan and Alderman 2004, NatureServe 2008). In Virginia, the Atlantic Pigtoe still occurs in the Upper and Middle James, Nottoway, Appomatox, Lower Dan, Meheriin, Rivanna, and Upper Roanoke systems. In North Carolina, this mussel has been extirpated in Northampton County and from the Deep River in Moore County, Cape Fear River in Harnett and Cumberland Counties, and Black River in Sampson, Bladen, and Pender Counties (Bogan 2002, LeGrand et al. 2006, NatureServe 2008). It still occurs in North Carolina in the Catawba, Pee Dee (including Goose Creek), Cape Fear, Neuse, Pamlico, and Roanoke River basins, in Bladen, Caswell, Chatham, Curham, Edgecombe, Franklin, Granville, Halifax, Harnett, Johnston, Montgomery, Moore, Nash, Orange, Pender, Person, Pitt, Randolph, Sampson, Union, Wake, Warren, Wayne, and Wilson counties (Bogan 2002, LeGrand et al. 2006, NatureServe 2008).

Habitat:
The Atlantic Pigtoe is dependent on clean, fast flowing water with high dissolved oxygen content in riverine or larger creek environments. Because this species prefers more pristine conditions, it typically occurs in headwaters and rural watersheds. It is associated with gravel and coarse sand substrates at the downstream edge of riffles, and less commonly occurs in cobble, silt, or sand detritus mixtures (Adams et al. 1990, Bogan and Alderman 2004, NatureServe 2008).

Ecology:
The ecology of the Atlantic Pigtoe has not been studied, but based on its drastically reduced range, this mussel is likely negatively affected by reduced water quallity, altered flow regimes, euthrophication, siltation, and pollution (NatureServe 2008).

Populations:
The Atlantic Pigtoe was once widespread, but now exists in fewer than 20 populations, having experienced a large reduction in range, numbers and extent. The total population size for this species is unknown (NatureServe 2008).

Population Trends:
The Atlantic Pigtoe has undergone a very rapid population decline of 50-70 percent in the short term, and has also declined substantially over the long term, from 50-75 percent. In most historic large river habitats, populations have either been extirpated or are highly reduced. The species was once found in

every Atlantic drainage in North Carolina except for two, but has been reduced to only six basins (Johnson 1970, Bogan 2002, NatureServe 2008). In Georgia the species is either extirpated or nonviable (Sukkestad et al. 2006). The species may also be extirpated in South Carolina (Bogan and Alderman 2004, NatureServe 2008).

Status:
NatureServe (2008) ranks the Atlantic Pigtoe as critically imperiled in Georgia and North Carolina, imperiled in Virginia, and its status in South Carolina has not been determined. It is ranked as Endangered by the IUCN. Both range and population size for this species have been highly reduced, with most extant populations harboring only a few individuals (NatureServe 2008). It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Habitat loss and degradation is the greatest threat to the Atlantic Pigtoe. This species depends on clean, fast-flowing water with high dissolved oxygen content and is thus negatively affected by impoundments, alterations in flow regime, and water pollution. Augspurger et al. (2003) found that the glochidia of this mussel are especially sensitive to pollution. High intensity land use, point and non-point source pollution, siltation, and eutrophication all threaten the continued existence of this species (NatureServe 2008). This mussel is specifically threatened by reduced water quality due to logging (NatureServe 2008). Because mussels are dependent on host fishes for reproduction, any factor which threatens the Atlantic Pigtoe's host fish threatens the survival of the mussel. In Georgia, the Dept. of Natural Resources reports that this species is threatened by development and timber removal in the Ogeechee River basin, excessive sedimentation from development and agriculture, and eutrophication and degraded water quality from poor agricultural practices (Wisniwewsi 2008). The Virginia Dept. of Game and Inland Fisheries (2010) reports that the Atlantic pigtoe is threatened by habitat fragmentation from agriculture and municipal development, sediment load and turbidity alteration from agriculture and forestry, and hydrologic regime alteration from municipal development.

Inadequacy of existing regulatory mechanisms:
Existing regulatory mechanisms are inadequate to protect the Atlantic Pigtoe which has declined precipitously and is in dire need of protection. This mussel is state listed as endangered in South Carolina where historical populations may no longer be extant (Bogan and Alderman 2004, NatureServe 2008). It is listed as endangered in the state of Georgia, but this designation does not confer substantial regulatory protection for the species' habitat. Riparian lands purchased to mitigate adverse effects to mussels on sections of Turkey and Moccasin creeks in North Carolina may provide the species with some habitat protection, but it lacks meaningful protective status throughout its range.

Other factors:
Factors which degrade water quality and contribute to pollution threaten the Atlantic Pigtoe including point and non-point contamination, siltation, eutrophication, and alterations in flow regime (NatureServe 2008). The Virginia Dept. of Game and Inland Fisheries (2010) reports that the Atlantic pigtoe is threatened by insecticides from agriculture and municipal development. Because mussels are dependent on host fishes for reproduction, any factor which threatens the Atlantic Pigtoe's host fish threatens the survival of the mussel (Neves et al. 1997).

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Scientific Name:
Fusconaia rotulata
Common Name:
Round Ebonyshell

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	EN - Endangered

Range:
The Round Ebonyshell has one of the most restricted ranges of any North American mussel. The total historical range of this species is approximately 95 km, and the extant range is 43 km. It is endemic to the Apalachicolan region and is restricted to the main channel of the Escambia/Conecuh River in Florida and Alabama, where it is known from east Brewton, Escambia County, Alabama (Conecuh River), downstream for a distance of approximately 75 river km, with no known occurrences in tributaries (Williams and Butler 1994, Johnson 1967, NatureServe 2008). The historical range of the Round Ebonyshell was recently expanded, based upon the detection of relict shells, to include the Conecuh River from the junction with the Sepulga River, Escambia County, Alabama, downstream in the Escambia River to Bluff Springs, Escambia and Santa Rosa Counties, Florida for a total historic range of approximately 95 km (59 river miles B RM) (USFWS 2003, Williams et al. 2000).

Habitat:
The Round Ebonyshell occurs in moderate current in areas of sand and gravel substrate (Williams and Butler 1994, Mirarchi et al. 2004).

Ecology:
This species is presumed to be a short-term brooder based on characteristics of its congeners. Host fishes are unknown (Mirarchi et al. 2004).

Populations:
There are three remaining populations of Round Ebonyshell, which consist, on average, of two live individuals per population. Only 3 of 9 historic locations contain living mussels. It is not known whether remaining populations are capable of reproduction and recruitment (USFWS 2003, NatureServe 2008). NatureServe (2008) estimates total population size of this species at 50 - 1000 individuals.

Population Trends:
The Round Ebonyshell is declining very rapidly (decline of 50-70 percent) in the short term and substantially declining (decline of 50 - 75 percent) in the long term (NatureServe 2008). There are three remaining sites which support an average of two individuals each.

Status:
The Round Ebonyshell is critically imperiled in Florida and Alabama (NatureServe 2008). It is a Federal Candidate and is likely to become extinct on the candidate list waiting for full protection as there are only three extant populations supporting roughly two individuals each. This mussel is in critical need of immediate ESA protection. It is ranked as endangered by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
The Round Ebonyshell is particularly susceptible to extinction from habitat degradation based on its limited distribution and rarity (Mirarchi et al. 2004). It occurs only in a small stretch of a

single river, and NatureServe (2008) describes this river as "one of the most degraded in Florida." NatureServe (2008) states that habitat modification is the most significant threat to this species. A single habitat destroying event could drive this species to extinction. It is threatened by activities which degrade water quality (eg. eutrophication, sedimentation) including road building and maintenance, logging, agricultural and municipal runoff, urbanization, and livestock grazing.

Overutilization:
Any level of collection would have dire consequences for this species since so few individuals remain.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Round Ebonyshell, and no occurrences are appropriately protected and managed, with all known populations occurring in an unprotected reach of the Conecuh/Escambia River (NatureServe 2008). It is a Priority 1 Species of Greatest Conservation Concern in Alabama, but this designation does not afford the mussel with any regulatory protection. It is not state-listed in Florida. This species is currently a Federal Candidate and should be immediately listed to prevent extinction.

NatureServe (2008) provides the following management recommendations for the Round Ebonyshell: "Strongly consider federal listing as endangered; propagate for culture/future reintroduction. Protect populations through acquisitions and easements by working with government agencies and conservation organizations; establish buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; maintain high water and benthic habitat quality. Conservation activities have been limited to working with private landowners in south Alabama and west Florida to encourage the use of Best Management Practices to reduce the effects of agriculture and silviculture (see U.S. Fish and Wildlife Service, 2003)."

Other factors:
The Round Ebonyshell is threatened by several other factors. Because there are only three extant populations, all or which are small and isolated, this species is particularly vulnerable to catastrophic events. Remaining populations may be below effective population size to maintain long-term genetic viability. This mussel is potentially threatened by invasive species such as Asiatic clam, zebra mussel, and black carp (USFWS 2003, NatureServe 2008). Any factor which threatens host fishes also threatens the Round Ebonyshell (NatureServe 2008).

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Scientific Name:
Fusconaia subrotunda
Common Name:
Longsolid

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The longsolid is a relatively large freshwater mussel native to the eastern United States; it is found in Alabama, Arkansas, Georgia, Illinois, Indiana, Kentucky, North Carolina, Ohio, Pennsylvania, Tennesssee, Virginia, and West Virginia (NatureServe 2008). It is known from the Detroit River, Lake Erie, the Ohio River drainage from Pennsylvania downstream to Illinois and Kentucky, the Cumberland River drainage downstream of the falls, and the Tennessee River drainage (Williams et al. 2008).

Habitat:
It is found in large and medium-sized rivers with moderate or fast flow gradients, and prefers sand or gravel substrate (Watters 1995, Cicerello and Schuster 2003).

Ecology:
Reproduction is similar to that of other freshwater mussel species, but glochidial hosts are currently unknown (NatureServe 2008). Juveniles (glochidia) are parasitic on their hosts, and adults filter feed on detritus in the water column. This species is not migratory: adults are essentially sessile, though may be moved downstream by water currents. The longsolid is highly sensitive to water pollution, siltation, or other disturbance to habitat, and to the loss of glochidial hosts (NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are 6-20 elemental occurrences of this species, and total population size is estimated at 1000-2500 individuals.

Once widely distributed across the Ohio River drainage, this mussel is now found only in the Muskingum River and parts of the upper Tennessee and Cumberland River drainages in Ohio, and is considered rare. It is known from the Hiwassee and French Broad Rivers (Bogan 2002), and from Cherokee, Clay, and Transylvania Counties (LeGrand et al. 2006) in North Carolina, and is extirpated from Buncombe County. In Tennessee, it is reported from the Clinch, Powell, Elk, lower Tennessee, and Cumberland Rivers, occasionally from the Holston, Tellico and Hiwassee Rivers, and is likely extirpated from the Little Tennessee (Parmalee and Bogan 1998). In Alabama, it remains only in the Tennessee River tailwaters of the Guntersville and Wilson dams, and in the Paint Rock River (rare in all locations), though it was once present in reaches of the Tennessee, Cumberland, and Ohio River (Mirarchi et al. 2004, Williams et al. 2008). Kentucky's populations are patchily distributed in the lower Green River (Cicerello and Schuster 2003), and in the middle Green and Barren Rivers (Cochran and Layzer 1993). In Pennsylvania, the longsolid is found in Muddy Creek, and in the Connoquenessing and middle Allegheny-Tionesta, though it was once widespread throughout the state (PA NHP pers. comm. as cited in NatureServe 2008). Remnant populations are known in Copper Creek and the upper Clinch River in Virginia (Fraley and Ahlstedt 2000, Jones et al. 2001). This species is believed extirpated from Indiana (Fisher 2006) and from Illinois (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the longsolid has experienced long-term decline of up to 75 percent, and that this mussel has declined in the short-term by up to 30 percent. It is extirpated from many historical locations.

Status:
NatureServe (2008) lists the longsolid as critically imperiled in Alabama, North Carolina,and Pennsylvania, imperiled in Arkansas and West Virginia, and vulnerable in Kentucky, Tennessee, and Virginia. It is reportedly extirpated from Illinois and Indiana, likely extirpated from Georgia, and its status is under review in Ohio. It is state-listed as endangered in Ohio and Indiana, threatened in West Virginia, and of special concern in Kentucky and Virginia. The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that this mussel is vulnerable to critically imperiled in over 90 percent of its global range. Its rank is being changed from special concern (Williams et al. 1993) to threatened by the American Fisheries Society (draft 2010, in review).

Habitat destruction:
Numerous sources report that longsolid is threatened by habitat loss and degradation caused by impoundments, dredging, gravel and sand quarrying, agriculture, development, and coal mining (U.S. EPA 2002, Kentucky Dept. of Fish and Wildlife Resources 2005, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the longsolid: though some populations occur in ostensibly protected sanctuaries or natural areas, it is not possible to exclude the impacts of upstream impoundments, pollution, dredging, or other harmful activity from these areas. NatureServe (2008) reports that no occurrences of this species are adequately protected. Though it is listed as endangered, threatened, or of special concern in several states (Ohio, Indiana, West Virginia, Kentucky, Virginia), these state-level designations afford the longsolid no substantial regulatory protection.

Other factors:
The longsolid is threatened by water pollution from agriculture, coal mining, urban runoff, and confined animal feeding operations (U.S. EPA 2002, Kentucky Dept. of Fish and Wildlife Resources 2005, NatureServe 2008). It is also potentially threatened by invasive bivalves, such as the zebra mussel (NatureServe 2008). Many populations of this species are now isolated and have very low abundance, which diminishes their genetic viability.

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Scientific Name:
Gomphus consanguis
Common Name:
Cherokee Clubtail

G Rank:
G3

IUCN Status:
EN - Endangered

Range:
This dragonfly is recorded from Virginia, Tennessee, Georgia, Alabama and North Carolina. It is known from the SE highlands area from SW Virginia to NE Alabama, plus one locality in the western Piedmont of North Carolina (Roble 1997).

Habitat:
The Cherkoee clubtail inhabits small, spring-fed streams (usually first or second order) with sand, gravel and fine detritus substrate in partly shaded to open areas. Adults and larvae are often concentrated in mud-bottomed sections of these streams (NatureServe 2008). G. consanguis requires high water quality, and its habitats are usually spring-fed (NatureServe 2008).

Populations:
NatureServe (2008) estimates 21 - 80 populations with fewer than 1000 individuals of this species. There are probably not more than 50 adults at any time in most populations, but this species may have a two-year larval stage (Carle in Terwilliger 1991).

In Georgia, this species is known from nine streams in the extreme northwestern part of the state (Beaton, 2007b). It is rare and locally uncommon and occurs in Chattooga, Floyd, and Walker counties (Mauffray and Beaton, 2005). In Alabama, this species is rare and only known from Blount and St. Clair counties (Tennessen et al., 1995). In North Carolina, known from Burke and Davie counties (LeGrand et al., 2006). In Tennessee, known from Sullivan County (TN Natural Heritage Program, 2008) and Meigs and McMinn counties (Hopper and Tennessen, 2007). In Virginia there are 9-10 occurrences (Roble, 1997). There are 3 occurrences in Washington County and 6 occurrences in Scott County (VA Natural Heritage Program, 2008). Surveys in Virginia (Stevenson and Roble, 1995; Roble, 1996, 1997) suggest that this species is considerably more common than previously (e.g., Carle in Terwilliger, 1991; Morse et al. in Benz and Collins, 1997) believed. Tennessen and Hopper (2007) found G. consanguis in two counties in eastern Tennessee (McMinn and Meigs) in 2004-2005. There are probably several dozen more populations to be discovered elsewhere within the current known range.

Population Trends:
NatureServe (2008) reports a short-term decline of 10-30 percent. It is probably declining due to habitat loss and degradation, but may be stable. Apparently the species is tolerant of some organic pollution.

Status:
This species is listed as Endangered by IUCN (Odonata Specialist Group, 1996), and it was a Federal C-2 Candidate Species until that list was abolished. The Cherokee clubtail is listed as Threatened in the State of Georgia (Ga. Comp. R. & Regs. r. 391-4-10-.09 2009).

According to Tennessen and Hopper (2007), “Dunkle (2004) rated G. consanguis as a species of conservation concern, stating that it occurs in ‘rather pristine spring fed streams’ and appears to be sensitive to watershed disturbance."

NatureServe (2008) ranks this species as critically imperiled in Alabama (S1S2), Georgia (S1S2), North Carolina (S1S2), and Tennessee (S1), and imperiled in Virginia.

Habitat destruction:

Although this dragonfly is tolerant of some organic pollution, its habitat faces numerous threats across its range.

NatureServe (2008) indicates that part of one Tennessee stream is used as a fish hatchery. Other streams where this species occurs are subject to agricultural pollution, and spring-fed habitats are subject to developmental usage and pollution. NatureServe also reports that the headwaters of some streams are degraded by cattle grazing.

Tennessen and Hopper (2007) report that "[t]he streams in which the species was found are impacted by farm operations, and population numbers appear to be low. … The streams surveyed in this report are not pristine. Evidence indicates that logging, road building, farming practices, and cattle waste continue to impact the watersheds. It is highly likely that population numbers were higher prior to settlement and development of this area, but without historical data, it is not possible to assess the degree of impact. The new records fill a gap in knowledge of the distribution of G. consanguis, but the low population numbers indicate its status as rare should not be changed. "

The Cherokee Clubtail is threatened by a proposed quarry near Alabaster, Alabama. The threats the quarry poses, according to the University of Montevallo, are water cycle changes that would dry up the swamp; accelerated sinkhole development in the surrounding area; and increased downstream flooding. Mike Hardig, UM associate professor of biology, warns that "a limestone quarry in this location will have widespread and profound effects on the ecology of the region. It will adversely impact the local flora and fauna as well as the people that live in the area" (Wilstach 2005).

This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Individuals of G. consanguis and its habitat were likely impacted by the Tsali Forest Health Project on the Cheoah Ranger District of the Nantahala National Forest (USFS 2001a).

G. consanguis is found near Beaver Creek and Clear Creek Reservoirs in Tennessee, managed by the Tennessee Valley Authority (TVA 2009a). The TVA Index of Biotic Integrity Scores for Beaver Creek Reservoir has been poor every year since 1995, and for Clear Creek Reservoir it has been fair or poor.

It also occurs near South Holston Reservoir in Tennessee and Virginia, where the Benthic

Community Assemblage scores have been poor every year since 2000 in both the forebay and the transition zone, except for 2006 when the transition zone was Fair (TVA 2009b).

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that there are no currently protected sites occupied by this species. One site in Virginia is likely to be purchased by the state in the near future (1999-2000) but the headwaters of this stream will continue to be impacted by grazing cattle. Gomphus consanguis is a U.S. Forest Service Sensitive Species on the Cherokee National Forest (USFS 2001b) and is found on the Nantahala National Forest (USFS 2001a), but protection provided to Sensitive Species is discretionary. In 2001The Nature Conservancy bought The Cleveland Barrens in Russell County, VA, including habitat for G. consanguis, and donated it to the State of Virginia (Bowman 2000).

Other factors:

The invasive Hemlock Woolly Adelgid may impact individuals of G. consanguis (USFS 2005).

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Scientific Name:
Gomphus sandrius
Common Name:
Tennessee Clubtail

G Rank:
G1

IUCN Status:
EN - Endangered

Range:
This dragonfly is known from six streams, all northern tributaries of the Duck River in the southern one-third of the Inner Basin of the Central Basin of south-central Tennessee (NatureServe 2008). It occurs in a 60 square mile area within three counties.

Habitat:
G. Sandrius is found in slow streams with limestone substrate (NatureServe 2008). Larvae burrow in silt behind rocks or clumps of water willow, while adults forage in fields.

Populations:
G. sandrius is known from six streams. There are probably hundreds to thousands on each stream, with a total estimated population of at least 2500 adults.

Population Trends:
Tennessen (1994), based on anecdotal evidence, thought the population had decreased by 25-50 percent in ten years.

Status:
NatureServe (2008) ranks this species as critically imperiled. IUCN (2010) now considers this species Vulnerable. It was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
This species is threatened by agriculture including pesticide run-off, organic pollution, and cattle trampling of banks (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

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Scientific Name:
Gomphus septima
Common Name:
Septima's Clubtail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
Septima's clubtail is a river-breeding dragonfly endemic to the mid-Atlantic and southeastern United States; populations are disjunctly distributed in New Jersey, New York, North Carolina, and Alabama (NatureServe 2008, Krotzer 2002). Natural heritage records place this species in Chatham, Harnett, Lee, Moore, Stanley, Union, and Wake Counties in North Carolina (extirpated from Durham County), in Mercer, Sussex and Warren Counties in New Jersey, and in New York's Sullivan County. It is currently known from roughly 16 rivers, the majority in North Carolina (NatureServe 2008).

Habitat:
This clubtail is present only in rocky sites with high water quality (well-oxygenated, rapid current) over gravel substrate, often in areas with silt or muddy reaches (NatureServe 2008, IUCN 2007). It is found in inland wetlands and permanent streams, rivers, and creeks (IUCN 2007).

Ecology:
Adults are diurnally active and feed on invertebrates, foraging both from the ground and from trees. Juveniles overwinter in their larval form, emerging in May and June (NatureServe 2008).

Populations:
This dragonfly is known from approximately 16 rivers. The Delaware River population could count as four occurrences, but additional surveys may link these occurrences into one continuous occurrence. Total population size is unknown (NatureServe 2008).

Population Trends:
Septima's clubtail has declined by up to 30 percent in the short-term, and up to 50 percent in the long-term (NatureServe 2008). This species has been extirpated from several sites in North Carolina (North Carolina Dept. of Environment and Natural Resources 2001).

Status:
NatureServe (2008) reports that this species is critically imperiled in New Jersey, New York, Alabama, and North Carolina, and not yet assessed in Tennessee and Virginia. It is considered a species of special conservation concern across most of its range, and is a former candidate for federal protection.

Habitat destruction:
Loss and degradation of habitat is a primary threat to this dragonfly (Hudsonia Environmental Research Institute 2010, NatureServe 2008). The New York State Dept. of Environmental Conservation (2005) reports that this species is threatened by changes in the natural hydrology such as the building of dams, and increases in sediment loads resulting from logging, agriculture, and other activities. The type locality of the subspecies of this species was destroyed by the construction of a dam (Bick 2003). The damming of rivers is an ongoing threat to this species (Abbott 2007 in IUCN 2008).The Laurel Bluffs North Carolina site on the Rocky River is threatened by runoff from a large agricultural field that extends to the river with no riparian buffer

(Chatham County Planning Dept. 2010). This dragonfly is also threatened by development (NatureServe 2008). Populations are also fragmented and isolated by changes in habitat quality, which contributes to declines in long-term viability.

Overutilization:

This species is sought by dragonfly collectors, as evidenced by this blog account of a collector actively seeking this species:

"Weather is always a major factor in any dragonfly collecting trip . . . My target was Septima's Clubtail, Gomphus septima, a fairly large, dully marked species that I had originally planned to look for on my return trip through North Carolina. Giff and Steve Krotzer had seen them on the Cahaba River just a few days before . . . Later I did find my Septima's Clubtails (males are very wary) then headed back east" (Accessed March 31, 2010 at: http://homepage.mac.com/edlam/dragonflyroad/5_07SE.html).

The extent to which collecting affects populations has not been assessed, but given the rarity of this species, and in conjunction with other threats such as pollution and habitat loss, collecting could increasingly threaten this dragonfly.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that few occurrences are appropriately protected or managed: the Delaware population occurs within the Delaware River National Recreation Area, and the Little Cahaba River population in Alabama is on a Nature Conservancy preserve (Krotzer 2002).

No existing regulatory mechanisms adequately protect the Septima's clubtail; though it is considered a species of special conservation concern in much of its range, this designation offers the clubtail no substantial regulatory protection.

Other factors:

Septima's clubtail is limited to areas of high quality water, and is thus threatened by pollution (Abbott 2007 in IUCN 2008). The New York State Dept. of Environmental Conservation (2005) reports that this species is threatened by changes in dissolved oxygen content, direct effects of pesticides, and chemical contamination. The Laurel Bluffs North Carolina site on the Rocky River is threatened by agricultural run-off and wastewater treatment effluent (Chatham County Planning Dept. 2010). Chemical pollution can kill larvae and adults directly and can negatively impact both life stages by reducing prey availability. Mosquitoes and blackflies are important food sources for dragonflies, and spraying to control these pests may greatly reduce available food in any given location (Hudsonia Environmental Research Institute 2010). Adult dragonflies can be killed by collisions with vehicles, which can negatively impact small populations in areas of limited habitat availability (Hudsonia Environmental Research Institute 2010).

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Scientific Name:
Gomphus westfalli
Common Name:
Westfall's Clubtail

G Rank:
G1

Range:
The entire range of Westfall's clubtail in Florida is only about 25 km in diameter (Deyrup and Franz 1994). This dragonfly is known from only four streams in Santa Rosa County within or near the Blackwater River State Forest. Westfall's clubtail could possibly be a subspecies of G. diminutus , and the Center is hereby petitioning for either the species of the subspecies, should it be validated.

Habitat:
G. westfalli is associated with sphagnum-bog trickles and streams (Deyrup and Franz, 1994). Larvae burrow in silt, and adults forage in open forest near ground level. Surrounding habitat needs periodic burning, which should not be done during the spring flight season. Larvae require acidic slowly moving water (NatureServe 2008).

Populations:
G. westfalli is known from only four streams in Santa Rosa County within or near the Blackwater River State Forest (NatureServe 2008). It is estimated that there are hundreds of individuals on each stream.

Population Trends:
NatureServe (2008) reports that this species is stable in the short term, based on the assumption that state forest habitat is being properly managed for this species.

Status:
NatureServe (2008) ranks this species as critically imperiled. IUCN categorizes it as Vulnerable (Abbott 2007). It was also a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
Excessive clear-cutting is a threat to this species (NatureServe 2008). This species requires patches created by fire, and is potentially threatened by altered fire regime or by prescribed fires if conducted in the wrong season.

According to Abbott (2007): "Gomphus westfalli is in greater jeopardy than previously believed; although this insect is locally abundant, the entire known range is encompassed within a radius of a few kilometers. At present the future of the species must be considered highly uncertain (Carle and May 1987). Bick (2003) indicated that the total range of this species is very likely the smallest of any U.S. Anisopteran. The species is known from only four streams, but most populations are within a state forest and so could be fairly well protected/managed. The assessment is based on its restricted range, with less than five known locations, and the potential threat of deforestation."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that most populations of G. westfalli are within Blackwater State Forest so could be fairly well protected/managed. There are no data, however, to indicate that the forest is being appropriately managed to accommodate this species, which is threatened by clearcutting and requires appropriate fire regime. No existing regulatory mechanisms protect this dragonfly.

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Scientific Name:
Graptemys barbouri
Common Name:
Barbour's Map Turtle

G Rank:
G2

IUCN Status:
NT - Near threatened

Range:
Barbour's Map Turtle occurs in Florida, Georgia, and Alabama (NatureServe 2008). It principally occurs in the Apalachicola River system in the panhandle of Florida and in adjacent Georgia and Alabama, including the Flint River up to Lack Blackshear, the Chattahoochee River up to Russell County, and Chipola rivers and tributaries. It was recently detected in the Ochlockonee River, but this could have resulted from introduction (Enge et al. 1996). There is an erroneous record from the Escambia River (Sanderson and Lovich 1988, Lovich and McCoy 1992). There are Pleistocene fossils of this turtle from the Santa Fe River in Florida (NatureServe 2008).

Habitat:
This turtle is associated with relatively wide, clear streams with swift currents and abundant snags and downed trees, often in areas with exposed limestone. It is found in alluvial and spring-fed rivers and tributaries in areas that support its mollusk prey. At night it uses submerged limbs just below the water's surface for resting. During cold periods, it rests in limestone substrate depressions. Eggs are buried in sand at the water's edge. Like many turtles, Barbour's Map Turtle uses logs for basking (NatureServe 2008).

Ecology:
Barbour's Map Turtles prey primarily on snails and bivalves and also consume aquatic insects, particularly caddisfly larvae. Ashton and Ashton (1985) reported that this turtle's home range consists of only a few hundred square yards. Females may not become sexually mature until age 15 or older. Clutch size ranges from 4 to 11 eggs which are deposited on sandbars or on the riverbank. Multiple clutches may be produced annually.

Populations:
There are fewer than 20 populations of Barbour's Map Turtle, but the exact number of elemental occurrences is difficult to determine as all individuals within a river system potentially interbreed. Total population size is unknown and is estimated at 1000-10,000 individuals, with a few thousand individuals considered likely (NatureServe 2008). It is scarce in some parts of its range, such as the Chattahoochee, and fairly abundant in others. In the Apalachicola, Flint, and Chipola rivers it is relatively common, with more than 12 turtles being detected per mile. Updated population data are needed due to increasing threat from collection.

Population Trends:
Based on survey data from the 1990's, Barbour's Map Turtle has experienced moderate decline. Decline in Florida has been suggested but is undocumented, and available data more strongly suggest decline in Georgia (P. Moler, pers. comm., 1995, cited in NatureServe 2008).

Status:
Barbour's Map Turtle is imperiled (S2) in Alabama, Florida, and Georgia (NatureServe 2008). It is classified as Near Threatened by the IUCN. It is a State Protected species in Alabama, a Species of Special Concern in Florida, and is listed as Threatened by the State of Georgia.

Habitat destruction:
Habitat loss and degradation resulting from channelization, dredging, and pollution are known threats for Barbour's Map Turtle (NatureServe 2008). The Georgia Dept. of Natural Resources also reports that habitat degradation resulting from impoundment is a threat to this species (http://georgiawildlife.dnr.state.ga.us/assets/documents/gnhp/graptemys_barbouri.pdf). This turtle is dependent on a healthy molluscan prey base for survival, and its mollusk prey are also threatened by siltation and water quality deterioration resulting from dredging, channelization, impoundment and pollution (NatureServe 2008). According to the Georgia Dept. of Natural Resources (GDNR), anthropogenic impacts have slowed water flow, altered water quality conditions, and drastically reduced the native molluscan prey base. Removal of trees and snags for navigability also threatens this turtle by reducing the availability of basking sites (GDNR). This turtle is also threatened by collisions with barge traffic (NatureServe 2008).

Overutilization:
Overutilization is a dire threat for Barbour's Map Turtle. Despite some legal restrictions, this turtle is harvested for meat, collected for the pet trade, and snagged and killed on trotlines and bush hooks intended for other targets (NatureServe 2009, GDNR 2009). Recreational shooting also threatens the Barbour's Map Turtle (GDNR 2009). Collection exacerbates the threat this species already faces from habitat loss. Overutilization contributes to localized declines and extirpations and is pushing this restricted-range species closer to extinction. Reed and Gibbons (2003) report that nearly 1,200 Barbour's Map Turtles were declared as exported from 1996-2000, at least 800 of which were wild-caught. This does not include the number of unreported and illegally harvested turtles. Schlaepfer et al. (2005) argue that the status of map turtles is so dire that the trade in wild-caught animals should be halted or severally reduced due to the level of export and life-history characteristics that make them particularly vulnerable to overharvesting. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).

Disease or predation:
Proliferative shell disease is a known threat for Barbour's Map Turtle (Society for the Study of Amphibians and Reptiles 2009, http://www.ssarherps.org/pages/stateconservation.php). The Flint River population of this species is also threatened by a sometimes fatal disease of unknown etiology (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this species. It is a Species of Special Concern in Florida. NatureServe (2008) reports that no occurrences are appropriately

protected and managed. Despite some state protections against take, this turtle is illegally harvested for meat and for the pet trade, is intentionally shot, and is accidentally trapped on lines set for other species. Schlaepfer et al. (2005) state that map turtles are not adequately protected against overcollecting despite their current legal status under CITES. This species is in dire need of Endangered Species Act protection.

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Scientific Name:
Graptemys ernsti
Common Name:
Escambia Map Turtle

G Rank:
G2

IUCN Status:
NT - Near threatened

Range:
The Escambia Map Turtle is found only in the Pensacola (Escambia) Bay drainage (NatureServe 2008). It occurs in the Conecuh, Escambia, Yellow, and Shoal rivers in southern Alabama and western Florida (Lovich and McCoy 1992, 1994).

Habitat:
This turtle uses medium to large rivers that have more alluvial than blackwater characteristics (Lovich and McCoy 1992). It is also frequently detected in small streams. It requires basking sites and beaches with fine sand for nesting. It does not occur in rivers that do not support its freshwater mollusk prey and also avoids salt waters, rarely occurring within a mile of the river mouth (NatureServe 2008).

Populations:
There are fewer than five populations of Escambia Map Turtle, with this turtle only occurring in two river systems, both of which drain into a single bay, making elemental occurrences difficult to determine. Data are lacking on total population size, but it is estimated that there are several thousand individuals (NatureServe 2008).

Population Trends:
The population trend for this turtle is thought to be stable, but due to recent collection pressure, surveys are needed to confirm stability (NatureServe 2008).

Status:
The Escambia Map Turtle is Imperiled in Alabama and Florida (NatureServe 2008). It is a State Protected species in Alabama. It is categorized as Near Threatened by the IUCN.

Habitat destruction:
This turtle is threatened by habitat loss and degradation due to channelization, impoundment, and removal of snags which are required for basking (NatureServe 2008, Buhlmann and Gibbons 1997). It is also threatened by any factor that reduces habitat suitability for its molluscan prey, as it is absent from streams that lack mollusks (NatureServe 2008). The Florida Wildlife Conservation Commission reports that this species' stream habitats are highly threatened by fragmentation, altered hydrologic regime, and sedimentation (http://myfwc.com/docs/WildlifeHabitats/Legacy_Softwater_Stream.pdf). The Army Corps of Engineers (2006) reports that this turtle is threatened by habitat loss due to urbanization encroachment (http://www.crrel.usace.army.mil/library/technicalreports/ERDC-TR-06-4.pdf).

Overutilization:
Overutilization is a primary threat for the Escambia Map Turtle. The majority of adult mortality is attributable to trapping, shooting, and commercial collection (NatureServe 2008). Currently this species is legally allowed to be taken with a possession limit. Schlaepfer et al. (2005) argue that the status of map turtles is so dire that the trade in wild-caught animals should be halted or severally reduced due to the level of export and life-history characteristics that make them particularly vulnerable to overharvesting. Studies have shown that the removal of long-lived, slow-growing animals with life

history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).
The Florida Turtle Conservation Trust (2008) suggests that due to the broad range of conservation challenges this species faces, legal take should be eliminated and enforcement programs should be developed.

Disease or predation:
This species is preyed upon by alligator snapping turtles (NatureServe 2008). In conjunction with other threats, natural predation could increasingly threaten this species. Nest predation has been reported in excess of 90 percent (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this species (NatureServe 2008). The Yellow River forms the boundary of Eglin Air Force Base, but this does not assure habitat protection. It has no status in Florida. It is state-listed in Alabama, but this designation conveys no habitat protection. Schlaepfer et al. (2005) state that map turtles are not adequately protected against overcollecting despite their current legal status under CITES. Due to recent commercial collection pressure, this species is in dire need of Endangered Species Act protection.

Other factors:
This turtle is threatened by water pollution, particulary heavy metal pollution. Because of its dependence on molluscan prey, it also threatened by any form of pollution which harms freshwater mollusks, including siltation (Buhlmann and Gibbons 1997).

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Scientific Name:
Graptemys gibbonsi
Common Name:
Pascagoula Map Turtle

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The Pascagoula Map Turtle has a relatively small range in the Pascagoula and Pearl river systems in Mississippi and eastern Louisiana (Lovich and McCoy 1992, NatureServe 2008). In the Pascagoula watershed, this turtle occurs in the Pascagoula, Leaf, and Chickasawhay rivers, and in Red, Bowie, Okatoma, and Tallahala creeks. This species is not found in Big Creek, Black Creek, the Escatawpa River, or in Alabama tributaries of the Pascagoula River (Lovich and McCoy 1992, 1994). In the Pearl River watershed, this species is found in the Pearl and Bogue Chitto rivers and in Ross Barnett Reservoir (Lovich and McCoy 1992). Dundee and Rossman (1989) reported this turtle from the Tickfaw River in Livingston Parish, Louisiana, but Lovich and McCoy (1992, 1994) questioned the validity of this record.

Habitat:
The Pascagoula Map Turtle uses medium to large rivers especially those with abundant mollusk prey, deep pools, sandy banks or sandbars for nesting, and logs or other structures for basking (Lovich and McCoy 1992). At night it usually clings to submerged objects just below water's surface, but sometimes comes onto sandy beaches or into shallow water (Dundee and Rossman 1989).

Populations:
There are an estimated 6-20 populations of Pascagoula Map Turtle, with occurrences in several streams in two major drainage basins (Lovich and McCoy 1994). Total population size is unknown but it is thought that there are at least a few thousand individuals (NatureServe 2008).

Population Trends:
The population trend of this turtle is reported as moderately declining to relatively stable (NatureServe 2008), but better documentation of trend is needed due to recent increases in commercial collection. It is thought to be declining in the Pascagoula River (Robert Jones, pers. comm., 1997 cited in NatureServe 2008). Lindeman (1999) suggested decline in the Pearl River. Selman and Qualls (2009) reported low abundances of G. gibbonsi in the Pascagoula River system, and failed to find this species in many historical locations, suggesting localized extirpations.

Status:
NatureServe (2008) categorizes the Pascagoula Map Turtle as vulnerable in Lousiana and Mississippi. It is categorized as Near Threatened by the IUCN. Based on updated survey data, Selman and Qualls (2009) recommend that G. gibbonsi be listed as state Endangered in Mississippi and Louisiana, U.S. federally listed as Threatened, and upgraded to Endangered (EN) under IUCN listing guidelines.

Habitat destruction:
The The Pascagoula Map Turtle is threatened by loss of basking sites due to the removal of logs and snags for boat navigation (Dundee and Rossman 1989). This turtle is also threatened by habitat loss and degradation due to stream channelization, point-bar mining, and impoundment (NatureServe 2008). The

state of Mississippi reports that this turtle's stream habitat is highly threatened by channel modification, dams and impoundments, headcutting, forestry, resource extraction, and urban and suburban development (http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%2012-2.pdf). Similarly, the state of Mississippi reports that this turtle's sandbar habitat is highly threatened by channel modification, dams and impoundments, recreational activities, resource extraction, and invasive species (http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%205.pdf).

Overutilization:

Overutilization threatens the survival of the Pascagoula Map Turtle. Commerical collection of this turtle has increased dramatically in recent years (Chris Lechowicz, unpublished report, 2006; http://graptemys.com/exploitation.htm). There has been a substantial increase in trade of Graptemys species (FWS Office of Law Enforcement 2000, http://www.fws.gov/policy/library/2005/05-24099.html). Schlaepfer et al. (2005) argue that the status of map turtles is so dire that the trade in wild-caught animals should be halted or severally reduced due to the level of export and life-history characteristics that make them particularly vulnerable to overharvesting. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries.

Disease or predation:

In conjunction with other threats, predation poses an increasing threat to this turtle. Synanthropic species such as raccoons and crows are known to be major nest predators of this species (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Pascagoula Map Turtle. Reed and Gibbons (2003) rank the Pascagoula Map Turtle among the ten most vulnerable turtle species that lack significant legal protection. Schlaepfer et al. (2005) state that map turtles are not adequately protected against overcollecting despite some existing state regulations. This species is included in CITES Appendix III (USFWS 2005). Selman and Qualls (2009) recommend Endangered Species Act protection for this species.

Other factors:

Pollution is a threat to the Pascagoula Map Turtle. The state of Mississippi reports that water quality degradation is high-level threat to this turtle's stream habitat (Mississippi's Comprehensive Wildlife Conservation Strategy, http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%2012-2.pdf). This species is threatened by industrial effluents (Dundee and Rossman 1989). Ernst et al. (1994) report that Graptemys species were absent downstream of a pulp processing plant on the Leaf River in 1986, whereas upstream they were abundant. This turtle is also threatened by any factor which threatens the molluscan prey on which it depends.

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Scientific Name:
Graptemys nigrinoda
Common Name:
Black-knobbed Map Turtle

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The Black-knobbed Map Turtle occurrs in the Mobile Bay drainage system of Alabama and Mississippi (NatureServe 2008). It is found below the Fall Line in the Alabama, Tombigee, Black Warrior, Coosa, Tallapoosa, and Cahaba rivers (Tinkle 1959, Shoop 1967, Cliburn 1971, Lahanas 1986, Conant and Collins 1991, Ernst et al. 1994).

Habitat:
This turtle uses rivers and streams with moderate current and sand or clay substrates. It uses logs and other structures for basking (Ernst et al. 1994). Eggs are deposited in nests excavated on sandy beaches generally within 50 meters of the water line in sunny areas (Ernst et al. 1994).

Populations:
It is estimated that there are fewer than 20 populations of Black-knobbed Map Turtle (NatureServe 2008). This turtle occurs in several dozen locations in several rivers (Iverson 1992). There are less than ten elemental occurrences if each major river is classified as a distinct occurrence (NatureServe 2008). Mirarchi (2004) reports that this turtle is locally fairly common.

Population Trends:
This turtle is declining, but the rate of decline is not known (NatureServe 2008). Mirarchi (2004) reports the turtle as fairly common in Alabama, but not as common as in the past. There has been strong documented decline in Mississippi (Ernst et al. 1994).

Status:
The Black-knobbed Map Turtle is classified as Vulnerable in Alabama and Imperiled in Mississippi (NatureServe 2008). It is listed as Endangered by the state of Mississippi and as a species of Moderate Conservation Concern in Alabama (Mirarchi 2004). It is categorized as Near Threatened by the IUCN.

Habitat destruction:
The Black-knobbed Map Turtle is threatened by habitat loss and degradation from channelization, impoundment, and removal of logs and snags which eliminates essential habitat elements including nesting and basking sites (McCoy and Lovich 1993, NatureServe 2008). This turtle is also threatened by recreation. Adults are killed in collisions with outboard motors and drowned in gill nets, and nests are destroyed by picnickers and hikers (Ernst et al. 1994).

Overutilization:
Overutilization poses a dire threat to the Black-knobbed Map Turtle. The map turtle's life history traits make it especially vulnerable to overharvesting, with loss of adult females having long-term population effects. Reed and Gibbons (2003) report that nearly 10,000 Black-knobbed Map Turtles were declared as exported from 1996-2000, at least 5,500 of which were wild-caught. This does not include the number of unreported and illegally harvested turtles. Schlaepfer et al. (2005) argue that the status of map turtles is so dire that the trade of wild-caught animals should be halted or severally reduced due to the level of export and life-history characteristics that make them particularly vulnerable to overharvesting. NatureServe (2008) reports that this species is also threatened by target shooting and exploitation for the

pet trade. This turtle's meat and eggs are also harvested for use as food (Lahanas 1982, CITES Proposal 1996). Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this species, and few if any occurrences are adequately protected and managed (NatureServe 2008). Due to harvesting pressure, Reed and Gibbons (2003) rank the Black-knobbed Map Turtle among the ten most vulnerable turtle species that lack legal protection. Schlaepfer et al. (2005) state that map turtles are not adequately protected against overcollecting despite their current legal status. This species is in dire need of Endangered Species Act protection.

Other factors:
Pollution threatens this species (NatureServe 2008).

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Scientific Name:
Graptemys pulchra
Common Name:
Alabama Map Turtle

G Rank:
G4

IUCN Status:
NT - Near threatened

Range:
The Alabama map turtle occurs in Alabama, Georgia, and possibly Mississippi (NatureServe 2008). The global range of this turtle is restricted to the Tombigbee and Alabama river systems that empty into Mobile Bay. In northwest Georgia it is only known from the Conasauga River (Buhlmann and Gibbons 1997).

Habitat:
This turtles occurs in large creeks to medium-sized rivers with moderate current, an abundance of aquatic vegetation, and logs for basking. It also occurs in oxbows and lakes. It requires sand bars or sandy banks for nesting, logs or other structures for basking, deep pools, and an abundance of molluscan prey (Lovich and McCoy 1992, Behler and King 1979).

Ecology:
Females of this species take up to 14 years to reach sexual maturity. Males may become sexually mature in 4 years (Behler and King 1979).

Populations:
NatureServe (2008) reports that there are likely at least several occurrences of this species, assuming each major occupied stream system is a distinct occurrence. Total population size is unknown. This is the most common turtle in the Pearl, Tombighee, and Escambia rivers (NatureServe 2008).

Population Trends:
The Alabama Map Turtle is moderately declining (NatureServe), but due to recent increases in collection pressure, updated surveys are warranted to determine trend. Populations of this species have been notably reduced in accessible portions of its range (Bartlett and Bartlett 1999). Buhlman and Gibbons (1997) report that this species is declining in Mississippi due to degraded water quality in the Tombigbee River system (T. Mann, Mississippi Natural Heritage Program, pers. comm.)

Status:
NatureServe (2008) ranks this turtle as critically imperiled (S1) in Georgia, imperiled in Mississippi (S2?), and vulnerable in Alabama (S3). It is categorized as Near Threatened by the IUCN. It is categorized as Rare by the state of Georgia.

Habitat destruction:
NatureServe (2008) reports that this species is threatened by impoundment and stream channel alteration. The State of Georgia reports that this species is threatened by habitat loss and degradation due to impoundment, hydrological modifications, and the removal of snags and logs which are necessary for basking (http://www.georgiawildlife.com/sites/default/files/uploads/wildlife/nongame/pdf/accounts/reptiles/graptemys_pulchra.pdf). The state of Mississippi reports that this turtle's sandbar habitat is highly threatened by channel modification, dams and impoundments, recreational activities, resource extraction, and invasive species

(http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Type%205.pdf). Similarly, the state of Mississippi reports that the Tombigbee drainage is highly threatened by channel modification, dams and impoundments, headcutting, agriculture, forestry, resource extraction, and industrial development (http://www.mdwfp.com/homeLinks/More/Final/Chapter%204.%20Habitat%20Types%2012-1.pdf). Buhlman and Gibbons (1997) report that this species is declining in Mississippi due to degraded water quality in the Tombigbee River system (T. Mann, Mississippi Natural Heritage Program, pers. comm.).

Overutilization:

The Alabama Map Turtle is threatened by commercial collection and by intentional shooting for recreation (NatureServe 2008). Bartlett and Bartlett (1999) cite collection for the pet trade as a threat to this turtle. The State of Georgia reports that this species is threatened by illegal take for human consumption and the pet trade (http://www.georgiawildlife.com/sites/default/files/uploads/wildlife/nongame/pdf/accounts/reptiles/graptemys_pulchra.pdf). Reed and Gibbons (2003) report that over 160 Alabama Map Turtles were declared as exported from 1996-2000, at least 111 of which were wild-caught. This does not include the number of unreported and illegally harvested turtles. There has been a substantial increase in trade of Graptemys species (FWS Office of Law Enforcement 2000, http://www.fws.gov/policy/library/2005/05-24099.html). Schlaepfer et al. (2005) argue that the status of map turtles is so dire that the trade in wild-caught animals should be halted or severally reduced due to the level of export and life-history characteristics that make them particularly vulnerable to overharvesting. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Alabama Map Turtle. Schlaepfer et al. (2005) state that map turtles are not adequately protected against overcollecting despite their protected status in some states, due to the recent increase in collection pressure.

Other factors:

This species is threatened by pollution (Buhlman and Gibbons 1997, NatureServe 2008). The State of Georgia reports that this species is threatened by siltation and pollution, and by factors which threaten its molluscan prey (http://www.georgiawildlife.com/sites/default/files/uploads/wildlife/nongame/pdf/accounts/reptiles/graptemys_pulchra.pdf).

degraded water quality in the Tombigbee River system (T. Mann, Mississippi Natural Heritage Program, pers. comm.).

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Scientific Name:
Grus canadensis pratensis
Common Name:
Florida Sandhill Crane

G Rank:
T2

Range:
The Florida sandhill crane has a limited range in Florida and Georgia. It occurs in extreme southeastern Georgia around Okefenokee Swamp and in suitable habitat throughout Florida, but is scarce south of Lake Okeechobee (NatureServe 2008).

Habitat:
The Florida sandhill crane occurs in prairies, shallow flooded open areas, marshy lake regions, low lying pastures, along sloughs and in open flats, and near ponds and scattered wooded hammocks. The crane avoids forests and deep marshes, and may preferentially use open upland habitats such as pastures and transitional pastures (Nesbitt and Williams 1990). Nesting typically takes place in marshes, or shallow lakes and ponds with dense emergent vegetation (Johnsgard 1983). Nests are composed of herbaceous plant material in shallow water or on the ground in marshy areas. Nest disturbance can lead to abandonment (Stys 1997), but some populations appear to have become tolerant to limited distrubance (Dwyer and Tanner 1992).

Ecology:
The Florida sandhill crane is non-migratory and exhibits year-round home-range fidelity. Subadult home ranges in north-central Florida average 2132 ha (Nesbitt and Williams 1990). Territorial adult home ranges are influenced by several factors including habitat quality, status, and season, and average 447 ha (Nesbitt and Williams 1990). In Georgia, adult cranes establish several nonoverlapping annual home ranges which average 92 ha, and they move less than 1.0 km among seasonal ranges (Bennet 1989). Subadult home ranges in Georgia average several hundred hectares (Bennet 1989). In a study in Georgia, maximum recorded linear movement for adults was 2.6 km, and was 10.5 km for subadults (Bennett 1989).

Populations:
NatureServe (2008) estimates that there are from 21-80 populations of this subspecies. The exact number of populations is unknown and is dependent upon how isolated ponds and pairs are lumped into population delineations. There are "a few dozen" population concentrations. A 2003 GIS analysis estimated a total population size of 4,594 individuals (Florida Fish and Wildlife Conservation Commission 2009).

Population Trends:
NatureServe (2008) reports that this subspecies is declining (decline of 10-30 percent). The Florida Fish and Wildlife Conservation Commission (2009) reports a 35.7 percent decline in the crane population statewide from 1974 to 2003. In 2003, a GIS analysis of landcover using occupied suitable crane habitat and annual home range sizes, age structure, and average flock size yielded a population estimate of 4,594 cranes. Based on landcover in 1974, the same analysis yields a population estimate of 7,142 cranes. Bennett (1989) estimated the total population size as 5000-6000 individuals, about a quarter of which were nonbreeding subadults. When the 2003 land cover information was compared to actual land-use data from 2006, it was determined that only 12.2 percent of occupied suitable habitat remained in areas of conservation lands. The Fish and Wildlife Conservation Commission reports that this habitat is probably not actively managed

for cranes, and is therefore of average quality. Based on this assumption, there are probably no more than 263 breeding pairs of sandhill cranes currently being sustained on public lands in Florida (Nesbitt and Hatchitt 2007).

Status:

The Florida sandhill crane is ranked by NatureServe (2008) as imperiled in Florida and critically imperiled in Georgia. It is listed as threatened by the state of Florida, and has no status in Georgia.

Habitat destruction:

NatureServe (2008) reports that habitat destruction threatens the Florida sandhill crane, especially the draining of wetlands for agriculture and real estate development. Activities in crane habitat threaten this bird because it disappears from areas of heavy human usage.

The Florida Fish and Wildlife Conservation Commission (2009) reports that habitat loss and degradation is the most common threat to this subspecies. The shallow freshwater marshes and adjacent uplands on which this bird depends are easily degraded.

Scott (2004) reports that many wetlands that were inhabited for generations by sandhill cranes have now been drained for agriculture and development. Within its already limited range, the crane's specialized habitat is shrinking. Sandhill cranes do forage in improved pastures, but these areas do not usually furnish adequate nesting sites (Scott 2004).

The Florida Natural Areas Inventory (2001) reports that the crane is threatened by ongoing loss of open rangeland and native prairie to development and conversion to more intensive agricultural uses such as citrus groves and row crops. The shallow wetlands used by cranes are easily threatened by drainage change patterns in adjacent uplands even if the wetlands themselves are not directly disturbed (Florida Natural Areas Inventory 2001). The crane is threatened by altered fire regime, as periodic fire is important to retard the invasion of woody vegetation in crane habitat (Florida Natural Areas Inventory 2001). The crane is also threatened by altered hydrologic regimes (Florida Natural Areas Inventory 2001).

Stys (1997) reports that the long-term survival potential of the Florida sandhill crane is at risk due to the increasing rate of habitat loss or modification from filling or draining of wetlands, degradation or loss of prairie and range habitats, and fragmentation of remaining habitat into patches too small or too isolated to be suitable for use. Habitat fragmentation and human disturbances may force sandhill cranes to temporarily or permanently abandon the areas they inhabit, and may reduce the overall fitness of populations by forcing cranes to travel greater distances to find foraging and roosting sites. Loss of habitat has resulted in an increasing number of cranes using suburban and urban areas where they are easily disturbed and face increased mortality (Stys 1997).Breeding may be delayed or abandoned if suitable foraging or breeding habitat cannot be located (Nesbitt 1996, Nesbitt and Williams 1990).

The crane is also potentially threatened by reduced wetland habitat quality due to livestock grazing, which can reduce the amount of vegetation in and around wetlands (Florida Fish and Wildlife Conservation Commission 2009). The crane can be threatened by poorly timed wetland management activities which can flood existing nests or detrimentally impact foraging habitat (Florida Wildlife Conservation Commission 2009).

The Florida Fish and Wildlife Conservation Commission (2005) identifies threats to the crane's habitat by habitat type. The agriculture habitats where this species forages are threatened by conversion to commercial, industrial, and residential development, and by pollution from pesticides and nutrient loading. The disturbed and transitional habitats with which this species is associated are threatened by development, incompatible recreational activities, and invasive species such as Melaleuca, Australian pine, Brazilian pepper, and Eucalyptus. The crane's dry prairie habitat is very highly threatened by conversion to housing and urban development and road construction and highly threatened by conversion to commercial and industrial development, and altered hydrologic and fire regime. The crane's freshwater marsh and wet prairie habitat is very highly threatened by conversion to agriculture, and conversion to housing and urban development, and highly threatened by surface water withdrawal, nutrient loading, mining and drilling, road building, and invasive vegetation. The grassland and improved pasture habitat which supports the crane is highly threatened by conversion to more intensive agriculture, conversion to housing, urban development, and recreation areas, and road building. The large alluvial streams with which the crane is associated are highly threatened by impoundments, water control structures, and channel modification. The crane's natural lake habitats are highly threatened by nutrient loading, invasive plants, dam operations, and conversion to housing and urban development. The reservoir and managed lake habitats which support the crane are highly threatened by water quality degradation, contaminants, sedimentation, nutrient loading, recreation, and invasive plants and animals (Florida Fish and Wildlife Conservation Commission 2005).

Overutilization:

Historically, overhunting negatively impacted this subspecies (Meine and Archibald 1996). Concerning the threat of hunting to the crane, Scott (2004) states: "Shooting cranes for sport and fun caused the initial decline of this species in Florida. The state now outlaws the hunting of sandhills, although a few cranes are undoubtedly shot each year" (p. 175).

Disease or predation:

Predation by raccoons and fish crows is a cause of nest failure. Eggs and chicks are also lost to feral hogs, river otters, red-tailed hawks, great-horned owls, American alligators, and coyotes (Stys 1997). Free-ranging dogs and cats also prey on crane eggs and young (Nesbitt 1996, Scott 2004). Predation by synanthropic predators such as raccoons, crows, coyotes, and feral pets is likely to increase with increasing development.

Cranes in other states have succumbed to avian cholera, avian botulism, and avian tuberculosis, and have been killed by mycotoxins from moldy agricultural wastes (Windingstad 1988).

The degree to which disease and/or predation are negatively affecting the Florida sandhill crane has not been quantified, but in conjunction with ongoing habitat loss and degradation, could increasingly threaten this subspecies.

Inadequacy of existing regulatory mechanisms:

The crane occurs on several managed areas in Florida and on Okefenokee National Wildlife Refuge in Georgia. The Florida Natural Areas Inventory (2001) reports that due to the crane's large home-range requirements, public lands do not protect large populations of cranes (Florida Natural Areas Inventory 2001). Also, nesting success in human-altered areas is well below that of native areas (Florida Natural Areas Inventory 2001). Cranes are also easily disturbed (Stys 1997).

NatureServe (2008) states that the protection of large tracts (at least 2000 acres) of suitable nesting and foraging habitat is an important measure that could be taken to conserve this bird. This subspecies is listed as threatened by the state of Florida, but this designation does not provide meaningful habitat protection. Scott (2004) suggests that a few cranes are still shot annually, despite state protection. No existing regulatory mechanisms adequately protect this subspecies.

Other factors:

The Florida sandhill crane is threatened by several other factors. Standing water is an important nesting component for this subspecies, and drought conditions can seriously threaten sandhills during the breeding season (Scott 2004). Flooding also threatens this bird, as flooding is a major cause of egg loss in north central Florida (Stys 1997). Proximity of road surfaces to nest sites increases the risk of flooding and has contributed to nest failure (Dwyer and Tanner 1992). The crane is easily disturbed and field observers and other disturbances have contributed to nest failure (Dwyer and Tanner 1992, Hipes et al. 2000).

Sandhill cranes are vulnerable to hazards such as powerlines and fences (Windingstad 1988). Becoming entangled in barbed wire and other fences is a leading cause of injury and death for Florida sandhill cranes (Scott 2004). Several cranes in south Florida have been killed or injured due to collisions with vehicles or airplanes (Stys 1997). Vehicle mortality is especially high when Florida sandhill cranes are caring for fledgling young (Hipes et al. 2000). Lead poisoning has caused crane deaths in Colorado and Nebraska (Windingstad 1988).

The long-term survival potential of the Florida sandhill crane is at risk due to small population size and low reproductive potential (i.e. small clutch size, low recruitment rate, seasonal nesting) (Stys 1997). The relatively low reproductive rate of Florida sandhill cranes is not conducive to rapid recovery (Scott 2004).

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Scientific Name:
Gyrinophilus palleucus
Common Name:
Tennessee Cave Salamander

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The Tennessee Cave Salamander is patchily distributed in central and south-central Tennessee, northern Alabama, and northwestern Georgia (Frost 2002, Beachy 2005, NatureServe 2008). Two subspecies of Tennessee Cave Salamanders are recognized: Sinking Cove Cave Salamanders (G. p. palleucus) and Big Mouth Cave Salamanders (G. p. necturoides) (AmphibiaWeb 2009).

Habitat:
The Tennessee Cave Salamander occurs at elevations ranging from 150-400 meters. NatureServe (2008) describes this species' habitat as "streams in caves that contain amphipods and other aquatic organisms that can serve as food; individuals may be found in rimstone pools, stream runs and pools, and pools isolated by receding waters; water tends to be clear and free of sediment; substrates include rock, gravel, sand, and mud (Godwin 1995). Sinkholes are an important habitat component, allowing for detritus inflow (Caldwell and Copeland 1992). Occasionally occurs in epigean environments; probably these individuals have been washed out of caves (Bury et al. 1980)."

AmphibiaWeb (2009) provides the following description of this species' habitat: "Tennessee cave salamanders are found in sinkhole-type caves or phreatic cave systems in the vicinity of sinkholes. This association is due to the nutrients that flow into these systems and the prey base they support. Caldwell and Copeland (1992) suggest that inflow (sinkhole) caves versus outflow caves may provide the best habitat. Animals are found under rocks in rocky and sandy substrates in quiet, shallow pools (McCrady, 1954; Simmons, 1975; see also Petranka, 1998)."

Ecology:
The Tennessee Cave Salamander is primarily neotenic with only a few transformed adults to have ever been found. Conant and Collins (1998) state, "Like most salamanders that spend their entire existence beneath the water, this one has external gills, lacks eyelids, and has small eyes." AmphibiaWeb (2009) provides the following information on the ecology of this species. Females likely lay eggs in autumn or early winter, based on the detection of males with spermatophores in August (Lazell and Brandon, 1962) and the occurrence of small hatchlings in caves in December–February (Simmons, 1975; see also Petranka, 1998 in AmphibiaWeb 2009). Tennessee Cave Salamanders consume benthic invertebrates. They are found both under rocks and in the open and are highly sedentary with individuals often being detected repeatedly in exactly the same location, indicating small home ranges. Population estimates from various caves reveal sizes of 25, 32, 48, and 88 animals, with densities ranging from 0.06–0.15 animals/m2 (AmphibiaWeb 2009). Males reach sexual maturity at 66-100 mm SVL. The inner contour of the vent is sexually dimorphic (Brandon, 1967a). Tennessee Cave Salamanders prey on conspecifics and on invertebrates such as amphipods, annelids (oligochaetes and earthworms), cladoceran zooplankton, crayfish, and insects such as coleopterans, plecopterans, ephemeropterans, trichopterans, dipterans (chironomid larvae), and thrips. Tennessee Cave Salamanders are eaten by

conspecifics (Lazell and Brandon, 1962; Simmons, 1975) and American bullfrogs (Rana catesbeiana), which can inhabit the mouths of cave entrances (Lee, 1969b), and possibly crayfish (in AmphibiaWeb 2009).

Populations:

NatureServe (2008) reports that there are approximately 24 known populations of Tennessee Cave Salamanders, with other possible occurences (Godwin 1995). Abundance is difficult to determine but total adult population size probably exceeds 1,000. Available information suggests that populations contain small numbers of individuals, based on surveys which rarely yield more than 10-20 individuals per cave visit (Petranka 1998). Population estimates for individual caves usually are a few to several dozen individuals per cave (Simmons 1975, Petranka 1998). Jess Elliot Cave is reported as the most significant site in Alabama (Godwin 1995), and Cave Cove Cave (elevation approximately 425 meters) supports the largest population in Tennessee (Caldwell and Copeland 1992).

Population Trends:

The Tennessee Cave Salamander is declining in the short term and appears to be relatively stable over the long term (NatureServe 2008), but several researchers have reported that most populations appear to be declining (Simmons 1975, Caldwell and Copeland 1992, Redmond and Scott 1996 in AmphibiaWeb 2009, Beachy 2005). The population in Custard Hollow Cave, Tennessee, appears to be declining (Caldwell and Copeland 1992).

Status:

NatureServe (2008) ranks the Tennessee Cave Salamander as critically imperiled (S1) in Georgia and imperiled (S2) in Alabama and Tennessee. It is ranked as Vulnerable by the IUCN. It lacks legal protective status.

Habitat destruction:

Dodd (1997) lists habitat alteration as a threat to the Tennessee Cave Salamander. Habitat destruction and alteration is reported by NatureServe (2008) as a major threat to the Tennessee Cave Salamander. Petranka (1998) reports that the abundance of some populations has been affected by siltation and increased water flows associated with deforestation (Petranka 1998). Tennessee Cave Salamanders are also known to be threatened by mining, urbanization, deposition of fill and trash in sinkholes, and flooding following dam construction (Caldwell and Copeland 1992, Godwin 1995, Petranka 1998, Beachy 2005).

Miller and Niemiller (2008) cite habitat degradation as an immediate threat to Tennessee Cave Salamander populations, stating, "In particular, agricultural and silvicultural practices, and urbanization adversely affect water quality by increasing herbicide and pesticide load, silt load, and exhaust runoff from roads. . . the Rutherford and Wilson Co. populations of G. palleucus are in expanding urban areas and are likely to be negatively impacted by urban development" (p. 13). Gratwicke (2008) states that coal mining threatens cave salamanders in Appalachia.

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007).
Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Overutilization:
Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:
New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (http://amphibiaweb.org/declines/diseases.html, Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and potentially threatens the Tennessee Cave Salamander.

Inadequacy of existing regulatory mechanisms:
The Tennessee Cave Salamander was designated by the U.S. Fish and Wildlife Service (1994) as a Category 2 candidate for Federal listing, but was dropped from the 1996 list (USFWS 1996). Currently it is a federal species of management concern and is a Priority 2 species of greatest conservation need in Alabama, but these designations do not provide the species with any regulatory protection. It is listed as threatened by the states of Tennessee and Georgia. The state listings do not provide regulatory protection for the species or its habitat, but do require scientific permits for collection. This salamander occurs in Russell Cave National Monument (Godwin 1995), which provides some habitat protection at that site. NatureServe (2008) recommends protecting all known populations. Petranka (1998) recommends protecting water quality and watersheds that drain into sinkhole systems through protective land management initiatives. Caldwell and Copeland (1992) provide management recommendations for specific sites in Tennessee.

Other factors:
Tennessee Cave Salamanders are threatened by any factor which decreases water quality including water pollutants in runoff from agricultural and residential areas (NatureServe 2008).

On threats to cave-dwelling organisms, Scott (2004) states: "Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers. Humans have slaughtered entire bat colonies in some caves and caused partial or total abandonment of others, depleting the guano that supplies important nourishment for many cave invertebrates. Degradation of surface habitats may also threaten cave fauna" (p. 77).

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: "Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis" (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: "If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations" (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997). Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians.

Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets “may exact a substantial toll on amphibian populations” (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: “Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast” (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): “The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects” (p. 185).

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Scientific Name:
Gyrinophilus subterraneus
Common Name:
West Virginia Spring Salamander

G Rank:
G1

IUCN Status:
EN - Endangered

Range:
The West Virginia Spring Salamander occurs in a single small cave system in southeastern West Virginia in Greenbrier County. The entire range of the species is less than 100-250 square km (NatureServe 2008).

Habitat:
The elevation of the cave system where this species occurs is approximately 530 m (Petranka 1998, NatureServe 2008). This salamander is restricted to the cave and the muddy banks along the stream in the vicinity of the limestone cave. The stream has sizeable quantities of decaying organic matter. The salamander relies on consistent water quality and the recharge of organic material supplied from outside the cave (NatureServe 2008). The stream usually varies in depth from 15–30 cm, but will flood following rains. Spelunkers have observed West Virginia Spring Salamanders almost 2 km into the cave (NatureServe 2008, AmphibiaWeb 2009).

Ecology:
This salamander feeds on small invertebrates in and along the cave stream (Conant and Collins 1998) including crayfish (Cambarus nerterius), amphipods (Gammarus minus; Stygobromus spinatus), isopods (Asellus holsingeri), and carabid beetles (Pseudanophthalmus grandis; P. laldermani) and potentially Cavernous collembolans (Pseudosinella gisini), millipedes (Trichopetalum weyeriensis and Pseudotremia sp. [probably fulgida]), a pseudoscorpion (Kleptochthonius henroti), and an oligochaete (Allobophora chlorotica) (AmphibiaWeb 2009). Larvae metamorphose at about 95 mm SVL, and the largest larvae are either near or have attained sexual maturity (AmphibiaWeb 2009).

Populations:
The West Virginia Spring Salamander is known only from a single population, the species type locality. Population size is unknown but is likely less than 300 individuals. Surveys have reported from ten to less than 100 individuals per survey (NatureServe 2008).

Population Trends:
The population trend for the West Virginia Spring Salamander is uncertain, but is estimated to be likely stable in the absence of habitat alteration (NatureServe 2008).

Status:
NatureServe (2008) ranks this species as critically imperiled (G1S1) (WV). It occurs in a small population in single cave system which is incompletely protected (NatureServe 2008). It is classified as Endangered by the IUCN. It lacks legal protective status.

Habitat destruction:
The West Virginia Spring Salamander is threatened by habitat modification. The current land owner has proposed logging within the watershed which supports the species. Recently during the construction of a pond, the land owner nearly compromised the structural integrity of the cave (NatureServe 2008). Because this species occurs at only a single site, modification of its habitat will result in extinction.

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous” (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: “There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations” (p. 325-326).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: “Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)” (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: “In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers” (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Overutilization:
The West Virginia Spring Salamander occurs at only a single location, therefore collection is a potential threat to the species. Because of its restricted distribution, Besharse and Holsinger (1977) strongly recommend that future collecting of specimens be done sparingly (AmphibiaWeb 2009). Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: “Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available” (p. 183).

Disease or predation:
The West Virginia Spring Salamander is not currently known to be threatened by disease, but given the rapid spread of disease to amphibian populations globally, disease is a potential threat to this species, especially in conjunction with the species' restriction to a single cave system. Because this salamander occurs at a single site, population extirpation would result in species extinction. Because this cave is used recreationally, spelunkers could inadvertently introduce disease to this population.

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (http://amphibiaweb.org/declines/diseases.html, Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and thus potentially threatens this salamander.

Inadequacy of existing regulatory mechanisms:
Existing regulatory mechanisms are inadequate to protect the West Virginia Spring Salamander. It is considered Rare by the state of West Virginia, but this designation does not provide any regulatory protection. The single occurrence of this species is not appropriately protected (NatureServe 2008). The Nature Conservancy holds title to one entrance to the cave which supports this species, and holds an easement on the cave system, but one entrance to the cave is unmanaged and the watershed which supports the cave is unprotected (NatureServe 2008). For the protection of the species, NatureServe (2008) recommends acquiring the second cave entrance, restricting activities in the watershed, limiting human access to the cave, and protecting the surface environment which supports the cave ecosystem. AmphibiaWeb (2009) states, "Every attempt should be made to preserve this (species') habitat and its water sources."

Other factors:
On threats to cave-dwelling organisms, Scott (2004) states: “Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers. Humans have slaughtered entire bat colonies in some caves and caused partial or total abandonment of others, depleting the guano that supplies important nourishment for many cave invertebrates. Degradation of surface habitats may also threaten cave fauna” (p. 77).

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: "Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis" (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: "If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations" (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians.
Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states:

“Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast” (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): “The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects” (p. 185).

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Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows Press, Washington, D.C.

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LaClaire 1997). LaClaire (1997) states: “Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)” (p. 327).

Scientific Name:
Haideotriton wallacei
Common Name:
Georgia Blind Salamander

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The Georgia Blind Salamander occurs in Jackson County, Florida, and in Dougherty and Decatur counties, Georgia, in the Marianna Lowlands-Dougherty Plain physiographic region which is a vast karst area of passageways and exposed vadose caves (NatureServe 2008, AmphibiaWeb 2009). The species is known from a deep well in Albany, Georgia, and from Climax Cave. In the Florida Panhandle the species has been detected at approximately a dozen sites which allow access to the Floridan Aquifer, which circulates in underground passageways in limestones of the Ocala and Suwannee formations (AmphibiaWeb 2009).

Habitat:
This salamander is a resident of the Marianna Lowlands (Dougherty Plain) karst aquifer, at 20-60 m elevation. It is usually found at the bottom of subterranean streams, in clear pools in caves, or in deep wells, but may sometimes leave the water and climb the limestone walls of caves (NatureServe 2008). AmphibiaWeb (2009) provides the following information on Georgia Blind Salamander habitat: Georgia Blind Salamanders are commonly encountered in pools and underground streams where bats defecate over or near the water. They become less abundant farther back in subterranean tunnels away from air, likely because their food is scarce. Their water is usually crystal clear, but following heavy rainfall becomes turbid. Water temperature is generally 18–21 ˚C. Their habitat has limestone walls and ceiling with fine red clay and silt floors.

Ecology:
Blind salamanders have no need for functional eyes because they spend their entire lifetime in the dark. They have pink or white translucent skin and dark internal organs are visible through the lower sides and belly. The Georgia Blilnd Salamander has a long, broad, but not greatly flattened head (Conant and Collins 1991). These salamanders move slowly, resting on the bottom or climbing on limestone sidewalls and underwater ledges (Pylka and Warren 1958, Means 1992c in AmphibiaWeb 2009). Breeding may be aseasonal; gravid females have been detected in May and September, and adults possibly move to sites of energy recharge (bat caves, sinkholes) to breed. Gravid females with enlarged ova have been found in May and November (Carr 1939, Means 1977 in AmphibiaWeb 2009). This species is most likely an obligate neotene-- no transformed individuals have been detected, and larvae do not respond to metmorphosis-inducing agents in the lab (Dundee 1962, Petranka 1998). This salamander is commonly detected with the Dougherty Plain blind crayfish (Cambarus cryptodytes; Pylka and Warren, 1958; Means, 1977, 1992c in AmphibiaWeb 2009). Adult Georgia Blind Salamanders measure 51–76 mm TL; growth rates and size at maturity have not been studied (Petranka 1998). These salamanders prey on ostracods, amphipods, isopods, copepods, mites, and beetles, and are likely preyed upon by Dougherty Plain blind crayfish, freshwater eels (Anguilla rostrata), brown bullheads (Ameiurus nebulosus), and Florida chubs (Notropis harperi) (Means 1992c, AmphibiaWeb 2009).

Populations:
There are less than fifteen known populations of Georgia Blind Salamander. Total adult population size is unknown (NatureServe 2008).

Population Trends:
The population trend for the Georgia Blind Salamander is uncertain, but is believed to be relatively stable or slighly declining in the short term and moderately declining in the long term (NatureServe 2008). NatureServe (2008) estimates a long-term decline of 30 percent.

Status:
The Georgia Blind Salamander is critically imperiled in Georgia (S1) and imperiled in Florida (S2). It is categorized as vulnerable by the IUCN.

Habitat destruction:
The Georgia Blind Salamander is threatened by habitat loss and degradation from activities that negatively affect water quality, including pollution and water level fluctuation. Activities which disturb the ground surface above the caves could also degrade or destroy this species' habitat (NatureServe 2008). At least two formerly occupied caves are known to have been destroyed by human activities (Means 2005).

The Florida Wildlife Conservation Commission Natural Areas Inventory (2001) cites changes in water level due to groundwater withdrawal and stream impoundment as threats to this salamander, as well as rock quarrying (http://myfwc.com/docs/FWCG/Georgia_BLind_sal.pdf). The commission cites threats to cave habitats associated with this species as incombatible resource extraction, mining, and drilling (http://myfwc.com/docs/WildlifeHabitats/Legacy_Terrestrial_Cave.pdf).

Florida's karst biota, including the Georgia Blind Salamander, are threatened by habitat loss, spring modification, ground-water contamination, aquifer withdrawals, saltwater intrusion, and recreational activities (Drew and Hötzl, 1999, Katz et al. 1999, Walsh 2000, cited in Walsh 2001). Walsh (2001) states: "Springs are frequently modified for consumptive or recreational purposes, with concomitant impacts on aquatic organisms. Many of Florida's karst species are threatened by habitat modifications due to their very localized distributions . . . Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped . . . In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources. Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: "The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous” (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: “There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations” (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: “Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species” (p. 178).

Logging is a potential threat if it leads to decreased water quality or reduced input of external nutrients into Blind Salamander habitat (Dodd 1997, LaClaire 1997).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: “In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers” (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Overutilization:

NatureServe (2008) states that "over-collecting for science or by herp enthusiasts" is a potential threat to this species. AmphibiaWeb (2009) states that "heavy collecting" of this species has occurred in one or two locations. Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: “Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available” (p. 183).

Disease or predation:

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009 (http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and thus poses a potential threat to this species.

Inadequacy of existing regulatory mechanisms:

The Georgia Blind Salamander is a threatened species in Georgia and is a species of special concern in Florida. These state designations do not provide this species with substantial regulatory protection. There are two occurences of this species on managed areas in Florida, but these management areas may not overlie entire aquifiers/occurrences, and NatureServe (2008) reports that few to no occurences of this salamander are appropriately protected. The caves in Marianna Caverns State Park have habitat protection, but are potentially vulnerable to recreational impacts. NatureServe (2008) recommends protecting from all disturbance all inhabited caves as well as protecting the ground surface above the entire cave system, and limiting pollution and water table fluctuations. Additional recommendations include limiting human entrance into caves with signs and fencing and protecting associated bat populations.

Other factors:

The Georgia Blind Salamander is threatened by factors which degrade water quality, such as runoff, siltation, and pollutants, and by water level fluctuations from human use (NatureServe 2008) and potentially from drought and climate change.

Dodd (1997) lists rarity as a threat to the Georgia Blind Salamander.

The Florida Wildlife Conservation Commission Natural Areas Inventory (2001) cites pollution from agricultural chemicals and vandalism as threats to this species (http://myfwc.com/docs/FWCG/Georgia_BLind_sal.pdf). The Commission also cites recreation and solid waste as threats to the cave habitats with which this species is associated (http://myfwc.com/docs/WildlifeHabitats/Legacy_Terrestrial_Cave.pdf).

Florida’s karst biota are threatened by competition and predation from nonindigenous species (Walsh 2001).

Because this salamander commonly occurs in pools where bats defecate, loss of bat populations also potentially threatens this species (NatureServe 2008).

On threats to cave-dwelling organisms, Scott (2004) states: “Subterranean ecosystems, aquatic and terrestrial, are extremely delicate environments with stable, constant temperatures, humidity, air circulation patterns, chemical characteristics, and detrital inputs. Even minor perturbative events can result in large kills of cave fauna. Threats include agricultural, industrial, and residential pollutants, especially pesticides and herbicides (which may simply leach through soils); erosion and siltation caused by destruction of vegetation at sink perimeters; changes in detrital input; pumping of water; collection of fauna; invasive exotic species; and disturbance of fauna or nutrient reserves by spelunkers and divers. Humans have slaughtered entire bat colonies in some caves and caused partial or total abandonment of others, depleting the guano that supplies important nourishment for many cave invertebrates. Degradation of surface habitats may also threaten cave fauna" (p. 77).

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Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians.

Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets “may exact a substantial toll on amphibian populations” (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: “Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast” (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): “The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects” (p. 185).

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Scientific Name:
Hamiota australis
Common Name:
Southern Sandshell

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	NE - Not evaluated

Range:
The Southern Sandshell occurs in the Escambia River drainage in Alabama, and the Yellow and Choctawhatchee River drainages in Alabama and Florida (Blalock-Herod et al. 2002). The historical range of this mussel was recently expanded (Williams et al. 2000, Blalock-Herod et al. 2002, 2005). In the Escambia River basin in Alabama, this mussel is known from the main channel of the Conecuh River in Covington, Crenshaw, and Pike Counties, from Burnt Corn Creek in Escambia County, from the Sepulga River in Conecuh County, and from Little Patsaliga Creek in Crenshaw County. In the Yellow River drainage, this mussel is known from the main stem of the Yellow River in Covington County, Alabama. From the Choctawhatchee River drainage in Florida, this mussel is known from Alligator Creek in Washington County, from Holmes and Tenmile Creeks in Holmes County, from Limestone Creek in Walton County, and from the main stem of the Choctawhatchee in Holmes County. From the Choctawhatchee drainage in Alabama, it is known from the Choctawhatchee main stem in Dale, Geneva, and Houston counties, from the Pea River in Barbour, Coffee, and Dale counties, from the East Fork Choctawhatchee in Dale and Henry Counties, from the West Fork Choctawhatchee in Barbour and Dale counties, from the Little Choctawhatchee in Dale and Houston counties, from Whitewater Creek in Coffee County, from Pea Creek in Dale County, and from another Pea Creek in Barbour County (Williams et al. 2000, Blalock-Herod et al. 2002, 2005).

Habitat:
This mussel is found in slow to moderate current in sandy substrate in clear, medium-sized creeks to rivers (Deyrup and Franz 1994, Williams and Butler 1994).

Ecology:
This mussel often occurs syntopically with Ptychobranchus jonesi, but H. australis occurs more often in smaller streams than P. jonesi (NatureServe 2008).

Populations:
Blalock-Herod et al. (2005) detected this mussel at 4 of 16 historical sites and at 15 new sites in the Choctawhatchee River drainage of Alabama and Florida including the West Fork Choctawhatchee River, Eightmile Creek, Yellow River, East Fork Choctawhatchee River, and Jordan Creek. This mussel remains widespread but fragmented in the Choctawhatchee River and many of its tributaries, but it appears to be declining in many areas. From the Escambia and Yellow River drainages, there are few recent records (Williams et al. 2008). In the Escambia basin, the sandshell has declined from 7 historic sites to 3 currently active sites and one site where its status is unknown. In the Yellow River basin, it has declined from 9 historic sites to 8 currently active sites. In the Choctawhatchee River basin, the sandshell has declined from 35 historic sites to 19 currently active sites (Blalock-Herod et al. 2002) and 4 sites with unknown population status. Overall this mussel has declined from a total of 51 historic sites to 30 active sites and 5 sites with unknown status. The Southern Sandshell is now extirpated from approximately 31-41 percent of its historic range.

At the best known location in 1988, roughly one dozer per hour were detected. Florida populations are modest. Williams et al. (2000) consider its abundance to be low in the Escambia and Yellow River systems. In recent surveys an average of 2 -3 live animals per site were detected (fide Williams et al. unpublished data; Blalock-Herod et al. unpublished data cited in NatureServe 2008). In the Choctawhatchee drainage, only two sites were encountered which supported at least 20-30 individuals (Blalock-Herod et al. 2002). Gravid females were detected in these two larger populations, and low levels of recruitment are likely occurring, but no juveniles were detected. Other populations may no longer be viable (USFWS 2003).

Population Trends:
This mussel is declining in the short-term (10-30 percent), and has experienced a long-term decline of 25-50 percent. It is extirpated from 31-41 percent of its historic range (FWS 2003). In the Choctawhatchee drainage, it is reduced 75 percent from its historic distribution, but has been recently detected at a few new sites in recent surveys (Blalock-Herod et al. 2002, 2005). It has been extirpated from multiple historic occurrences in the Pea, Escambia, and Yellow rivers, but has been found at a few new sites in these systems.

Status:
NatureServe (2008) ranks the Southern Sandshell as critically imperiled in Alabama and not ranked in Florida. This mussel is restricted to three river drainage basins where it occurs at extremely low abundance at all but a few sites (NatureServe 2008). It is a federal candidate for ESA protection. Its rank is being changed from threatened (Williams et al. 1993) to endangered (2010 draft, in review) by the American Fisheries Society.

Habitat destruction:
NatureServe (2008) reports that habitat loss and degradation is the primary threat to this species, from a variety of sources. The Southern Sandshell is thought to be highly sensitive to siltation and habitat modification and to require stable substrate and clean water. Because it produces a superconglutinate lure to attract host fish, it requires clear water to complete its life cycle. Its habitat is threatened by runoff from agricultural and silvicultural activities, gravel and sand mining, industrial and municipal pollution, development, and livestock grazing (NatureServe 2008). In southern Alabama, it is threatened by pollution from the growing poultry farm industry. It is threatened by oil and gas operation in the Escambia drainage. This mussel is also threatened by impoundment. In the Choctawhatchee river system alone, there are about two dozen proposed impoundments (Blalock et al. 1998). Blalock-Herod et al. (2002) report that increased turbidity in the waterways where this mussel occurs may reduce the efficiency of superconglutinates to attract host species or delay attraction time to the lures, interfering with reproduction.

Inadequacy of existing regulatory mechanisms:
The Southern Sandshell was listed as a federal candidate in 2004, but this listing provides the species with no meaningful protection. There are no existing regulatory mechanisms which protect this declining mussel.

Other factors:
This mussel is threatened by stochastic genetic and environmental events due to its distribution in generally small and isolated populations. Some populations may no longer be of effective size to be reproductively viable. It is threatened by any factor which threatens the host fish on which it depends for reproduction. It is also potentially threatened by invasive species such as the Asiatic clam, zebra mussel, and black carp (FWS 2003).

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Scientific Name:
Hartwrightia floridana
Common Name:
Hartwrightia

G Rank:
G2

Range:
This plant is endemic to a small range in Florida and Georgia. It has been recently confirmed in Nassau, Clay, Putnam, Alachua, Polk, Highlands, and Volusia Counties, Florida, and in Camden, Charlton and Ware Counties, Georgia (NatureServe 2008, Patrick et al. 1995).

Habitat:
Hartwrightia occurs in wet substrates that are usually sphagnous or peat-enriched and sometimes sandy (FNA 2006). It generally prefers full sunlight or only partial shade. It is most often found in slash pine (Pinus elliotti) or longleaf pine (P. palustris), saw palmetto (Seronoa repens), gallberry (Ilex spp.), or titi (Cyrilla racemiflora) flatwoods, acidic seepages, or pineland swamps or bogs (Kral 1983). Its habitat is at least partially maintained by fire, which eliminates competing shrub or grass species.

Ecology:
This perennial plant reaches 1.2 m in height. It blooms September-November, and fruits October-December (Patrick et al. 1995).

Populations:
There are currently approximately 50 known occurrences in Florida and eight in Georgia (NatureServe 2008, Chafin 2007). Population size is not known.

Population Trends:
Trend information is not available for this species.

Status:
Hartwrightia is restricted to a small range where it is threatened by extensive and systematic habitat destruction. NatureServe (2008) ranks H. floridana as critically imperiled in Georgia and imperiled in Florida.

Habitat destruction:
Habitat loss is the primary threat to H. floridana: much of this species' habitat has been systematically converted to grazing lands or pine plantations (NatureServe 2008). Livestock razing may damage individuals and/or habitat (Chafin 2000). Residential development also poses a significant threat. Drainage, ditch construction, and other hydrological alterations degrade or destroy habitat, and fire suppression has also played a role in the decline of this species as it alters natural patterns of succession and facilitates canopy closure (Patrick et al. 1995, Chafin 2000, 2007).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect Hartwrightia or its habitat; though it is listed as endangered in both Alabama and Florida, this designation offers it no substantial regulatory protections.

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Scientific Name:
Helianthus occidentalis ssp. plantagineus
Common Name:
Shinner's Sunflower

G Rank:
T2

Range:
The fewleaf sunflower is restricted to a small area within east Texas, Arkansas, and Louisiana. Current natural heritage records exist for Perry County, Arkansas, Austin, Caldwell, Colorado, DeWitt, Lavaca, Lee, and Newton Counties, Texas, and for Caddo, Lincoln, and Beauregard Counties, Louisiana (NatureServe 2008, USDA Plant database 2009).

Habitat:
The sunflower grows in thin sandy soil on top of clay, often in claypan savannas with post oak (Quercus stellata) and blackjack oak (Q. marilandica), or upland sandstone woods. It is occasionally found in high quality cobble bars or terraces in mountain streams (NatureServe 2008).

Ecology:
This plant is perennial (Cronquist 1980).

Populations:
Roughly five populations of this sunflower are known in Arkansas, and between 10 and 15 are known in Texas. Reports from Louisiana need verification (NatureServe 2008). Population sizes have not been not reported.

Population Trends:
NatureServe (2008) determined that this species is experiencing moderate decline as urbanization expands into historic habitat.

Status:
Restricted to a relatively small range within which it is infrequently reported, this species is threatened by habitat loss. NatureServe (2008) ranks H. occidentalis ssp. Plantagineus as critically imperiled in Arkansas and Louisiana, and imperiled in Texas.

Habitat destruction:
Urbanization is a substantial threat to this species' habitat, particularly in Texas (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

References:

Cronquist, A. 1980. Vascular flora of the southeastern United States. Vol. 1. Asteraceae. Univ. North Carolina Press, Chapel Hill. 261 pp.

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Univ. Arkansas, Fayetteville. 489 pp.

USDA Plant database. 2009. Louisiana county-level distribution of Helianthus occidentalis ssp. plantagineus. Accessed online January 28, 2010 <<http://plants.usda.gov/java/county?state_name=Louisiana&statefips=22&symbol=HEOCP>>

Scientific Name:
Hexastylis speciosa
Common Name:
Harper's Heartleaf

G Rank:
G2

Range:
Harper's heartleaf is known from only Chilton, Autauga, and Elmore counties in Alabama (NatureServe 2008).

Habitat:
This plant is found in open pine-deciduous woodlands and alluvial swamps in shaded habitat, and prefers well-drained sandy loam soils, often establishing above acidic streams or bogs (FNA 1997, Blomquist 1957).

Ecology:
Harper's heartleaf is low-growing, perennial, and evergreen, and blooms during April and May (NatureServe 2008).

Populations:
Number of occurrences and total population size are unknown for this rare plant.

Population Trends:
NatureServe (2008) reports that H. speciosa is experiencing substantial declines, primarily as a result of habitat loss.

Status:
Harper's heartleaf is endemic to a small range comprised of just 3 counties in Alabama, is in decline, and is threatened by extensive habitat loss and invasive exotics. NatureServe (2008) ranks H. speciosa as imperiled.

Habitat destruction:
Harper's heartleaf is threatened by the loss of habitat to residential development and timber harvesting, which both destroy and fragment habitat (Southern Appalachian Sepcies Viability Project 2002).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that few occurrences of this species are appropriately protected. It is not protected by the state of Alabama.

Other factors:
Invasive exotics, such as kudzu (Pueraria montana var. lobata) and Japanese honeysuckle (Lonicera japonica) threaten H. speciosa across much of its range: these fast-growing non-natives outcompete native plant life and may cause local or regional extirpations (Southern Appalachian Species Viability Project 2002).

References:

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Flora of North America Editorial Committee. 1997. Flora of North America north of Mexico. Vol. 3. Magnoliophyta: Magnoliidae and Hamamelidae. Oxford Univ. Press, New York. xxiii + 590 pp.

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Scientific Name:
Hobbseus cristatus
Common Name:
Crested Riverlet Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008), the Crested Riverlet crayfish has a range of 250-5000 square km (about 100-2000 square miles). It is known from four sites in the Tombigbee River basin in Kemper, Lauderdale, Lowndes, and Noxubee counties, Mississippi (Hobbs 1989).

Habitat:
According to Adams (2008), "Most of the H. cristatus were collected from roadside ditches with shallow (less than 0.3 m), turbid water, and some were from "sluggish" portions of streams or simple burrows (about 0.3 – 0.5 m deep). All those collected from the water were in grass and or accumulations of detritus on clay substrate. The species is probably a secondary burrower (Hobbs 1955)."

Populations:
This species has only been collected once since 1957 with all other occurrences documented as historical (NatureServe 2008).

Population Trends:
In the short term, NatureServe (2008) reports that this species is very rapidly declining (decline of 50-70 percent). In the long term, a large decline is noted (75-90 percent).

Status:
Hobbseus cristatus is restricted to a single river drainage in a four county area. It is ranked as imperiled by NatureServe (2008), as a Tier 1 species of greatest conservation need by the state of Mississippi, and as vulnerable by the IUCN. It is ranked as threatened by the American Fisheries Society.

Habitat destruction:
The reasons for the large decline of this species are unknown, but NatureServe (2008) reports that it is likely to be undergoing localized declines in areas of urbanization due to alteration to the hydrological regime, water pollution, and the paving of roadside ditches.

Inadequacy of existing regulatory mechanisms:
Part of the range of the Crested Riverlet crayfish is in the Tombigbee National Forest, but this provides no regulatory protection for the species or its habitat.

References:

Adams, S. B. 2008. Hobbseus cristatus fact sheet. Version 1.0. USDA Forest Service, Crayfishes of Mississippi website. Available online at maps.fs.fed.us/crayfish/factsheets/FS0048.pdf. Last accessed April 28, 2009.

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Scientific Name:
Hobbseus orconectoides
Common Name:
Oktibbeha Riverlet Crayfish

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	VU - Vulnerable

Range:
Hobbseus orconectoides has a range of less than 100 square km (less than about 40 square miles) according to NatureServe (2009). Most records are historical with few substantiated recent occurrences. The type locality was lost to development. It is known from the Sand Creek drainage in Oktibbeha, Lowndes, and Webster counties, Mississippi (Hobbs 1989).

Habitat:
NatureServe (2008) reports that the Oktibbeha Riverlet crayfish can be found in lentic situations such as wodland ponds, puddles, ditches, and also in lotic habitats such as moderately flowing sand-bottomed streams (Fitzpatrick and Payne 1968). It is found in association with emergent vegetation and littoral zones with abundant detritus (Fitzpatrick and Payne 1968). This species burrows during the summer dry periods and is a secondary burrower (Hobbs 1989). It appears to be reasonably tolerant of variable water quality conditions.

Populations:
NatureServe (2010) reports that there are fewer than five occurrences of this species, and that abundance is unknown.

Population Trends:
NatureServe (2010) reports that this species is very rapidly declining (decline of 50-70 percent) in the short-term, stating: "Most records are from the late 1960's and much of the remaining habitat in the Sand Creek drainage is uder intense development pressure associated with expanding populations in Starkville and Columbus. The type locality is apparently gone (housing development) and recent surveys found it in only one place (couple of specimens), after having looked at most of the localities where it once occurred (several historic localities were in roadside ditches which are now lined with concrete or otherwise dredged clean and smooth with no crayfish) (MS NHP, pers. comm., January 2009)." Long-term decline is estimated at up to 90 percent.

Status:
NatureServe (2010) changed the status of this species from vulnerable to critically imperiled. The State of Mississippi lists it as a Tier 1 Species of Immediate Conservation Need. This species was a Federal C2 Candidate species before that list was abolished. It is ranked as threatened by the American Fisheries Society.

Habitat destruction:
NatureServe (2010) reports that this species is imminently threatened by habitat loss and degradation, stating: "Development of regional airport area or growth of Mississippi State University could imperil this species. Most records are from the late 1960's and much of the remaining habitat in the Sand Creek drainage is uder intense development pressure associated with expanding populations in Starkville and Columbus. The type locality is apparently gone (housing development) and recent surveys found it in only one place (couple of specimens), after having

looked at most of the localities where it once occurred (several historic localities were in roadside ditches which are now lined with concrete or otherwise dredged clean and smooth with no crayfish) (MS NHP, pers. comm., January 2009)."

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that no occurrences of this species are protected.

References:

Adams, S. B. 2008. Hobbseus orconectoides. USDA Forest Service, Crayfishes of Mississippi website, Oxford, MS. Available online at http://maps.fs.fed.us/crayfish/factsheets/FS0065.pdf. Last accessed November 18, 2009.

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Scientific Name:
Hobbseus petilus
Common Name:
Tombigbee Riverlet Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008) the Tombigbee Riverlet crayfish is endemic to Mississippi, occurring in Itawamba, Lee, Monroe, and Oktibbeha Counties (Hobbs, 1989; Fitzpatrick, 1977; 1996; 2002). Fitzpatrick (2002) also reported the species from Clay County, Mississippi, but the location of voucher specimens from that county is unknown.

Habitat:
H. petilus occupies slow to moderately flowing small shallow streams with silty bottoms and emergent vegetation (NatureServe 2008).

Populations:
NatureServe (2008) roughly estimates that there are 21 - 80 populations with 2500-10,000 individuals. Precise population data is lacking. The species is common within its limited range.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as imperiled. The State of Mississippi has classified this species as a Tier 1 Species in need of Immediate Conservation Action. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
The potential impact of the Tenn-Tom Waterway on the habitat of Hobbseus petilus is great. Its headwaters location makes it espescially vulnerable to early effects (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that it is unknown whether any occurrences are appropriately protected and managed.

References:

Adams, S. B. 2008. Hobbseus petilus. USDA Forest Service, Crayfishes of Mississippi website, Oxford, MS. Available online at http://maps.fs.fed.us/crayfish/factsheets/FS0066.pdf. Last accessed November 18, 2009.

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Scientific Name:
Hobbseus yalobushensis
Common Name:
Yalobusha Riverlet Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Endangered	VU - Vulnerable

Range:
This species occurs in the headwaters of the Yalobusha River (Yazoo River system) in Calhaun, Chickasaw and Webster Counties, Mississippi (Fitzpatrick and Busack, 1989; USFS, 2009). Fitzpatrick (2002) also reported the species from Attala and Choctaw counties, Mississippi, but the locations of voucher specimens from those counties are unknown (NatureServe 2010).

Habitat:
Hobbseus yalobushensis is found in restricted to small headwater streams in the upper Yazoo River system, with silty bottoms and emergent vegetation (NatureServe 2008). The type locality was a shaded stream reach, 1 - 2 m wide and up to 0.7 m deep, flowing slowly through agricultural land. The type specimens were collected by dipnet on bare clay with some leaf litter nearby.

Ecology:
Adams (2008) reports that Fitzpatrick and Busack (1989) collected specimens in streams from February to June, which suggests that the species is not a primary burrower.

Populations:
NatureServe (2010) estimates 6-20 occurrences of this species, stating: "A wider range of localities than indicated by type series was once thought to be probable but most collections are from over 20 years ago and he species is no longer present in the type locality and was recently found to be absent from several previously known localities (MS NHP, pers. comm., January 2009)."

Population Trends:
NatureServe (2010) estimates that this species is rapidly declining to stable (10 percent fluctuation to 50 percent decline). It has been extirpated from the type locality and from several other previously known localities (MS NHP, pers. comm., January 2009 cited in NatureServe 2010).

Status:
This crayfish is ranked as imperiled by NatureServe (2008). It is a Tier 1 Species in Need of Immediate Conservation Action in Mississippi. It is ranked as vulnerable by the IUCN and as Endangered by the American Fisheries Society.

Habitat destruction:
According to Taylor et al. (2007), "[h]abitat alteration, such as stream channelization and substrate removal can negatively impact crayfishes. Channelization and high erosion rates at the type-locality for the Yalobusha riverlet crayfish (Hobbseus yalobushensis) … may have contributed to its extirpation at the site."

This crayfish occurs in a very rural area. NatureServe (2010) reports that channelization, head-cutting, and loss of riparian strips are all potential threats but none are imminent, though this species is known to have been extirpated from several sites.

Inadequacy of existing regulatory mechanisms:

NatureServe (2010) reports that no occurrences of this species are appropriately protected and managed.

References:

Adams, S. B. 2008. Hobbseus yalobushensis. USDA Forest Service, Crayfishes of Mississippi website, Oxford, MS. Available online at http://maps.fs.fed.us/crayfish/factsheets/FS0068.pdf. Last accessed November 18, 2009.

Fitzpatrick, J. F., Jr. 1996. Rare and endangered crawfishes of Mississippi. Museum Technical Report No. 93, Mississippi Department of Wildlife, Fisheries, and Parks, Jackson.

Fitzpatrick, J. F., Jr. and C. A. Busack. 1989. Hobbseus yalobushensis, a new crawfish from central Mississippi. (Decapoda: Cambaridae). Proceedings of the Biological Society of Washington. 102(3):637-643. 1 figure, 1 table.

Taylor, Christopher A., Schuster, Guenter A., Cooper, John E., DiStefano, Robert J., Eversole, Arnold G., Hamr, Premek, Hobbs, Horton H., III., Robison, Henry W., Skelton, Christopher E., Thoma, Roger F.. 2007. A reassessment of the Conservation Status of Crayfishes of the United States and Canada after 10+ Years of increased awareness. Fisheries 32(8):372-389

Scientific Name:
Hydroptila okaloosa
Common Name:
Rogue Creek Hydroptila Caddisfly
G Rank:
G1
Range:
This caddisfly is only known from Eglin Air Force Base, Florida (NatureServe 2008).
Habitat:
This caddisfly is dependent on clean creeks.
Populations:
This species is only known from three creeks in Eglin Air Force Base, Florida (Rasmussen 2006).
Population Trends:
Trend is unknown for this rare species.
Status:
This caddisfly is critically imperiled (NatureServe 2008).
Habitat destruction:
Because it is dependent on clean water, this caddisfly is threatened by any form of pollution, siltation or degradation of surrounding habitat (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
This species occurs on Eglin Air Force Base in the Florida Panhandle (NatureServe 2008). It is unknown if it is appropriately protected from activities what would degrade water quality and eliminate the species.

References:

Clemson University Department of Entomology (J.C. Morse, ed.). 2002. Last Updated 5 September 2006. Trichoptera World Checklist. Online. Available: http://entweb.clemson.edu/database/trichopt/index.htm.

Harris, S.C. 2002. New species of microcaddisflies (Trichoptera: Hydroptilidae) from northern Florida. Annals of Carnegie Museum, 71(1): 47-57.

Rasmussen, A.K. 2006. Caddisfly (Insecta: Trichoptera) records from the Florida A&M University database.

Scientific Name:
Hydroptila sarahae
Common Name:
Sarah's Hydroptila Caddisfly

G Rank:
G1

Range:
There are four known occurrences of Hydroptila sarahae within approximately 500 square kilometers in Eglin Air Force Base, Florida (NatureServe 2008).

Habitat:
This caddisfly is dependent on clean creeks.

Populations:
There are four known occurrences of this species, all are in Eglin Air Force Base (NatureServe 2008).

Population Trends:
Trend is unknown for this rare species.

Status:
This species is critically imperiled (NatureServe 2008).

Habitat destruction:
NatureServe (2008) reports that anything that adversely affects water quality, such as pollution, siltation or degradation of surrounding habitat would be a threat to this species.

Inadequacy of existing regulatory mechanisms:
This species occurs only on Eglin Air Force Base (NatureServe 2008). It is unknown if it is appropriately protected from activities what would degrade water quality and eliminate the species.

References:

Clemson University Department of Entomology (J.C. Morse, ed.). 2002. Last Updated 5 September 2006. Trichoptera World Checklist. Online. Available: http://entweb.clemson.edu/database/trichopt/index.htm.

Harris, S.C. 2002. New species of microcaddisflies (Trichoptera: Hydroptilidae) from northern Florida. Annals of Carnegie Museum, 71(1): 47-57.

Rasmussen, A.K. 2006. Caddisfly (Insecta: Trichoptera) records from the Florida A&M University database.

Scientific Name:
Hydroptila sykorai
Common Name:
Sykora's Hydroptila Caddisfly

G Rank:
G1

Range:
This species is only known from one spring run (NatureServe 2008) with a total range less than 100 square km (less than about 40 square miles).

Populations:
H. sykorai is known from one spring run in Gadsden County, Florida, on the Florida Agricultural and Mechanical University Farm (Rasmussen 2006). This caddisfly is known from only five specimens (NatureServe 2008).

Status:
This species is critically imperiled (NatureServe 2008).

Habitat destruction:
This species is only known from the farm at Florida AMU and is threatened by pollution, siltation or degradation of surrounding habitat (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this rare species.

References:

Clemson University Department of Entomology (J.C. Morse, ed.). 2002. Last Updated 5 September 2006. Trichoptera World Checklist. Online. Available: http://entweb.clemson.edu/database/trichopt/index.htm.

Harris, S.C. 2002. New species of microcaddisflies (Trichoptera: Hydroptilidae) from northern Florida. Annals of Carnegie Museum, 71(1): 47-57.

Rasmussen, A.K. 2006. Caddisfly (Insecta: Trichoptera) records from the Florida A&M University database.

Scientific Name:
Hymenocallis henryae
Common Name:
Henry's Spider-lily

G Rank:
G2

Range:
Henry's spider-lily is endemic to a small range within the Florida panhandle. This species is currently present in Bay, Gulf, Liberty, and Walton Counties, Florida (NatureServe 2008, FNA 2009).

Habitat:
This plant is found only within the narrow ecotone between dome swamps and wet flatwoods or prairies, often in cypress depressions (Kral 1983, Smith and Flory 1990). It occurs in a variety of soil types, and has been found in standing water, wet sandy peat soil, or dry soil (Smith and Flory 1990).

Ecology:
This plant is perennial, forms clumps, and reproduces both sexually and vegetatively (NatureServe 2008). It flowers during May and June (Smith and Flory 1990).

Populations:
At last survey, the Florida Natural Areas Inventory recorded 25 occurrences of this species sporadically distributed throughout the south-central area of the Florida panhandle. Population size data are not available (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that H. henryae is experiencing substantial declines across its already small range.

Status:
The spider-lily is endemic to a small range within the Florida panhandle, and is in decline across this range as a result of habitat loss or degradation. This species is a habitat specialist and therefore highly sensitive to habitat loss. NatureServe (2008) reports that it is imperiled in Florida, and the state also lists H. henryae as endangered.

Habitat destruction:
Habitat loss is the primary threat to this species: conversion of habitat to silvicultural plantations, agricultural use, or residential development is widespread, and wetland drainage and fire suppression also destroy or degrade habitat suitable for H. henryae (NatureServe 2008, Weekley et al. 2008).

Overutilization:
Overcollection threatens some populations of this rare plant (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though occurrences on the Apalachicola National Forest are somewhat protected from habitat destruction, specimens are still frequently collected (NatureServe 2008).
No existing regulatory mechanisms adequately protect this species; though it is listed as endangered in Florida, this designation affords H. henryae no substantial regulatory protections.

References:

Clewell, A.F. 1985. Guide to the vascular plants of Florida Panhandle. University Press of Florida, Gainesville. 605 PP.

Flora of North America, Vol. 26. Species account for Hymenocallis henryae. Accessed online December 16, 2009 <<http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242101678>>

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed October 5, 2009.

Smith, G., and W. Flory. 1990. Studies on Hymenocallis henryae (Amaryllidaceae). Brittonia 42: 212-220.

Weekley, C., Gordon, D., Maguire, J., Maschinski, J., Menges, E., Pence, V., and C. Peterson. 2008. Florida's Endangered and Threatened Plant Conservation Grant Program. The Palmetto 25: 8-12.

Scientific Name:
Hypericum edisonianum
Common Name:
Edison's Ascyrum

G Rank:
G2

Range:
This plant is endemic to a small area in Florida's Lake Wales Ridge; natural heritage records show presence in Polk, Highlands, Glades, and DeSoto Counties, though the species may be extirpated from DeSoto County. Its range encompasses less than 100 square miles (NatureServe 2008).

Habitat:
This plant occurs in sandy soils in low, wet prairies, pine flatwoods, and along the margins of flatwood ponds or other water bodies (Godfrey and Wooten 1981). It grows amongst a diversity of grasses, sedges, orchids, and palmetto (Sabal palmetto). Its preferred habitat is naturally fire-maintained (Kral 1983).

Ecology:
Edison's ascyrum is a perennial shrub that is generally insect-pollinated (Cronquist 1981). Its persistence in any given area is closely tied to the maintenance of natural hydrologic and fire regimes (NatureServe 2008).

Populations:
The Florida Natural Areas Inventory database contains 24 occurrence records in Florida as of 1997, the most recent survey (NatureServe 2008). Population size is unknown and is difficult to estimate because the species spreads vegetatively, often forming dense colonies.

Population Trends:
Populations across this species' already-small range are in decline (NatureServe 2008)

Status:
This species is uncommon across its very narrow range, and remaining populations are rapidly diminishing as a result of high development pressure and other anthropogenic threats. NatureServe (2008) ranks the species as imperiled in Florida.

Habitat destruction:
Habitat loss is the principle threat to this species: anthropogenic changes in hydrological regime and rapid and extensive land use change in the form of residential and agricultural development are the forces responsible for the decline of this rare endemic plant (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Populations of this species on Archbold Biological Station are fairly well-protected, but across the remainder of its range, no existing regulatory mechanisms adequately protect the Edison's ascyrum. Though it is state listed as threatened in Florida, this designation offers it no substantial regulatory protections.

References:

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. Georgia Press, Athens. 933 pp.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life. Available at: http://www.natureserve.org/explorer. Accessed December 3, 2009.

Ward, D.B. (ED). 1979. Rare and Endangered Biota of Florida, Vol. 5: Plants. University Press of Florida, Gainesville.

Scientific Name:
Hypericum lissophloeus
Common Name:
Smooth-barked St. John's-wort

G Rank:
G2

Range:
This species occurs only in Bay and Washington Counties in Florida (NatureServe 2008).

Habitat:
Very specific in its habitat preferences, this species is found along the fluctuating, sandy, moist-to-wet shores of sinkhole ponds or small lakes. Plants are tolerant of temporary extremes of inundation and exposure, and are generally found in full sun and acidic soils. It also grows in longleaf pine-scrub oak sandhills in the Coastal Plain (Kral 1983). This plant is often found with Kral's yellow-eyed grass (Xyris longisepala), quillwort yellow-eyed grass (X. isoetifolia), and panhandle meadow beauty (Rhexia salicifolia)(NatureServe 2008).

Ecology:
Perennial and long-lived, this species forms dense thickets and may be the most abundant shrub in some locations where it is found (Godfrey and Wooten 1981, Kral 1983).

Populations:
The Florida Natural Areas Inventory reported 35 occurrences as of 1997; more recent survey data is not available (NatureServe 2008). Populations are reportedly large, but it has not been determined whether these dense occurrences are composed of clones or genetic individuals.

Population Trends:
Population trend has not been reported for this species.

Status:
This species has very high habitat specificity, and preferred sites are naturally rare and ecologically fragile. NatureServe (2008) ranks this species as imperiled. It is state-listed as endangered in Florida.

Habitat destruction:
Ongoing lakeshore development is widespread in this species' range, and poses an immediate threat to some populations (NatureServe 2008). Various activities, such as timber harvesting or establishment of timber plantations, and agricultural, residential, or commercial development, within the upland matrix that surrounds H. lissophloeus' shoreline habitat promote erosion, pollution, and other habitat-degrading influences. The use of off road vehicles (ORVs) for shoreline recreation presents a direct threat to some populations.

Inadequacy of existing regulatory mechanisms:
One population is present on Eglin Air Force Base, and some occur on land owned by the Northwest Florida Water Management District, and so are protected from direct threats, though not more diffuse or widespread factors (NatureServe 2008). Though this species is listed as endangered in Florida, this designation confers no substantial regulatory protection; no existing regulatory mechanisms adequately protect H. lissophloeus.

References:

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. Georgia Press, Athens. 933 pp.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 22, 2010)

Wunderlin, R.P. 1982. Guide to the vascular plants of Central Florida. University Press.

Scientific Name:
Illicium parviflorum
Common Name:
Yellow Anisetree

G Rank:
G2

Range:
Though it was historically also present in Georgia, I. parviflorum is now thought to be restricted to a few counties in Florida: natural heritage records exist for Lake, Marion, Orange, Polk, Seminole, and Volusia Counties (NatureServe 2008).

Habitat:
This plant occurs in moist sandy loams or sandy peat mucks in wetland hammocks and floodplain swamps, often along large spring-fed streams. It is found with Atlantic white cedar, Chamaecyparis thyoides, Florida leucothoe (Agarista populifolia), cabbage palmetto (Sabal palmetto), dwarf palmetto (Sabal minor), needle palm (Rhapidophyllum hystrix), sweetbay magnolia (Magnolia virginiana), and swamp bay (Persea palustris), sometimes on karst formations (NatureServe 2008). This species is often an understory tree in floodplain forest, though it can reach over 6 m in height.

Ecology:
This plant is perennial, long-lived, and restricted to moist soils (Godfrey 1986).

Populations:
As of 1997 this species was known from fewer than 20 occurrences in five Florida counties (NatureServe 2008).

Population Trends:
This tree is in decline, and its range is contracting (historically present in Florida).

Status:
NatureServe (2008) ranks the yellow anise tree as imperiled in Florida, where it is also listed as endangered.

Habitat destruction:
This species' habitat is threatened by a variety of human activities, including wetland drainage and various timber management practices (Kral 1983).

Overutilization:
This tree is used for landscaping, and may be taken from the wild for cultivation (Kral 1983, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are two occurrences of this tree in Ocala National Forest, and it also found in Wekiwa Springs State Park and DeLeon Springs State Recreation Area, though none of these occurrences are appropriately protected or managed. Though it is listed as endangered in Florida, this designation offers I. parviflorum no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species.

References:

Godfrey, R.K. 1988. Trees, shrubs, and woody vines of northern Florida and adjacent Georgia and Alabama. Univ. Georgia Press, Athens. 734 pp.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 13, 2010)

Scientific Name:
Io fluvialis
Common Name:
Spiny Riversnail

G Rank:
G2

IUCN Status:
EN - Endangered

Range:
The total range of the Spiny Riversnail is less than 100-250 square km. This snail is endemic to western Virginia and eastern Tennessee in the Tennessee River drainage and its main tributaries including the Clinch, Powell, French Broad, Holston, and Nolichucky rivers (Burch 1989). This snail once occurred in the Tennessee Rivery systems south to Muscle Shoals, Alabama, but was extirpated in Alabama as the result of impoundment in the early 20th century (Ahlstedt 1991, Mirarchi 2004). Reported occurences from Kentucky are erroneous (NatureServe 2008). There are historical specimens from the Little Tennessee, Tellico, and West Prong Little Pigeon Rivers in Tennessee where the species is no longer extant (Parmalee and Bogan 1987).

Habitat:
The Spiny Riversnail occurs in shallow water shoals with moderate to rapid flow and high dissolved oxygen content.

Populations:
There are from 6-20 extant populations of the Spiny Riversnail (NatureServe 2008). Total population size is unknown. Davis (1974 in NatureServe 2008) reported less than 28 occurrences in three river drainages. Bogan and Parmalee (1983) reported that this species was restricted to relict populations in the lower Nolichucky River and Powell River (Claiborne, Hancock, and Lee counties, TN), and the Clinch River from Claiborne County, TN upstream to Lee County, Virginia. The Riversnail has been reintroduced successfully into the lower North Fork Holston River at two sites (Ahlstedt 1991) and into the tailwaters of Nickajack Dam in Marion County, TN (Mirarchi et al. 2004).

Population Trends:
In the short term, the Spiny Riversnail has declined rapidly, from 30-50 percent. Over the long term the species has experienced widespread declines of 75-90 percent (NatureServe 2008). As of the mid-1970's, the number of extant sites was reported as 21 percent of historical locations (Davis 1974).

Status:
The Spiny Riversnail is imperiled in Tennessee and Virginia and is presumed to be extirpated in Alabama (NatureServe 2008). It is classified as Endangered by the IUCN.

Habitat destruction:
This species is a narrow endemic threatened by habitat alteration and changes in water quality (NatureServe 2008). Part of its habitat has been destroyed by impoundment (Ahlstedt 1991, Mirarchi 2004). EPA (1996) reports that agricultural runoff and livestock grazing is a serious threat to aquatic species in this snail's habitat. EPA (2002) reports that coal mining activities and agricultural practices, past and present, are having adverse impacts on stream habitats in the Clinch and Powell watershed. This snail is sensitive to chemical pollution and populations were documented as being threatened by chemical pollution before the turn of the 20th century (FWS

1984). Virginia's Comprehensive Wildlife Conservation Strategy (2006) cites siltation, dredging, pollution, mining, water withdrawal, and impoundment as threats to aquatic species in the Southern Cumberlands. This snail occurs within the potentially affected watershed of a proposed industrial facility by the Chicago Bridge and Iron Company on the Tennessee River in Marion County (TVA 2009). The Commonwealth of Virginia (2005) reports that the Clinch River is threatened by declining water quality from coal mining and agricultural practices, by litter and trash, and by development of second homes in remote areas. Part of this species habitat could be affected by proposed developments at the Oak Ridge Reservation (U.S. DOE 2009). The spiny riversnail is specifically threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Inadequacy of existing regulatory mechanisms:

There are no occurrences of the Spiny Riversnail which are appropriately protected (NatureServe 2008) and there are no regulatory mechanisms in place to protect this snail. Pendleton Island on the Clinch River in Virginia is owned by The Nature Conservancy, but is subject to outside pollution. The North Fork of the Holston River harbors a successfully reintroduced population of this species, and a propagation effort is being conducted (Ahlstedt 1991).

Other factors:

Any factor which leads to declines in water quality or alterations in hydrologic regime will negatively impact the Spiny Riversnail. The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996), and much of this species' habitat has been polluted by coal mining and agriculture.

References:

Ahlstedt, S.A. 1991. Reintroduction of the spiny riversnail Io fluvialis (Say, 1825) (Gastropoda: Pleuroceridae) into the north fork Holston River, southwest Virginia and northeast Tennessee. American Malacological Bulletin 8(2):139-142.

Bogan, A.E. and P.W. Parmalee. 1983. Tennessee's rare wildlife. Vol. 2: The mollusks. Tennessee Wildlife Resources Agency and the Tennessee Conservation Department. 123 pp.

Burch, J.B. 1989. North American Freshwater Snails. Malacological Publications: Hamburg, Michigan. 365 pp.

Commonwealth of Virginia, Dept. of Conservation and Recreation. 2005. The Recreational Development Potential of the Clinch River Valley in Russell County. House Document No. 106. http://leg2.state.va.us/dls/h&sdocs.nsf/By+Year/HD1062005/$file/HD106.pdf

Dillon, R.T., Jr. 1989. Karyotypic evolution in pleurocerid snails. I. Genomic DNA estimated by flow cytometry. Malacologia, 31(1): 197-203.

Environmental Protection Agency. 1996. Non-Point Source News Notes #46. Community-Based Conservation on the Clinch Partners, Pearlymussels, and Patience. http://www.epa.gov/owow/info/NewsNotes/pdf/46issue.pdf Last accessed Jan. 13, 2010.

Hinkley, A.A. 1906. Some shells from Mississippi and Alabama. The Nautilus, 20(3): 34; 20(4): 40-44; 20(5): 52-55.

Mirarchi, R. E., J. T. Garner, M. F. Mettee, and P.E. O'Neil. 2004. Alabama wildlife. Volume 2. Imperiled aquatic mollusks and fishes. University of Alabama Press, Tuscaloosa, Alabama. xii + 255 pp.

Mirarchi, R.E. 2004. Alabama Wildlife. Volume One: A Checklist of Vertebrates and Selected Invertebrates: Aquatic Mollusks, Fishes, Amphibians, Reptiles, Birds, and Mammals. University of Alabama Press: Tuscaloosa, Alabama. 209 pp.

Palmer, M.A., E.S. Bernhardt, W.H. Schlesinger, K.N. Eshleman, E. Foufoula-Georgiou, M.S. Hendryx, A.D. Lemly, G.E. Likens, O.L. Loucks, M.E. Power, P.S. White, and P.R. Wilcock. 2010. Mountaintop mining consequences. Science 327: 148-149.

Parmalee, P.W. and A.E. Bogan. 1987. New prehistoric distribution records of Io fluvialis (Say, 1825) (Gastropoda, Pleuroceridae) in Tennessee with comments on form variation. Malacology Data Net, 2(1/2): 42-54.

Stansbery, D.H.and W.J. Clench. 1974. The Pleuroceridae and Unionidae of the North Fork Holston River above Saltville, Virginia. Bulletin of The American Malacological Union, Inc., May 1974: 33-35.

Tennessee Valley Authority. 2009. Final Environmental Assessment. Chicago Bridge and Iron Company Marion County, Tennessee. http://www.tva.gov/environment/reports/chicago_bridge_iron/fea.pdf Last accessed January 12, 2010.

U.S. Dept. of Energy. 2009. Site-wide Environmental Impact Statement. Y-12 National Security Complex. http://www.gc.energy.gov/NEPA/documents/Chapter_4.pdf Accessed Jan. 13, 2010.

U.S. Environmental Protection Agency (EPA) (2002). Clinch and Powell Valley watershed ecological risk assessment. National Center for Environmental Assessment, Washington, DC; EPA/600/R-01/050. Available from: National Technical Information Service, Springfield, VA. <http://www.epa.gov/ncea>

U.S. Environmental Protection Agency. 2005. Mountaintop Mining/Valley Fills in Appalachia Final Programmatic Environmental Impact Statement. Appendix F Federally Listed Threatened and Endangered and Species of Concern. Region 3, Philadelphia. EPA 9-03-R-05002.

U.S. Fish and Wildlife Service. 1984. Recovery Plan for the Green-Blossom Pearly Mussel Epioblasma (=Dysnomia) torulosa gubernaculum (Reeve, 1865). Prepared by Steven Ahlstedt for the United States Fish and Wildlife Service Southeast Region, Atlanta, GA. http://www.fws.gov/cookeville/recovery_plans/Green_Blossom_Pearly_1984.pdf

Virginia Dept. of Game and Inland Fisheries. 2006. Virginia's Comprehensive Wildlife Conservation Strategy. http://bewildvirginia.org/wildlife-action-plan/chapter-9.pdf Accessed Jan. 13, 2010.

Wood, D. 2009. Memorandum to J. Bailey, J. Wirts, and P. Campbell. Evidence for Secretary Randy Huffman. June 30, 2009. West Virginia Department of Environmental Protection, Charleston, WV.

Scientific Name:
Isoetes hyemalis
Common Name:
Winter Quillwort

G Rank:
G2

Range:
Also called the evergreen quillwort, this species is currently known in Virginia, North and South Carolina, Florida, Georgia, and possibly Alabama. It is found primarily in the Coastal Plain, though a few populations occur in the Piedmont region (Brunton et al. 1994). Natural heritage records indicate I. hyemalis is present in Houston County, Alabama, in Miller and Seminole Counties, Georgia, in Charlotte, Halifax, and Mecklenburg Counties, Virginia, ijn Holmes County, Florida, in Brunswick, Harnett, Hoke, Orange, and Richmond Counties, North Carolina, and possibly in Dorchester County, South Carolina (Wunderlin and Hansen 2002, Brunton et al. 1994, NatureServe 2008). Many sites, however, have not been confirmed since the early to mid-1990s.

Habitat:
This plant most often occurs in shallow, running waters of creeks, sloughs, and rivershores. It is found in dense shade beneath deciduous or mixed swamp forest. Species typical of this habitat include bald cypress (Taxodium distichum), red maple (Acer rubrum), longleaf pine (Pinus serotina), and American sweetgum (Liquidambar styraciflua). I. hyemalis generally grows in single-species patches, but may occasionally be associated with other herbaceous plants. I. hyemalis prefers fresh, cool, subacid-to-neutral flowing water (Brunton et al. 1994).

Ecology:
This plant is aquatic or amphibious, perennial, and spores mature in June-July (NatureServe 2008).

Populations:
At least 20 occurrences of this species are extant-- 10 in North Carolina, at least 4 in Virginia, and at least 2 each in South Carolina and Georgia, though surveys for this species have not been extensive (NatureServe 2008). Population sizes are not well-documented.

Population Trends:
Population trends have not been reported for this species, but threats to its habitat suggest that decline is occurring or imminent (NatureServe 2008).

Status:
NatureServe (2008) ranks the winter quillwort as critically imperiled in Alabama, Georgia, South Carolina, and Virginia and imperiled in North Carolina. Its status is under review in Florida, where it is state listed as endangered.

Habitat destruction:
This species' habitat is threatened by residential development, logging, channelization and other hydrological alterations (D. Brunton, pers. comm. as cited in NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in Florida, this designation affords the winter quillwort no significant regulatory protections; no existing regulatory mechanisms adequately protect this

species or its habitat.

References:

Brunton, D.F., D.M. Britton, and W.C. Taylor. 1994. Isoetes hyemalis, sp. nov. (Isoetaceae): A new quillwort from the southeastern United States. Castanea 59(1): 12-21.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 13, 2010)

Wunderlin, R.P., and B.F. Hansen. 2002. Atlas of Florida vascular plants. University Press of Florida, Tampa. 788pp.

Scientific Name:
Isoetes microvela
Common Name:
Thin-wall Quillwort

G Rank:
G1

Range:
Endemic to a small area of the Atlantic Coastal Plain, I. microvela is known only from Brunswick County, Jones, Onslow, and Sampson Counties, North Carolina, though some of these reports may not be current (Brunton and Britton 1998, NatureServe 2008).

Habitat:
The quillwort occurs along the banks of permanent streams on sandy alluvial soil, usually without other vegetation present. Its preferred habitat is frequently affected by storm-related flooding. It is most often found in areas of deep shade within deciduous swamp forests, associated with calcareous substrate (Brunton and Britton 1998).

Ecology:
This plant is perennial.

Populations:
This species was known from roughly three populations in North Carolina as of 2004 (NatureServe 2008).

Population Trends:
Because this species was described so recently, population trends are not reported (NatureServe 2008).

Status:
NatureServe (2008) ranks this species as critically imperiled.

Habitat destruction:
This species is threatened by any changes in local hydrology resulting from dams, diversions, or other anthropogenic alterations. One population is threatened by recreational activities at a campground (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

Other factors:
Severe rainfall events threaten this species because its habitat preferences expose it to flood scouring. Some populations were destroyed by post-hurricane flooding in 1996-1997 (NatureServe 2008). The frequency and intensity of severe storms is expected to increase in the southeastern United States due to global climate change, magnifying the threat to this species.

References:

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Scientific Name:
Kinosternon baurii pop. 1
Common Name:
Striped Mud Turtle - Lower Florida Keys

G Rank:
T2

Range:
The Lower Florida Keys Striped Mud Turtle, also known as the Key Mud Turtle, occurs in the Lower Keys in Monroe County, including many islands from Big Pine Key to Key West (NatureServe 2008).

Habitat:
This turtle usually uses soft-bottomed temporary freshwater ponds, but also occurs in permanent freshwaters and excavated mosquito control ditches that are fed by the freshwater table. It also occurs in brackish water, up to 15 ppt. Suitable ponds are generally found in or along the edge of elevated hardwood hammocks (Dunson 1992). Pondside vegetation is typically dominated by buttonwood (Conocarpus), sometimes with red and black mangroves. At disturbed sites, cattail is present (Dunson 1992). This turtle exhibits high site fidelity, with individuals rarely using more than a single pond (Dunson 1992). If ponds dry or become too saline, turtles may use terrestrial retreats, under rock ledges or among tree roots. Certain terrestrial retreats may be used repeatedly (Dunson 1992). Eggs are deposited in nests excavated in sand or decaying vegetation (NatureServe 2008).

Ecology:
In suitable habitat, Key Mud Turtles may occur at high densities. The highest recorded density is 59 turtles in 52 sq m of mosquito control ditches (Dunson 1992). Alligators are known predators (NatureServe 2008).

Populations:
It is estimated that there are from 6-20 populations of Key Mud Turtle (NatureServe 2008). Total population size is unknown. The largest populations are thought to occur in patches of especially favorable habitat on some of the smaller islands. On Summerland Key, it is estimated that a population of several hundred turtles occurs south of Highway 1 (Dunson 1992). It is estimated that 50 turtles occur on Johnston Key. Big Pine Key supports only a small population (Dunson 1992).

Population Trends:
Population trend is unknown. Because of specific habitat requirements and high site fidelity, loss and degradation of habitat likely leads to population extirpation (NatureServe 2008).

Status:
The Key Mud Turtle is imperiled (T2S2) (NatureServe 2008). It is listed as Endangered by the State of Florida.

Habitat destruction:
Rapid habitat destruction in the Lower Keys is a major threat to the Keys Mud Turtle (Dunson 1992). The Lower Keys are undergoing rapid development (NatureServe 2008). Increasing human demand for freshwater and resultant groundwater decline are dire threats for this freshwater-dependent turtle (NatureServe 2008). As this turtle uses mosquito control ditches, it is threatened

by filling in of ditches to accomodate management recommendations for key deer (Dunson 1992).

Overutilization:

This turtle is especially vulnerable to overutilization because of its extremely limited range. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect this turtle or its habitat. A large percentage of the total population occurs on private land which is undergoing rapid development pressure. There are six protected occurrences on Key Deer and Great White Heron national wildlife refuges. This turtle is listed as Endangered by the State of Florida, but this designation does not convey substantial regulatory protection.

Other factors:

The Florida Center for Environmental Studies reports that the Lower Florida Keys population of Striped Mud Turtle is in danger of extinction from sea level rise due to global climate change (http://www.ces.fau.edu/floc/presentations/presentations.php?id=14).

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Scientific Name:
Lampsilis fullerkati
Common Name:
Waccamaw Fatmucket

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Threatened	NT - Near threatened

Range:
The range of the Waccamaw Fatmucket consists of less than 100 square km in the Waccamaw River basin in North Carolina, and potentially in South Carolina (NatureServe 2008). This mussel occurs in Lake Waccamaw, below the lake dam, and near Longs, South Carolina (Johnson 1984, Porter 1985, Bogan 2002, Bogan and Alderman 2004, LeGrand et al. 2006).

Habitat:
In Lake Waccamaw this mussel is most abundant in deeper water with sandy substrate along the northeast and eastern shore (Johnson 1984). The lake has a maximum depth of approximately 3 m, there is little algal biomass in the water column, and pH is relatively constant (NatureServe 2008).

Populations:
There are an estimated 1-5 populations of Waccamaw Fatmucket (NatureServe 2008). There are three known occurrences of this mussel all within the Waccamaw basin in North Carolina and adjacent South Carolina (Bogan 2002, LeGrand et al. 2006). Within Lake Waccamaw, this mussel occurs in moderate densities, with an average density of 1.6 per square m (estimated population of 14,240 individuals if uniform density across lake bottom) (Porter 1985).

Population Trends:
The population trend of this mussel is fairly stable, but juvenile recruitment in Lake Waccamaw is low (Porter 1985).

Status:
NatureServe ranks the Waccamaw Fatmucket as critically imperiled in North Carolina. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Because of this mussel's extremely limited distribution, it is highly vulnerable to habitat loss and degradation. The survival of this mussel is dependent on high water quality in Lake Waccamaw and in the Waccamaw River basin. Water quality in the watershed and in the lake is threatened by several sources, including development along the lakeshore, agricultural runoff, and clear-cutting along the river bank. The Cape Fear Arch Conservation Collaboration (2009) identifies development, logging, and decreasing water quality as threats to aquatic species in the region, including this mussel. At certain times of the year, the lake is particularly sensitive to increased nutrient and sediment loading (NatureServe 2008). Nutrients, sediments, and pesticides from agricultural and forestry operations threaten water quality in the lake and river (NatureServe 2008). Channelization of swamp creeks north of the lake also threatens water quality, as many of these creeks drain agricultural areas. NatureServe (2008) reports that a golf course may be planned around the lake. Water quality is also threatened by out-of-compliance discharges from the Lake Waccamaw wastewater treatment plant (NatureServe 2008). The shoreline of Lake Waccamaw is densely developed with cottages and homes, which is likely to contribute to nutrient loading and wide-scale algal blooms in the lake (Shute 1997).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect this species, and no occurrences are appropriately protected and managed (NatureServe 2008). Lake Waccamaw is critical habitat for the Lake Waccamaw Silverside (Menidia extensa), but NatureServe (2008) states that this designation may not be sufficient to protect the Waccamaw Fatmucket population in the lake, likely due to the need to protect high water quality in order to ensure the mussel's survival.

Other factors:

This mussel is threatened by the invasion of the Asiatic clam, Corbicula fluminea. The Asiatic clam is established in Lake Waccamaw, and the mussels are currently coexisting, but if water quality in the lake deteriorates, Corbicula could become more dominant in more eutrophic conditions (Green 1971). The Asiatic clam has already become more abundant in the lake since 1997 (NC Wildlife Resources Commission 1998). Water pollution from a variety of sources is a also a primary threat (NatureServe 2008).

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Scientific Name:
Lasmigona holstonia
Common Name:
Tennessee Heelsplitter

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The Tennessee Heelsplitter occurs in Alabama, Georgia, North Carolina, Virginia, and Tennessee. The historic range of this mussel included the western slope of the Appalachians and the valley-ridge portion of the Cumberlandian section of the Tennessee River drainage in Virginia, Tennessee, Georgia, and Alabama, and the Alabama River basin in Georgia and Alabama (Clarke 1985). In Virginia, extant populations occur at a few sites in the Clinch and Middle Fork Holston River systems. In Tennessee, populations persist in very short sections of some tributaries to the Little, Little Tennessee, Hiawassee, and Holston Rivers. In Georgia the species is still extant in the Conasauga River drainage. Forms of the Tennessee Heelsplitter reported from the Cahaba and Coosa rivers in the Mobile Basin are likely a distinct species, Lasmigona etowaensis (Mirarchi et al. 2004 and update). Historical reports of the Heelsplitter from the Duck River may represent a different entity, Lasmigona diversa (Conrad 1856, Ortmann 1924).

Habitat:
The Tennessee Heelsplitter generally occurs in small streams on fine sand-mud substrates in shallow water. It is normally found near riffles, but has also been detected in backwaters and pool-like features. Historically it was reported from small side channels and sloughs of larger rivers (Clarke 1985, Ortmann 1918). It has been detected in springs with a width as small as 30 cm. This mussel is associated with headwater areas (NatureServe 2008). Mirarchi et al. (2004) describe this species' habitat as "creeks with flowing water over substrata of sand and mud (Parmalee and Bogan 1998). Sometimes found below riffles in shallow stream margins. May occur in very small creeks where often it is only mussel species present."

Ecology:
The ecology of the Tennessee Heelsplitter is not well known. In a second-order creek in Polk County, Tennessee, eighteen invididuals were observed over 300 m, sex ratio was approximately equal, and gravid females were detected (NatureServe 2008). This species is a long-term brooder (Parmalee and Bogan 1998). Fish hosts include banded sculpin, rock bass, and possibly other species of headwater fishes, because this mussel appears to be a host generalist (Mirarchi et al. 2004).

Populations:
There are from 21-80 populations of the Tennessee Heelsplitter, with several very small, disjunct populations having been recently detected. In Cherokee County, Alabama the species persists in a few tributaries of the Coosa River including Terrapin and Spring Creeks, and in Jackson County, a single mussel was detected in Hurricane Creek in the Paint Rock drainage (Mirarchi et al. 2004). NatureServe (2008) provides the following account on populations of this species: "McGregor et al. (2000) collected specimens in the Cahaba River, Alabama. In North Carolina, it is known from Valley Creek, Cherokee Co., Hiwassee River basin, Mills River, French Broad River basin, and Lotla Creek, Little Tennessee River basin (Bogan, 2002) in Cherokee (extirpated) and Henderson Cos. (LeGrand et al., 2006). In Tennessee, it was formerly in numerous small creeks and rivers in east Tennessee including the upper Holston River (Hawkins Co.), Hiwassee River (Polk Co.),

small streams in Campbell, Knox, Cocke, Sevier, Rhea, and Monroe Cos., and also in the Conasauga River (Polk and Bradley Cos.) and in Hickory Creek (Coffee Co.) (Parmalee and Bogan, 1998). In a survey of 134 sites in the New River Drainage in Virginia, Pinder et al. (2002) found this species at 4 sites (3 in the Upper Wolf Creek system, Bland Co.; 1 in the Bluestone River in Tazewell Co.; all Middle New drainage). Overall in Virginia, it occurs in the New River (upper Walker Creek, upper Wolf Creek), and tributaries of the Clinch (Jones et al., 2001), (Copper Creek- Fraley and Ahlstedt, 2000), Powell, and Holston drainages (Pinder et al., 2002). In the Coosa River basin in Georgia, it is known historically from the Etowah, Oostanaula, Conasauga, and Coosawattee River drainages but has not been collected live recently (except see below) (Williams and Hughes, 1998). It can also be found in shallow streams that are part of the Tennessee River system, Etowah River, Oostanaula River, and Conasuaga River in the extreme northwestern portion of Georgia (GA NHP, pers. comm., March 2007)." NatureServe (2008) states that is locally common in some areas (per Steve Ahlstedt) and that there are likely 1000 or more individuals combined for Tennessee, Georgia, and North Carolina.

Population Trends:
The Tennessee Heelsplitter is declining in the short term (decline of 10-30 percent) and moderately declining (decline of 25 - 50 percent) in the long term. Its distribution has been reduced and it continues to decline (NatureServe 2008).

Status:
The Tennessee Heelsplitter is critically imperiled in Alabama, Georgia, North Carolina, and Virginia, and is imperiled in Tennessee (NatureServe 2008). It is ranked as Near Threatened by the IUCN. Although a relatively large number of extant occurrences are known, some have extremely low population sizes and some local extirpations have occurred in Tennessee and Alabama. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Habitat loss and degradation is the greatest threat to imperiled southeastern mollusks like the Tennessee Heelsplitter (Neves at al. 1997). This species' habitat has already been majorly restricted (NatureServe 2008). Tennessee Heelsplitter habitat has been fragmented by impoundment and reservoir construction. Water quality for this mussel has been degraded by siltation and stream bed physical disruption from poor agricultural practices including uncontrolled cattle grazing, which NatureServe (2008) describes as a major threat for this species. This species is also threatened by urban and industrial development (NatureServe 2008). Virginia's Comprehensive Wildlife Conservation Strategy (2006) cites siltation, dredging, pollution, mining, water withdrawal, and impoundment as threats to aquatic species in the Southern Cumberlands. The strategy also outlines livestock, municipal development, and wastewater treatment as specific threats to this mussel (p. H-32). The Alabama Dept. of Environmental Management (2003) reports that the Tennessee River basin has been widely degraded by nonpoint source pollution from many sources, particularly agriculture, urban development, logging, and surface coal mining (ADEM 2003). There are more than 130 confined animal feeding operations in the Tennessee River basin (ADEM 2003). Aquatic habitats in the basin are also degraded by water-related recreational activities and nonpoint source pollution from onsite residential sewage systems (ADEM 2003). Mussels in the Clinch watershed are threatened by coal mining and agricultural practices (U.S. EPA 2002). This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants

associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009). This mussel is also threatened by impoundment and dam operations for the Claytor Hydroelectric Project (American Electric Power 2009).

Disease or predation:

Neves and Odom (1989) cite muskrat predation as a threat to imperiled mussels in the North Fork of the Holston in Virginia.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Tennessee Heelsplitter, and no occurrences are appropriately protected and managed (NatureServe 2008). This species was a federal Candidate for listing in 1994, and is still in dire need of ESA protection. It is listed as Endangered by the states of North Carolina and Virginia, and as a Species of Greatest Conservation Need in Alabama, but these designations do not provide substantial regulatory protection. This mussel has no state status in Georgia or Tennessee. NatureServe (2008) provides the following management recommendations for this species: "All populations should receive protection through acquisition, easement, registry, and working with local, state, and federal government agencies on issues relating to development, water quality, river designation, etc. Cooperative development of basin-wide development plans to maintain water quality and prevent environmental degradation should be a high priority. In particular, the establishment of environmentally compatible soil conservation programs need to be established and emphasized as economically advantageous to land owners (e.g., maintenance of higher agricultural productivity, cost effectiveness, etc.)."

Other factors:

The Tennessee Heelsplitter faces heightened susceptibility to extinction because of population isolation and low population abundance, which decrease the genetic viability of individual populations and increase the risk of extirpation from stochastic genetic and environmental events. Any factor which degrades water quality also threatens this mussel, and NatureServe (2008) lists pollution as a threat to the survival of this species. The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996).

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Scientific Name:
Lasmigona subviridis
Common Name:
Green Floater

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	NT - Near threatened

Range:
The green floater occurred historically in Alabama, Georgia, Tennessee, Kentucky, North Carolina, Virginia, Washington D.C., Maryland, West Virginia, Pennsylvania, New York, and New Jersey. It is extant only in Tennessee, North Carolina, Virginia, West Virginia, Pennsylvania, Maryland, New York and New Jersey. Williams et al. (2008) state: "Lasmigona subviridis occurs in Atlantic Coast drainages from the St. Lawrence and Hudson River drainages in New York south to the Cape Fear River drainage in North Carolina. A disjunct Atlantic Coast population is known from the Savannah River drainage (Fuller 1971). Disjunct populations also occur in the Kanawha River system of the Ohio River drainage in North Carolina, Virginia, and West Virginia (Clarke 1985, Pinder et al. 2003); the Tennessee River drainage, eastern Tennessee and western North Carolina (Parmalee and Bogan 1998; R.S. Butler pers. comm.); and the Apalachicola Basin, Alabama and Georgia (Brim Box and Williams 2000)" (p. 408).

Habitat:
This species inhabits medium-sized rivers and creeks, and strongly prefers calm, relatively shallow waters (Strayer and Jirka 1997). It is most often found in hydrologically stable environments as it is intolerant of frequent flooding and drying or changes in water flow (NatureServe 2009). It prefers gravel and sand substrates and high water quality (NatureServe 2008).

Ecology:
Lasmigona subviridis is a non-migratory species; adults are virtually sessile, though passive dispersal downstream may occur (NatureServe 2008).The green floater's life history is similar to that of many freshwater mussels: juveniles are incubated within females from August to the following June, when they are released and attach to their glochidial hosts (host species are as yet unidentified). Juveniles are parasitic, and adults feed on benthic detritus (James 1987). This species is one of a few hermaphroditic freshwater mussel species; large population sizes may therefore be less critical to reproductive success and persistence.

Populations:
Though the green floater is still present across a wide geographical range, many populations have been extirpated, and others are experiencing precipitous declines (NatureServe 2008). Between 21 and 80 occurrences are estimated, though sites generally contain few individuals of this species: the most populous surveyed site in New York found only 22 individuals (Strayer and Jirka 1997). Global abundance is unknown.

The green floater is extirpated from many historical sites, and few new populations are being found; most occurrences are thought to be marginally viable (NatureServe 2008). Few sites remain in New York: it has been extirpated from the Hudson and Mohawk Rivers, and is rare in the Oswego, Genesee, and Susquehanna basins (Strayer and Jirka 1997). In New Jersey, it was historically found in the middle Delaware and Raritan Rivers, and remains only in Stony Brook (Cordeiro 2003). The green floater was once present throughout much of Pennsylvania, but is now found only in the Susquehanna, Pine, Lower Juniata, and Sinnemahoning Rivers (Ortmann 1919, Bogan 1993, PA NHP as cited in NatureServe 2008). In Maryland, populations exist in the upper and middle Potomac, and some Washington Metro drainages (Bogan and Proch 1995). West Virginia populations are limited to the upper Potomac, Kanawha, New, Cascapon, and Greenbrier Rivers (Taylor 1987, pers. comm. as cited in NatureServe 2009). In North Carolina, this species is found in the Watauga, New River, Roanoke, Tar, Neuse, and Cape Fear River basins (Bogan 2002), and in Allegheny, Ashe, Durham, Edgecombe, Granville, Halifax, Johnston, Nash, Northhampton, Orange, Person, Rockingham, Stokes, Wake, and Watauga Counties (LeGrand et al. 2006). In Tennessee, it is known in the Watauga River and Johnson County (Parmalee and Bogan 1998). Populations were once extant in Georgia's Flint River, but more recent surveys have not confirmed this species in historical locations (Athearn 1992). The green floater is known at three sites in Virginia's New River drainage, and in the Holston and Clinch Rivers (Pinder et al. 2002). Though it was historically present in several sites in the Apalachicola Basin, recent surveys did not find this species at any documented historical locations (Brimbox and Williams 2000, Mirarchi 2004).

Population Trends:

NatureServe (2008) reports that the green floater has declined by up to 50 percent in the long-term, and by up to 30 percent in the short-term, stating:

"Few large populations remain and there has been a sharp decline in numbers where present (e.g., North Fork Shenandoah River) and it is extant at very few historic occurrences. Good populations, such as the West fork Greenbriar either shift or are lost after major flood events. Populations of this species were probably never very good . . . Although once widespread and common in the Susquehanna River drainage in New York, populations have declined in recent years, probably due to pollution (Strayer and Jirka, 1997) . . . In New York, it is extirpated in the Hudson River, Mohawk River, and is rare in the Oswego, Genesee, and Susquehanna basins (Strayer and Jirka, 1997)."

This species also appears to be extirpated from Georgia and Kentucky (NatureServe 2008) and from the Apalachicola Basin and the Tennessee River drainage of Alabama (Williams et al. 2008).

Status:

NatureServe (2008) lists the green floater as critically imperiled in Maryland, New Jersey, and North Carolina, imperiled in Pennsylvania, Tennessee, Virginia, and West Virginia, and reports that it is likely extirpated from Washington, D.C., and extirpated from Alabama, Georgia, and Kentucky. It is listed as threatened by the state of Virginia, and as endangered by New Jersey, and North Carolina. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

The green floater is threatened across its range by habitat loss and degradation resulting from riparian zone removal for agriculture and development, water-level fluctuations resulting from impoundment and diversion, and increased siltation resulting from a variety of activities including instream gravel mining (NatureServe 2008, Kentucky Department of Fish and Wildlife Resources 2005, Virginia Department of Conservation and Recreation 2009). The Virginia Department of Conservation and Recreation (2009) reports that this mussel's habitat in the North and South Fork Shenandoah Rivers is threatened by degradation from impoundment, flow alteration, agriculture, and industry. The New York State Dept. of Environmental Conservation (2005) reports that this mussel is threatened by instream gravel mining and dams. The Virginia Dept. of Game and Inland Fisheries (2010) reports that this mussel is threatened by sediment load and turbidity alteration from agriculture and forestry, and hydrologic regime alteration from municipal development.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the green floater. NatureServe (2009) reports that few occurrences of the green floater are appropriately protected or managed. Maryland's highest quality occurrence (most valuable population) is located within a watershed designated as a Nature Conservancy Bio-Reserve. It is listed as threatened or endangered in several states including Virginia, New Jersey, and North Carolina, but this designation does not protect the species' habitat.

Other factors:

Pollution is cited as one of the primary causes of this species' decline (Strayer and Jirka 1997). The green floater is threatened by increased siltation, algal blooms, cold-water releases from dams, and other causes of water quality degradation (NatureServe 2008, Virginia Department of Conservation and Recreation 2009). The Virginia Department of Conservation and Recreation (2009) reports that this mussel's habitat in the North and South Fork Shenandoah Rivers is threatened by agricultural runoff, arsenic contamination from past pesticide use, and mercury contamination from factory spills. The Virginia Dept. of Game and Inland Fisheries (2010) reports that this mussel is threatened by "complications due to small populations," toxins from roadways and municipal development, and water temperature regime alteration.

The green floater may also be threatened by the Asian clam (Corbicula fluminea), zebra mussel (Dreissena polymorpha), and quaga mussel (NatureServe 2008, Virginia Department of Conservation and Recreation 2009).

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Scientific Name:
Laterallus jamaicensis
Common Name:
Black Rail

G Rank:
G4

IUCN Status:
NT - Near threatened

Range:
During the breeding season, the eastern black rail occurs on the Atlantic Coast from Connecticut to southern Florida, along the Gulf Coast to Texas, in the West Indies and down through Mexico to Central America (Eddleman et al. 1994). Throughout this range, the species is irregular and rare (Ibid.) It historically bred in Massauchusettes and inland in Colorado, Kansas, Oklahoma, Minnesota, Michigan and east to Connecticut, but has not been documented to breed in these areas since the 1930s (Eddleman et al. 1994).

Habitat:
The eastern black rail nest in high portions of salt and freshwater marshes, wet meadows and flooded grasslands (Eddleman et al. 1994). Water depth is considered a key habitat component with black rails selecting areas with shallower water than other rails and infrequent tidal inundation or flooding (Todd 1977, Eddleman et al. 1988, Eddleman et al. 1994, Legare and Eddleman 2001). The species is found in sites with moist soils and pools and vegetation dominated by cordgrass (Spartina patens, S. alterniflora, S. cynosuroides, S. bakeri) and other high marsh species (Eddleman et al. 1994). Nests are built on the ground in dense vegetation (Eddleman et al. 1988). Black rails use wet prairie or grassland habitat as staging grounds along their migration route (Eddleman et al. 1988).

Ecology:
This species feeds on invertebrates and the seeds of aquatic vegetation and forages by probing substrate with its bill, or gleaning items from the water's surface (Terres 1980, Ehrlich et al. 1988). Mating occurs in late April – mid-May, and eggs may hatch anytime between late May and early August (Harrison 1975, Ehrlich et al. 1988). Clutch size is 6-8 eggs; both males and females incubate and care for offspring (Audubon 2009).

Populations:
Total population size of the eastern black rail is unknown as secretive habits and a dearth of information from most of this species' range make estimation difficult, but likely rare and irregular (Eddleman et al. 1988, Eddleman et al. 1994, NatureServe 2008).

Population Trends:
NatureServe (2008) cites a number of studies showing donward trends, noting that a 1988 census in southern New Jersey found rails at only 14 of 59 sites (Kerlinger and Sutton 1989), that "black rails were absent from many historical sites in Atlantic barrier island marshes, and observers attribute their disappearance to intense wetland alteration and human intrusion" (Ibid.), and that

black rails have nearly dissapeared in the Prime Hook National Wildlife Refuge/Broadkill Beach, Delaware area (Armistead 1990).

Status:

Though breeding populations are present in much of North America, populations are relatively small and declining. NatureServe (2008) lists the black rail as critically imperiled in Connecticut, Delaware, Illinois, Kansas, Maryland, Missouri, Nebraska, New York, Oklahoma, and Tennessee, imperiled in Florida, Georgia, New Jersey, Texas, and Virginia, vulnerable in North Carolina. It is not ranked in Alabama, Arkansas, Louisiana, Mississippi, and South Carolina.

It is state-listed as endangered in Illinois, Indiana, New York, Delaware,and Connecticut, threatened in New Jersey, and as a species of special concern in North Carolina, Maryland, and Virginia.

Eddleman et al. (1988) concluded that "The status of the midwestern population of inland breeding Black Rails is unknown, but sightings and calls have been alarmingly low in the last 40 years in breeding areas and in Gulf Coast wintering areas."

Habitat destruction:

Loss and degradation of habitat is the greatest threat to the continued existence of the eastern black rail (Todd 1977, Tiner 1984, Kerlinger and Sutton 1989, Kerlinger and Wiedner 1990, Eddleman et al. 1994, NatureServe 2008). As a wetland-obligate species, eastern black rails have become increasingly threatened by agricultural development and urbanization in the 20th century. Several states that comprise a substantial portion of the black rail's historical range have lost 70% or more of their wetlands; Connecticut and Maryland stand out particularly (Dahl 1990). Citing a number of sources, NatureServe (2008) noted large loss of wetland habitats for the black rail, stating:

"According to Tiner (1984), only 46% of the original 87 million ha of wetlands in the U.S. remained by the mid-1970s. Between the mid-1950s and the mid-1970s, 7,300 ha of estuarine and 178,000 ha of palustrine wetlands were lost each year. Most of this national wetland loss was attributed to agricultural development. The coastal marshlands of several Northeastern states diminished by hundreds to thousands of hectares each year in the 1970s (Tiner 1984). New Jersey and New York, suffered significant wetland loss from dredge and residential development in coastal areas (Tiner 1984, Kerlinger and Sutton 1989). Connecticut also lost approximately half of theits original wetland acreage (Tiner 1984)."

There are no indications that loss of habitat for the eastern black rail has ceased or that extensive areas have been restored.

Overutilization:

Black rails have not been considered a game species in decades, but are occasionally taken in hunts for other rails (Eddleman et al. 1994, NatureServe 2008).

Disease or predation:

Predation by various species is well documented, and is most likely to occur when high tides force black rails from dense vegetative cover, exposing them to predators (Evens and Page 1986). Common predators include great egrets (Ardea alba), great blue herons (Ardea herodias), and northern harriers (Circus cyaneus), several owl species, ring-billed gulls (Larus delawarensis), and domestic cats (NatureServe 2008). Other possible predators include foxes, snakes, snapping turtles (Chelydra serpentina), and raccoons (Procyon lotor).

Inadequacy of existing regulatory mechanisms:

There are few to no protections specifically targeted towards the eastern black rail. NatureServe (2008), for example, concluded:

"No state in the Northeast presently implements any management procedures or programs specifically designed to protect or enhance populations or breeding areas (Davidson 1992). Many breeding areas in the region are located on state wildlife areas and national wildlife refuges. However, large areas of high marsh on these public lands have been impounded and are managed primarily for waterfowl. Water levels in these areas are typically too high to support the required habitat."

The black rail is state-listed as endangered in Illinois, Indiana, New York, Delaware,and Connecticut, threatened in New Jersey, and as a species of special concern in North Carolina, Maryland, and Virginia. However, these designations afford the black rail no substantial regulatory protection for the rail's habitat despite the fact that the species is primarily threatened by habitat destruction.

Other factors:

The eastern black rail faces a number of other threats to its continued existence, including invasive species, pollution, climate change and burning of marshes. The common reed, (Phragmites spp.) is a weedy, invasive species that threatens the integrity of many tidal wetland or marsh communities. Anthropogenic disturbance and development near these habitats facilitates the incursion of Phragmites, particularly by increasing nitrogen availability through runoff from agricultural and urban or suburban areas (King et al. 2007). Disturbed and stressed wetlands are known to be most vulnerable to Phragmites invasion (NatureServe 2008). Phragmites outcompetes native plants, replacing them with dense, monospecific stands that are thought to be unsuitable as black rail habitat (Audubon 2009). While the specific effects of Phragmites on black rail populations are as yet unknown, this invasive plant is widely cited as a plausible contributor to the black rail's decline. The black rail also appears to be threatened by red fire ants (Solenopsis invicta). Legare and Eddleman (2001) observed that fire ants constructed mounds under nests and killed one hatchling.

Chemical contamination is reported in several other marsh bird species (e.g., Stendell et al. 1980) and is thought to have a potentially significant impact on the health of some black rail populations. Toxins may come from agricultural runoff (pesticides, fertilizers), recreation (lead shot), or other human activities.

Because climate change is projected to increase the frequency of major weather events and cause rising sea levels, it presents a serious threat to the black rail because of its use of coastal habitats and sensitivity to flooding.

Finally, many salt marshes in the eastern coastal plains are burned annually, a practice that may inadvertently cause habitat loss as the dead vegetation used by black rails for nesting is removed

(NatureServe 2008).

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Scientific Name:
Lepidostoma morsei
Common Name:
Morse's Little Plain Brown Sedge

G Rank:
G2

Range:
Morse's little plain brown sedge is a species of caddisfly endemic to the southeastern United States. It occurs in Florida, Mississippi, New Jersey, and Texas, though it is known from only a very few locations within this range and is considered rare (NatureServe 2008).

Habitat:
This caddisfly occurs in flowing water habitats and is most commonly sighted among dead plant material (NatureServe 2008). In Florida, this species is associated with blackwater (softwater) stream habitat, a unique ecosystem threatened by a multitude of factors (Florida FWC 2009).

Ecology:
Larvae are aquatic, and as members of the Lepidostomatidae, are tube-case makers, constructing encasements of sand, vegetative matter, or other available material that protect them from predators for the duration of their aquatic stage (NatureServe 2008, Grimaldi and Engel 2005). Emergent adults do not generally disperse great distances from their site of emergence, and dispersal distance is negatively correlated with vegetation density around the emergence site, emphasizing the importance of habitat continuity and integrity (Collier and Smith 1997, LaFontaine 1981). The Morse's little plain brown sedge does not migrate.

Populations:
Total global abundance is estimated to be less than 1000 individuals (NatureServe 2008). Until 2004, only two occurrences of Morse's little plain brown sedge were known: one in Little Alaqua Creek (Walton County, Florida), and one in Stone County, Mississippi. Cosgrove (2004 as cited in NatureServe 2008) reports an occurrence in New Jersey, and NatureServe (2008) reports another in Texas. Clearly, these occurrences are highly disjunct, and while other populations may exist, the viability of such isolated populations is likely to be quite low. This species is known from only two specimens in Florida, one from 1970 and one from 1984 (Rasmussen et al. 2008).

Population Trends:
Population trends, both short- and long-term, are unknown due to the rarity of this species (NatureServe 2008).

Status:
NatureServe (2008) lists Morse's Little Plain Brown Sedge as critically imperiled in Florida, and its status is under review in Mississippi, New Jersey, and Texas. It is state-listed as endangered in Ohio, Alabama, and New Jersey, and as a species of special concern in Maryland. The Florida Committee on Rare and Endangered Plants and Animals ranks this species as threatened (Rasmussen et al. 2008).

Habitat destruction:
This caddisfly is sensitive to siltation and pollution (NatureServe 2008) and is thus threatened by a variety of factors including unsustainable forestry practices; conversion of habitat to agriculture,

industrial, and residential development; surface water diversion; groundwater withdrawal for irrigation, municipal, and other uses; resource extraction, and unsustainable recreational activities (Florida Wildlife Conservation Commission 2009).

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that no occurrences are appropriately protected or managed. The range of this species in Florida is on Eglin Air Force base, which provides some habitat protection but does not necessarily protect this species from pollution, a primary threat.

Other factors:
This caddisfly is threatened by water pollution (NatureServe 2008). The Florida Wildlife Conservation Commission (2009) reports that the softwater streams which support this species are threatened by contamination by toxins and chemicals, eutrophication and nutrient loading from municipal and agricultural sources, and invasive species.

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Scientific Name:
Leptoxis arkansensis
Common Name:
Arkansas Mudalia

G Rank:
G1

Range:
The Arkansas Mudalia occurs in several creeks in Arkansas and in the North Fork of the White River basin watershed in Missouri (Wu et al. 1997). Its occurrence in Missouri was confirmed in 2006 (P. Johnson, AL DCNR, pers. comm., November 2006 cited in NatureServe 2008). It was thought to be extirpated in Arkansas, but was redetected in 2009 (Hayes et al. 2009).

Populations:
There are fewer than five populations of this snail (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this snail very rapidly declining (decline of 50-70 percent). It was thought to be extirpated in Arkansas (Wu et al. 1997) but was recently redetected at several historical sites in the state (Hayes et al. 2009).

Status:
NatureServe (2008) ranks the Arkansas Mudalia as critically imperiled in Arkansas (G1S1) and vulnerable (S3) in Missouri. It is a Species of Conservation Concern in Missouri.

Habitat destruction:
The Arkansas Mudalia is extremely vulnerable to habitat loss and degradation due to its limited range. The Missouri Dept. of Conservation (2001) reports that the North Fork of the White River watershed is threatened by water quality degradation due to high fecal coliform levels, nutrient loading, and sediment deposition. Activities such as gravel dredging, indiscriminate land clearing, livestock grazing in riparian zones, and contamination from septic systems and municipal discharges all threaten this species' habitat (Missouri Dept. of Conservation 2001).

Mining is also a threat to the Arkansas Mudalia. The Missouri Department of Natural Resources, Division of Geology and Land Survey, has identified 23 active mines and 137 past producers within the North Fork Watershed in Missouri, including gravel removal operations, limestone quarries, and iron mines, all of which threaten water quality (Missouri Dept. of Conservation 2010).

Recreational activities and developments also threaten this snail. The North Fork Watershed is heavily used for fishing and floating. Bank and shoreline development continues to occur in some areas on the major streams of the watershed, with housing construction on the North Fork River downstream of the Mark Twain National Forest being one example. Problems associated with recreational activities and developments include destabilization of stream banks and flood plains due to vegetation removal, increased sediment loading, and water quality impacts from poorly treated sewage (Missouri Dept. of Conservation 2010).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect this snail. It is a Missouri Species of Conservation Concern but this does not convey regulatory protection. It has no status in Arkansas (Anderson 2006).

Other factors:

This species is threatened by pollution from a variety of sources.

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Scientific Name:
Leptoxis picta
Common Name:
Spotted Rocksnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Spotted Rocksnail is 100-250 square km in Alabama. This species occurred historically in the main channel of the Alabama River in Monroe County, the main stem of the Cahaba in Dallas County, and the Coosa to the foot of the rapids in Elmore County (Goodrich 1941). Burch (1989) describes this snail's range as the Alabama River from the Coosa to Monroe County and the Coosa as far up as the gravel bars below the last series of rapids below Wetumpka. This species may now be extirpated in the Coosa and the Cahaba (NatureServe 2008). This snail was recently detected in a small section of the Alabama River downstream from Jones Bluff, Millers Ferry, and Claiborne Locks and Dams in Autauga, Dallas, Wilcox, Monroe, and Clark counties (Mirarchi et al. 2004).

Habitat:
The Spotted Rocksnail uses gravel, cobble, or bedrock substrate in flowing water (Mirarchi et al. 2004). This snail is associated with limestone outcroppings (Mirarchi et al. 2004).

Ecology:
Little is known about the ecology of the Spotted Rocksnail, but it is thought to be somewhat sedentary, moving little within appropriate habitats (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 6-20 populations of Spotted Rocksnail, but this may not reflect suspected extirpation from the Coosa and Cahaba (Bogan and Pierson 1993). This snail has been recently reported only from three short reaches of the Alabama River (Mirarchi et al. 2004). It appears to be doing well below Claiborne Dam, but is uncommon below Millers Ferry Dam. In the early 1990s, it was locally abundant downstream of Claiborn Lock and Dam, but more recent surveys detected only a few specimens (Mirarchi et al. 2004). Total population size is crudely estimated at 250 - 10,000 individuals (NatureServe 2008).

Population Trends:
The Spotted Rocksnail is rapidly declining (decline of 30-50 percent) in the short-term and has experienced a substantial long-term decline of 50-75 percent (NatureServe 2008). The decline may be even greater than this, in light of recent information on extirpations in the Coosa, Cahaba, and portions of the Alabama (Mirarchi et al. 2004).

Status:
The Spotted Rocksnail is critically imperiled (G1S1) (NatureServe 2008). Stein (1976) reports it as endangered in Alabama (Mirarchi 2004). It is categorized by the IUCN as vulnerable.

Habitat destruction:
Habitat loss and degradation from impoundment and pollution have already extirpated this species from much of its former range, and remain ongoing threats to its survival, particularly non-point source pollution from agriculture. Extensive portions of this snail's habitat in the Alabama and Coosa were lost to impoundment. Alterations in flow and water quality from the operation of

Jordan Dam contributed to extirpation in the lower Coosa. Water quality deterioration likely extirpated this snail from the lower Cahaba and portions of the Alabama River. Snail fauna in this region have been adversely affected by changing patterns of land use, particularly intensive agriculture and ensuing siltation and pollution (Dillon and Lydeard 1998).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species.

Other factors:
Limited distribution and rarity make this snail vulnerable to extinction (Mirarchi et al. 2004).

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Scientific Name:
Leptoxis virgata
Common Name:
Smooth Mudalia

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The range of the Smooth Mudalia encompasses 250-1000 square km (NatureServe 2008). This Tennessee River drainage endemic historically occurred from the headwaters of the Tennessee downstream to Jackson County, Alabama, and in the Holston River drainage from Sullivan to Knox counties, TN (Burch 1989). This snail still occurs in the Clinch, Powell, French Broad, Holston, Nolichucky, and Hiwassee river drainages in Tennesse, and potentially in North Carolina and Virginia (Mirarchi et al. 2004).

Habitat:
The habitat requirements of this snail have not been studied, but based on its extirpation in polluted waters and waters that have been dammed, it requires clean, flowing water (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are from 6-20 extant populations of the Smooth Mudalia. Overall population size is unknown. "Fairly dense" populations are present in sections of the Hiawassee River drainage.

Population Trends:
The Smooth Mudalia has been extirpated from much of its historical habitat. Remaining populations in the Tennessee River headwaters appear to be secure, but their survival depends on maintaining suitable habitat conditions.

Status:
The Smooth Mudalia is critically imperiled in Tennessee and presumed extirpated in Alabama (NatureServe 2008). NatureServe (2008) ranks the snail as SNA (Not Applicable) in North Carolina and Virginia, and reports of populations from those states may be erroneous (Mirarchi et al. 2004, LeGrand et al. 2006). It is classified as Vulnerable by the IUCN. Many populations have been extirpated and the snail's historical range has been dramatically reduced.

Habitat destruction:
The Smooth Mudalia is dependent on unpolluted, flowing water for survival. Much of this snail's historical range has been polluted or inundated by the creation of reservoirs, resulting in population extirpation (NatureServe 2008). This species is threatened by any activity which degrades water quality, including logging, mining, runoff, pollution, and disruption of flow regime. This snail potentially occurs within the project area of a proposed industrial development by the Chicago Bridge and Iron Company on the bank of the Tennessee River and Guntersville Reservoir in Marion County (TVA 2009). This snail is also potentially threatened by the development of a commercial marina on the bank of the Tennessee River in Marion County (U.S. ACOE 2009).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms for the protection of the Smooth Mudalia. Johnson et al. (2005) reported populations of this species in and adjacent to the Cherokee National Forest in Polk Co., Tennessee, so some habitat for this species is under federal management, but this does not convey habitat protection.

Other factors:

Any factor which degrades water quality will negatively affect the Smooth Mudalia, including pollution, alteration of hydrologic regime, introduction of invasive species, drought, etc. The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996).

References:

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U.S. Army Corps of Engineers. 2009. Rarity Club Marina Draft Environmental Assessment. File No. 200500237. Applicant: Nickajack Shores Holdings LLC. Application for Proposed Docks at Embayment Adjacent to Tennessee River Mile 426.7R Nickajack Reservoir. http://www.tva.gov/environment/reports/rarity_club_marina/rarity_club_marina_dea.pdf Accessed Jan. 12, 2010.

Scientific Name:
Leuctra szczytkoi
Common Name:
Louisiana Needlefly

G Rank:
G2

IUCN Status:
NE - Not evaluated

Range:
This stonefly, also known as the Schoolhouse Springs Leuctran Stonefly, is found in the Red River Drainage of central and north central Louisiana (NatureServe 2008). Its range is less than 100-250 square km (less than about 40 to 100 square miles).

Habitat:
The Louisiana needlefly is found in slow moving streams with tea colored water, abundant attached microbes, sandy substrate, and abundant woody debris (NatureServe 2008). It prefers areas that are shaded by overhanging hardwoods (USFS 2007).

Populations:
This species is known from four sites, one of which is now historical. There is a high probability more occurrences exist within its very limited global range (Red River Drainage of LA only). NatureServe (2008) estimates that this species could potentially have up to 20 genuinely discrete occurrences, but there is currently no data to confirm this assumption. This species can be locally abundant in appropriate habitat.

Population Trends:
Trend has not been quantified for this species. It is known from only four sites, and appears to have been extirpated from one of them. This would indicate a 25 percent decline, but this species is expected to be found in more locations following future surveys.

Status:
This species is known from only three sites, has an extremely limited range, and specialized habitat. It is ranked as imperiled by NatureServe (2008). It was a Federal C-2 and C-3B candidate species before those lists were abolished.

Habitat destruction:
NatureServe (2008) reports that this species is threatened by alteration of habitat by heavy siltation, dams, and diversions. This stonefly is also threatened by pesticide runoff, and could become threatened by Dimilin used in gyspy moth eradication efforts.

Leuctra szczytkoi faces habitat destruction from ATV use on the Kisatchie National Forest in Lousiana: “Heavy ATV use in the watershed could result in harmful scouring of the substrate, reducing available habitat for the Schoolhouse Springs leuctran stonefly. The Swafford, Beaver, and Jordon Creeks on the Catahoula District are three of the four places the Schoolhouse Springs leuctran stonefly has been found. Continued off-route motorized use … could therefore pose a threat to the Schoolhouse springs leuctran stonefly. The prohibition of off-route motorized travel … would benefit the stonefly” (USFS 2007).

Inadequacy of existing regulatory mechanisms:

The Nature Conservancy now owns the type locality for this stonefly, but this species no longer occurs there (NatureServe 2008).

Leuctra szczytkoi occurs in the Kisatchie National Forest in Lousiana, where it is a Regional Forester Sensitive Species. It has been collected from Loving Creek on the Evangeline Unit; and Swafford Creek, Beaver Creek, and Jordon Creek on the Catahoula District (USFS 2007). Protection offered to sensitive species is discretionary, and even on national forest lands this species is threatened by logging projects and recreation, particularly from ATV use.

No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Libellula jesseana
Common Name:
Purple Skimmer

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
This species is endemic to Florida (NatureServe 2008). It is found in two disjunct areas, nine counties on the eastern side of Florida Peninsula, and Bay/Washington Counties in the Florida Panhandle.

Habitat:
This dragonfly inhabits clear-water, sand-bottomed lakes, of the most infertile type, edged with sparse maiden-cane grass and St. John's Wort shrubs (NatureServe 2008). Adults forage in open woodland or shrubland.

Ecology:
In polluted lakes, this species is displaced by the common species L. Auripennis.

Populations:
This species was previously known from 15 lakes, but NatureServe (2008) cites a personal communication from Jerrell Daigle (2006) stating that this species is now only detected regularly at a single lake. It is thought that this dragonfly might occur in a few lakes in adjacent Georgia and Alabama, but to date there have been no detections outside Florida. This species is abundant in appropriate habitat.

Population Trends:
NatureServe (2008) reports a short term decline of 10-30 percents, and projects a long-term decline of over 75 percent because this species cannot persist in developed or polluted habitats. Paulson (2007) reports that recent information indicates the species has disappeared from all of its known former locations in the Florida Panhandle and has not been seen recently at some former locations in the Florida Peninsula.

Status:
According to NatureServe (2008), this species was previously ranked as imperiled based on recently known occurrences, at the suggestion of Sid Dunkle. Although it was suspected that additional occurrences probably existed, the rank also reflected the rapid development of sand bottom lakes in Florida and the sensitivity of this species to eutrophication. However according to Jerrell Daigle as of 2006 there is only one lake in a state park where this species can still be found regularly, and this species is now ranked as critically imperiled (G1S1). It is ranked as vulnerable by the IUCN. This dragonfly is highly threatened by lakeshore development and resultant pollution.

Habitat destruction:
This species is threatened by the explosive population growth in Florida, especially around the type of lake where this species occurs (NatureServe 2008). This dragonfly is highly sensitive to eutrophication, and sand-bottomed lakes in its habitat are being developed rapidly. Lake eutrophication caused by lawn fertilizers and septic tank outflows allows L. Auripennis to outcompete L. jesseana. NatureServe (2008) states: "relatively slight eutrophication of a lake would eliminate this species."

Paulson (2007) reports that "[e]utrophication and other types of water pollution from human settlement at and near lakes, ongoing in much of L. jesseana range in Florida, continue to threaten the habitat. Ground-water depletion because of irrigation could dry up some of the shallower ponds, which is also continuing to happen on the sandy ridges of Florida…. Recent information indicates the species has disappeared from all of its known former locations in the Florida Panhandle and has not been seen recently at some former locations in the Florida Peninsula. Although no exhaustive surveys have been conducted recently, right now anyone who wants to see the species is directed to a single location, Scheeler Lake in Gold Head Branch State Park, Clay County, as no one knows of other locations for certain. However, even this location may not be suitable in the future as natural succession may make it uninhabitable for this sufficiently specialized species."

According to the Florida Department of Environmental Protection (2006), the Site 1 Impoundment Project of the Central And Southern Florida Project Comprehensive Everglades Restoration Plan will destroy the habitat of L. jesseana. “The purple skimmer dragonfly (Libellula jesseana) is a rare odonate species recorded from aquatic areas throughout Palm Beach County… The project site is not expected to support a highly diverse aquatic invertebrate community due to the lack of habitat in the canalized canal and potential water quality issues in the existing pond and small lake on the project site (USFWS 2004)… Fish and wildlife habitat at the proposed impoundment site is expected to be adversely impacted by future residential development.”

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect this dragonfly. It occurs in a state park and on the Ocala National Forest.

References:

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Needham, James G., and Minter J. Westfall, Jr. 1954. A Manual of the Dragonflies of North America (Anisoptera). University of California Press, Berkeley, California. 615 p.

Paulson, D. R. 2007. Libellula jesseana. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. Available at http://www.iucnredlist.org/apps/redlist/details/11929/0. Last Accessed 17 March 2010.

Paulson, D.R. and S.W. Dunkle. 1999. A Checklist of North American Odonata. Slater Museum of Natural History University of Puget Sound Occasional Paper Number 56:86 pp.

Scientific Name:
Lilium iridollae
Common Name:
Panhandle Lily

G Rank:
G2

Range:
Lilium iridollae is endemic to the western Florida panhandle and southern Alabama (Chafin 2000). The range of this species is contested. Some say it ranges from northwest Florida and south Alabama to Virginia, though its distribution is discontinuous within this area. But others consider those in the sand hills of the Carolinas and Virginia to be a separate species, L. pyrophilum (NatureServe 2008). Accepting L. pyrophilum as distinct, L. iridollae is limited to the Gulf Coastal Plain, and its range encompasses fewer than 250 square km (100 square miles) (NatureServe 2008). It is found in Escambia, Okaloosa, Santa Rosa, and Walton counties, the four westernmost counties in Florida, and in two counties in adjacent Alabama (Chafin 2000, Coile 2000).

Habitat:
The Panhandle lily is a wetland obligate, meaning it occurs almost always in a wetland habitat (Tobe et al. 1998). It can be found in baygalls, swamps and bogs, wet savannas, seepage slopes, floodplain and bottomland forests, wet flatwoods, stream banks, and banks of blackwater creeks (Chafin 2000, Kral 1983, NatureServe 2008, Tobe et al. 1998). Seepage slopes are located where water flowing downhill is forced to the surface by an impermeable layer of clay or rock. Baygalls are seepage depressions at the base of slopes, with a canopy of dense, evergreen hardwoods, an open understory, and acidic, peaty soil. Floodplain and bottomland forests, located in stream corridors, have a closed canopy of hardwoods and a dense to open understory and experience occasional to frequent flooding. Soil types here vary and can consist of clay, organic materials, sand, and alluvials (NatureServe 2008). L. iridollae is often located at the edges of these areas or in clearings with full sunlight or semi-shade (Adams and Dress 1982, Kral 1983). The panhandle lily prefers moist, loamy, acidic soils, often low in nutrients, consisting of organic muck, sphagnous peat, and sand (Kral 1983, NatureServe 2008).

Ecology:
L. iridollae is an herbaceous, bulbous, perennial (Barrows 1989, Kral 1983). It reaches heights of 3 to 5 feet, and it flowers from July to August (Chafin 2000, Henry 1946). Its capsules ripen in mid-October, producing flat, winged, wind-dispersed seeds (Adams and Dress 1982, NatureServe 2008). Flowers and leaves provide a natural food source for herbivores and insects (Barrows 1989). L. iridollae prefers full or partial sunlight because shade and root competition cause it to lose vigor and eventually die (Kral 1983). Its habitats are fire dependent, with seepage slopes burning every five years and baygalls every 50. Fires act to reduce tree invasion and shrub height, and in areas where fire is less frequent, panhandle lily is limited to the margins (NatureServe 2008).

Populations:
Between six and 20 occurrences of L. iridollae are estimated by NatureServe (2008). Seventy sites were known in Florida in 2000, but over half of all known sites are considered to have poor viability, and are composed of fewer than ten plants (Chafin 2000, NatureServe 2008). There is

only one known large occurrence, located in Alabama, and most populations have only one or two stems reported (NatureServe 2008). Fewer than 1,000 individuals are estimated (NatureServe 2008).

Population Trends:
Lilium iridollae was already rare when first discovered in 1946 (Henry 1946).

Status:
NatureServe (2008) ranks the Panhandle lily as critically imperiled in Alabama and South Carolina, and imperiled in Florida. It has not been ranked in Virginia.

Habitat destruction:
The panhandle lily is threatened by habitat loss and degradation from several factors. Fire suppression in nearly the entire longleaf pine region has rendered unsuitable many panhandle lily habitats. Even in areas where appropriate fire regime has been reintroduced, in situ seeds may no longer be viable in many areas, so lilies would need to be reintroduced. Fire breaks in ecotones which prevent fire from reaching wetland habitats have already caused a decline in this species' viability and will continue to do so (Chafin 2000). Drainage of wetlands and conversion of vast areas to agricultural lands and pine plantations has resulted in the loss of many suitable sites. As panhandle lilies are dependent on inundated soils, draining wetlands for any type of land conversion is deleterious to this species (NatureServe 2008). Changes in hydrology resulting from logging, construction, and development also threaten this species (Chafin 2000). Extensive loss of habitat to housing and industrial tracts has had a permanent impact. Lilies can survive in powerline and gasline corridors, which need to be surveyed. In these areas, lilies may be threatened by herbicide applications. The construction of dams on streams where L. iridollae occurs has impacted at least one population in Florida, and the construction of farm and recreation ponds on dozens of streams has possibly impacted plants in the Carolina Sandhills. Drainage, bulldozing, root raking, bedding, chopping, and grazing can all lead to the elimination of this species (Kral 1983). L. iridollae is extremely sensitive to grazing pressure. Its leaves and stems are highly palatable to cattle and deer, and hogs uproot the bulbs (Henry 1946, Kral 1983). Grazing by deer in natural landscapes may be deleterious where their populations are not kept in check by hunting or natural predators. Kral (1983) states that "All lilies are highly palatable to both deer and cattle and are the first to go with any grazing pressure."

Overutilization:
Overutilization is a documented threat to this species. A population was removed by horticultural collectors from Conecuh National Forest (White et al. 1992). The Panhandle lily is "large and showy" and "collecting may be more common than currently believed, especially among those people desirous of possessing such a rare entity" (White et al. 1992, NatureServe 2008). The threat posed to this rare species by overcollection is magnified by the threats of habitat loss and predation from grazing.

Disease or predation:
The panhandle lily is threatened by predation from cattle, deer, hogs, and possibly insects (Henry 1946, Kral 1983, Barrows 1989). Barrows (1989) reports predation by an unknown animal and herbivory by insects. In conjunction with other threats, and given the drastically reduced range of this species, even natural levels of predation could increasingly threaten this species.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that no occurrences of this species are appropriately protected. Even on public lands where the lily is protected from development, it is threatened by fire suppression

and by collection (White et al. 1992, Chafin 2000). This lily is documented on Eglin Air Force Base, Blackwater River State Park and Blackwater River State Forest in Florida, and in Conecuh National Forest, Alabama.

References:

Barrows, E.M. 1989. Flower number, plant size, and plant vigor in a Florida population of the globally endangered pot-of-gold lily, Lilium iridollae. J. Washington Academy Science 79(3): 118-122.

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White, D.L., T.E. Ostertag, and R.A. Hilsenbeck. 1992. Draft final status survey report for the panhandle lily (Lilium iridollae Henry). U.S. Fish and Wildlife Service Cooperative Agreement No. 14-16-0004-89-961.

Scientific Name:
Lindera subcoriacea
Common Name:
Bog Spicebush
G Rank:
G2
Range:
Lindera subcoriacea is endemic to the Southern Coastal Plain and occurs in southeast Virginia, Florida, Louisiana, Alabama, Georgia, Mississippi, North Carolina, and South Carolina (Weakley 2004).
Habitat:
L. subcoriacea prefers shrub-dominated seepage wetlands that remain moist or wet year-round (Gordon et al. 1986). It was first identified in the evergreen peat bogs of southern Mississippi and southeastern Louisiana (Bridges and Orzell 1989, Wofford 1983). Within the Gulf Coastal Plain, this species inhabits pitcher plant bogs or quaking bogs on flat ground, and hillside seepage bogs on moderate slopes. In the more northerly portion of its range, the Sandhill region of the Carolinas and Georgia, it is found in pocosin swamps - forested wetlands that border stream headwaters (NatureServe 2008). Habitats are often fire-maintained (Wofford 1983). Soils in the southern part of this species' range are high in organic matter, acidic, and permanently saturated (Gordon et al. 1986). Further north, soils are drier but still consistently moist. L. subcoricea requires significant solar exposure, so limited canopy cover is essential (NatureServe 2008).

Ecology:
L. subcoriacea is a dioecious, deciduous, perennial shrub; flowering occurs in mid-March and fruits mature in late fall (Wofford 1983). This species often reproduces clonally, sending out new shoots to replace older stems (Gordon et al. 1986). Rangewide, it is often found with Magnolia virginiana, Myrica heterophylla, and Rhus vernix (Bridges and Orzell 1989).
Populations:
Few occurrences of this species remain, and most are of low quality because of small population size or unequal sex distribution (NatureServe 2008). Because L. subcoriacea reproduces clonally, most populations have notably low genetic diversity, generally consisting of just 1-5 genetically distinct individuals. There are currently fewer than 115 individuals in Mississippi, fewer than 150 in North Carolina, and fewer than 50 in the rest of the species' known range (NatureServe 2008).
Population Trends:
NatureServe (2008) reports that this species is rapidly declining, largely because of habitat loss, although establishing longterm trends is challenging as the species was first desecribed in 1983.
Status:
This species is naturally restricted to a small range because of its habitat specificity, and habitat loss and degradation are driving further range contraction. Remaining populations are very small and suffer from low genetic diversity, exposing them to the perils faced by all similar populations: e.g., stochastic extinction, inbreeding depression.

NatureServe (2008) reports that the bog spicebush is critically imperiled in Alabama, Florida, Georgia, and Louisiana, imperiled in Mississippi and North Carolina, and vulnerable in South Carolina. It is listed as endangered in North Carolina and Florida, and is a sensitive species or species of special concern in several other states where it occurs.

Habitat destruction:

Fire suppression is a major cause of the bog spicebush's decline, as this species' preferred habitat is maintained by fire. Without periodic fires, shrubs and trees encroach upon L. subcoriacea's habitat, outcompeting and excluding the spicebush. Prescribed burns have been proposed as a possible management solution, but as residential and agricultural development fill the longleaf pine/wiregrass upland areas surrounding swampland habitat, burns become a less viable and less popular option (NatureServe 2008). Siltation and pollution from development, agriculture, and other industry (primarily timber harvesting) degrade and destroy the bog spicebush's habitat, as do dams, diversions, and drainage of bogs and wetlands. It is estimated that 97 percent of Gulf Coast bog habitats have been considerably altered or destroyed by anthropogenic activities (Wofford 1983).

Inadequacy of existing regulatory mechanisms:

L. subcoriacea has only been recently described (1983) and so has not received as much attention as its conservation status may warrant. No existing regulatory mechanisms adequately protect this species. It is listed by the states of Florida and North Carolina as endangered, and as a species of special concern in several other states, but these designations offer the spicebush no substantial regulatory protection. Additionally, most populations occur on private lands (NatureServe 2008).

Other factors:

The bog spicebush has high environmental specificity (narrow habitat preferences) and occupies habitat that is naturally rare; it is therefore highly sensitive to further habitat losses (NatureServe 2008).

References:

Bridges, E.L., and S.L. Orzell. 1989. Lindera subcoriacea (Lauraceae) new to Alabama. Phytologia 67: 214-216.

Gordon, K.L., R.L. Jones, and J.B. Wiseman, Jr. 1986. Status report - Lindera subcoriacea B.E. Wofford. U.S. Fish and Wildlife Service, Endangered Species Office, Jackson, Mississippi. 31 pp. + appendix.

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Scientific Name:
Linum westii
Common Name:
West's Flax

G Rank:
G2

Range:
Restricted to northern portion of Florida, this plant occurs in Jackson, Gulf, Franklin, and possibly Liberty and Bay Counties. Reports from Mississippi and Georgia are thought to be misidentifications (NatureServe 2008).

Habitat:
This plant occurs along shallow pond margins within slash pine (Pinus elliottii) - saw palmetto (Serenoa repens) flatwoods, bogs, wet prairies or depression marshes. It is also found on the margins of cypress ponds and occasionally in ditches (NatureServe 2008).

Ecology:
This plant is perennial, and is thought to be fire-maintained.

Populations:
Only 14 occurrences of this species were reported as of 1998, all in Florida, but this flax may be under-reported because of the difficulty of field identification. It is not abundant at any known location (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that West's flax is declining across its range.

Status:
NatureServe (2008) ranks L. westii as imperiled in Florida, where it is also listed as endangered.

Habitat destruction:
This species' habitat is threatened by wetland conversion to other uses, fire suppression, and the establishment of timber plantations (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in Florida, this designation affords West's flax no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species or its habitat.

References:

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 13, 2010)

Scientific Name:
Lirceus culveri
Common Name:
Rye Cove Isopod

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
Lirceus culveri is confined to the hydrology of McDavids Cave in Scott County, Virginia.

Habitat:
The Rye Cove isopod inhabits gravel or fused gravel substrate in areas of streams marked by riffles (Estes and Holsinger 1976)

Ecology:
This species is not tolerant of stream perturbance or groundwater pollution (NatureServe 2008). According to the Va. DCR (1997), "[t]he isopod plays an important role in the ecosystem by removing bacteria and fine organic matter from the aquifer. It provides a food source for salamanders, fish and crawfish. Cave isopods also serve as natural indicators of water quality in that they can survive in only the cleanest karst systems."

Populations:
This species occurs at a single site. Surveys in other caves and drainages in Rye Cove and surrounding areas have not produced this species, therefore it is presumed to occur only at the type locality, McDavids Cave. It is found in large numbers in its proper habitat within the hydrology of McDavids Cave.

Population Trends:
According to NatureServe(2008), this species is currently stable. Population may fluctuate naturally but the species is stable providing water quality in its cave system is not degraded.

Status:
Virginia classifies this crayfish as a Species of Special Concern. It was a Federal C2 Candidate species until that list was abolished. It is ranked by NatureServe (2008) as critically imperiled and by the IUCN as vulnerable.

Habitat destruction:
Development of Rye Cove or perturbance/pollution of ground or surface water in McDavids Cave could lead to the decline in population or extinction of this isopod (NatureServe 2008).

The VA DCR (1997) reports that "The Rye Cove isopod is threatened by contamination of the groundwater flowing into its habitat. In cave country, or karstlands, surface water sinks quickly into underground channels with minimal natural filtration. Contaminated runoff from land-clearing activities can introduce fertilizers, pesticides, herbicides and sediment into the cave system that can travel downstream for thousands of feet, and even for miles. Threats to the water supply also exist from chemical spills, septic systems, leaking fuel tanks, and debris and trash dumps."

This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota

(Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), McDavids Cave is privately owned. Acquisition or closing of McDavids Cave in conjunction with protection of watershed are recommended. No existing regulatory mechanisms protect this species.

References:

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Wood, D. 2009. Memorandum to J. Bailey, J. Wirts, and P. Campbell. Evidence for Secretary Randy Huffman. June 30, 2009. West Virginia Department of Environmental Protection, Charleston, WV.

Scientific Name:
Lithasia curta
Common Name:
Knobby Rocksnail

G Rank:
G1

IUCN Status:
DD - Data deficient

Range:
Historically the Knobby Rocksnail occurred in Alabama, Kentucky, and Tennessee, with records from Muscle Shoals and adjacent Shoal Creek in Lauderdale County, Alabama (Burch 1989). This snail has not been detected in Alabama since the construction of Wilson Dam (Mirarchi et al. 2004). The current range of this Tennessee River endemic covers less than 100 square km, as the species is only known to be extant in the tailwaters of the Kentucky dam, having last been reported in 1986 (Mirarchi et al. 2004).

Habitat:
This species is only known to be extant in the tailwaters of the Kentucky Dam, where the current is moderate to strong (Mirarchi et al. 2004).

Populations:
There is only one known extant population of Knobby Rocksnail, in the tailwaters of the Kentucky dam (Mirarchi et al. 2004). Total population size for this species is unknown, as is exact occurrence information (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that the Knobby Rocksnail has declined very rapidly in the short-term (50-70 percent decline), and has experienced large long-term decline of 75-90 percent.

Status:
NatureServe (2008) ranks the Knobby Rocksnail as critically imperiled globally, and as extirpated in Alabama and Tennessee, and not evaluated in Kentucky. It is classified as data deficient by the IUCN. It is on the Alabama Natural Heritage Program Tracking List. It was formerly a federal candidate for ESA protection (FWS 1994).

Habitat destruction:
The majority of the Knobby Rocksnail's habitat has already been lost (NatureServe 2008). Once distributed in three states, this snail is now extant only in the tailwaters of the Kentucky Dam (Mirarchi et al. 2004). This snail's habitat in Alabama was destroyed by the construction of Wilson Dam (NatureServe 2008). Because this species' distribution is already so severely restricted, it is highly vulnerable to further habitat disturbances.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Knobby Rocksnail. It is on the Alabama Natural Heritage Program Tracking List, but this does not convey legal protection. It was formerly a candidate for ESA protection (FWS 1994).

Other factors:
The Knobby Rocksnail is threatened by any factor which decreases water quality. Because this species is only known to be extant in a single location, it is vulnerable to stochastic genetic and environmental events.

References:

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U.S. Fish and Wildlife Service. 1994. Endangered and Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species. November 15, 1994. http://www.epa.gov/EPA-SPECIES/1994/November/Day-15/pr-42.html

Scientific Name:
Lithasia duttoniana
Common Name:
Helmet Rocksnail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The range of the Helmet Rocksnail is less than 100 square km in the Duck River basin in Tennessee (NatureServe 2008). Van der Schalie (1973) reports that this snail was historically collected in the Duck River in Marshall, Maury, and Humphreys counties. Bogan and Parmalee (1983) report this snail from the Harpeth River in Davidson County. Burch (1989) cites two tributaries to the Duck River in Bedford County, and the Duck River mainstem from Bedford County to Humphreys County. Dillon (1989) lists occurrences from the Duck River north of Farmington in Marshall County. The Southeast Aquatic Resources Partnership (2005) lists this species as occurring in the Upper and Lower Duck mainstems, the Buffalo River Mainstem, and Eastern Highland Streams.

Habitat:
This snail occupies riffle systems with rocky substrate and has also been detected on bedrock (NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are from 6-20 populations of this snail. Total population size is unknown. Bogan and Parmalee (1983) report fewer than 10 localities.

Population Trends:
This species has very rapidly declined (decline of 50-70 percent) in the short-term, and has experienced a large long-term decline of 75-90 percent (NatureServe 2008).

Status:
The Helmet Rocksnail is classified as vulnerable by the IUCN. It is ranked as imperiled (G2S2) by NatureServe 2008.

Habitat destruction:
This snail is threatened by logging, mining, cattle grazing, and oil and natural gas development (Cumberland HCP 2009). The Northern Cumberlands are threatened by logging and rapid conversion of native hardwood forests to industrial pine plantations. Almost every coal seam within the region has undergone some degree of surface mining and surface mining is ongoing. A large number of mines have been abandoned and cause serious water quality issues. Streams in the region are threatened by sedimentation and water quality degradation from agriculture and cattle grazing (Cumberland HCP 2009). Oil and natural gas wells are also prevalent throughout the region and potentially threaten aquatic habitats (Cumberland HCP 2009). Mussel species in Eastern Highland Streams where the Helmet Rocksnail occurs have been in decline for several decades due to instream habitat alterations and poor instream habitat conditions, which likely threaten this snail as well (Ahlstedt et al. 2004, Southeast Aquatic Resources Partnership (SARP) 2005). Mollusks in the Upper Duck mainstem are threatened by alteration of flow conditions, substrate destabilization, and manganese precipitates created by the operation of Normandy Reservoir (SARP 2005). Aquatic species in the Lower Duck mainstem are threatened by

agricultural activities and livestock grazing. Mollusks in the Buffalo River mainstem have experienced dramatic decline due to siltation, substrate destabilization, and chronic chemical pollution which are an ongoing threat for mussels there and thus threaten this snail as well (Ahlstedt et al. 2004, SARP 2005).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species.

References:

Ahlstedt, S.A., J.R. Powell, R.S. Butler, M.T. Fagg, D.W. Hubbs, S.F. Novak, S.R. Palmer, and P.D. Johnson. (2004) Historical and current examination of freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) in the Duck River basin Tennessee. Contract report for the Tennessee Wildlife Resources Agency FA-02-14725-00.

Bogan, A.E. and P.W. Parmalee. 1983. Tennessee's Rare Wildlife: Volume II: The Mollusks. Report to the Tennessee Natural Heritage Program and Tennessee Wildlife Resources Agency. 123 pp.

Burch, J.B. 1989. North American Freshwater Snails. Malacological Publications: Hamburg, Michigan. 365 pp.

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Dillon, R.T., Jr. 1989. Karyotypic evolution in pleurocerid snails. I. Genomic DNA estimated by flow cytometry. Malacologia, 31(1): 197-203.

Southeast Aquatic Resources Partnership. 2005. Conserving the Duck River: A Plan for Collaborative Action. http://southeastaquatics.net/uploads/document/DuckRiverCAP-2005v2.1.pdf Last accessed Jan. 11, 2010.

van der Schalie, H. 1973. The mollusks of the Duck River drainage in central Tennessee. Sterkiana, 52: 45-56.

Scientific Name:
Lobelia boykinii
Common Name:
Boykin's Lobelia

G Rank:
G2

Range:
Boykin's lobelia, Lobelia boykinii, is a perennial herb present in parts of Alabama, Florida, Georgia, Mississippi, New Jersey, North Carolina, South Carolina (NatureServe 2008).

Habitat:
Once widespread in the mid-Atlantic and southeastern United States, this species has become increasingly imperiled as a result of the loss of its wetland habitat. It is native to coastal plains and inhabits cypress-gum depressions of ponds, pine savannahs, clay-based Carolina bays, and other seasonal or permanent wetland habitat (Godfrey and Wooten 1981).

Populations:
Total population size is unknown, but is estimated to be between 1,500 and 10,000 individuals (NatureServe 2008). The largest known occurrences contain approximately 1,000 individual plants.

Population Trends:
NatureServe (2008) reports that population size and resilience of Boykin's lobelia has declined substantially over recent decades, and continues to decline rapidly.

Status:
This species is restricted to scattered populations in the southeastern Coastal Plain with a few disjunct occurrences in New Jersey and Delaware. The species' wetland habitats were once common in the southeast but are now limited in number due to drainage for agriculture and development. In addition, many southeastern wetlands are threatened by a drawdown in the regional water table, a result of intensive development over the last 10-20 years. Populations in New Jersey have declined for unknown reasons.

NatureServe (2008) lists Boykin's lobelia as critically imperiled in Alabama, Florida, Mississippi, and New Jersey, imperiled in Georgia, North Carolina, and South Carolina, and extirpated from Delaware.

Habitat destruction:
This plant's habitat is vulnerable to drainage for irrigation or other human uses (many populations have been lost this way), and to conversion of habitat to tree farms or agriculture. Habitat is also threatened by the suppression of natural disturbances that promote succession (Southern Appalachian Species Viability Project 2002).Though this species was once widely distributed throughout the mid-Atlantic and southeastern states, the vast majority of its historical range has been altered or lost, largely because of drainage for agricultural and residential development and conversion of habitat to agricultural lands (croplands and tree plantations are common) (NatureServe 2008). It is estimated that over 97 percent of herbaceous seeps and wet savannas, two types of habitat favored by L. boykinii within the southeastern coastal plain, no longer exist (Harper et al. 1998). Anthropogenic suppression of natural processes leading to disturbance also threatens this species' habitat; natural succession following disturbances opens space for new

colonizers and creates the spatial heterogeneity necessary for diverse native plant communities (NatureServe 2008). The wet savannas where this species thrived historically burned at regular intervals as a result of lightning strikes, but the 1920s marked the beginning of a period of widespread fire suppression. This suppression allowed dense forests to develop to the exclusion of early-successional herbaceous species like L. boykinii (Harper et al. 1998). The creation of plowlines (fire ditches) interrupts and compromises the hydrology of the ecosystems where L. boykinii is found (Harper et al. 1998). Livestock grazing and siltation from upland activities may also threaten this species.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect Boykin's lobelia.

Other factors:
Currently, this species is limited to the southeastern coastal plain, with some outlier populations in Delaware and New Jersey (NatureServe 2008). Because seep and wetland ecosystems are naturally somewhat rare, populations of species endemic to these ecosystems are naturally small and often reliant on gene flow among adjacent populations within a landscape (Harper et al. 1998). Anthropogenic alteration of the landscape, manifested primarily in habitat loss and fragmentation, exacerbates the vulnerability of these populations to stochastic extinction, inbreeding depression, and other perils associated with a loss of connectivity among populations. Many remaining occurrences of L. boykinii are isolated and thus of uncertain long-term viability.

References:

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. Georgia Press, Athens. 933 pp.

Harper, M.G., Trame, A., and M.G. Hohmann. 1998. Management of herbaceous seeps and wet savannas for threatened and endangered species. United States Army Corps of Engineers Research Laboratories Technical Report 98/70.

LeBlond, R.J., J.O. Fussell, and A.L. Braswell. 1994a. "Inventory of the rare species, natural communities, and critical areas of the Camp Lejeune Marine Corps Base, North Carolina." North Carolina Natural Heritage Program, DPR, Department of Environment, Health, and Natural Resources, Raleigh, NC.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: August 4, 2009).

Norquist, C. 1985. "Savannas and bogs of the southeastern U.S.: Threatened ecosystems." Endangered Species Technical Bulletin, 10(9):4-5.

Scientific Name:
Ludwigia brevipes
Common Name:
Long Beach Seedbox

G Rank:
G2

Range:
Also known as the Long Beach primrose-willow, this plant is endemic to the eastern Coastal Plain of the United States: it is found in Arkansas, Georgia, Maryland, North Carolina, New Jersey, South Carolina, and Virginia (NatureServe 2008). It is known historically from Ocean County in New Jersey, and from Craven, Currituck, Dare, Gates, Harnett, Hyde, Johnston, Robeson, Sampson, and Wayne Counties in North Carolina but is considered extirpated from these locales now, and currently known from Baltimore County in Maryland, from Isle of Wight, Northumberland, Southhampton and Virginia Beach Counties in Virginia, from Brunswick, Columbus, and Cumberland Counties in North Carolina, and from one unlisted county in Georgia (NatureServe 2008).

Habitat:
This plant inhabits shallow wetlands and the shores of lakes, ponds, marshes, swamps, blackwater rivers, swales, ditches, and impoundments (NatureServe 2008).

Populations:
It is unknown how many extant populations of this species remain or overall population size (NatureServe 2008).

Population Trends:
Populations are declining, but precise trends are not specified (NatureServe 2008).

Status:
NatureServe (2008) lists the Long Beach Seedbox as critically imperiled in Arkansas, North Carolina,and South Carolina, and imperiled in Virginia. It is reportedly extirpated from New Jersey, and its status is under review in Florida, Georgia, and Maryland. NatureServe (2008) reports that the Long Beach seedbox is imperiled or critically imperiled throughout its range because of its rarity and disappearance from historical occurrences.

Habitat destruction:
The Long Beach seedbox has been extirpated in numerous historic locations, though no specific cause for this range loss is cited (NatureServe 2008). Extensive loss of wetland habitat likely contributed significantly to this species' decline.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect Ludwigia brevipes. Though it is listed as a species of special concern in some states (Carroll County Forest Conservation Technical Manual 2007, VA DCR 2001), this attention affords it no significant regulatory protection.

References:

Carroll County, Maryland Forest Conservation Technical Manual. 2007. Carroll County Commissioners, Westminster County, MD. Accessed online August 13, 2009 << http://ccgovernment.carr.org/ccg/resmgmt/forconsmanual.pdf>>

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: August 11, 2009).

Virginia Department of Conservation and Recreation: Division of Natural Heritage. 2001. Conservation Plan for the Southern Watershed Area. Richmond, VA. Accessed online August 13, 2009 << http://www.dcr.virginia.gov/soil_and_water/documents/15-SWAMP-2001.pdf>>

Scientific Name:
Ludwigia ravenii
Common Name:
Raven's Seedbox

G Rank:
G1

Range:
Also known as Raven's primrose-willow, Ludwigia ravenii is reported from a patchy distribution within the Coastal Plain area of Virginia, North Carolina, South Carolina, and Florida (NatureServe 2008, Chafin 2000). Reports from Georgia are not confirmed. Most historical occurrences are now thought to be extirpated.

Habitat:
This plant occurs in open, wet, peaty habitat, usually at the margins of swamps, ponds, or bogs. It is a wetland obligate (Peng 1984). This plant is frequently encountered in utility corridors, roadside verges, and ditches (NatureServe 2008).

Ecology:
This plant is perennial, flowers from July-September, and fruits August-October (Peng 1984).

Populations:
There are currently ten or fewer known occurrences of this plant, and populations are generally small (NatureServe 2008).

Population Trends:
NatureServe (2008) determined that L. ravenii is experiencing moderate declines in the short term, but does not report long-term trends. Based on the disappearance of numerous historical occurrences, it seems that long-term trends are also indicative of a substantial decline.

Status:
NatureServe (2008) ranks L. ravenii as critically imperiled in Florida, North Carolina, and Virginia, and unrated in South Carolina.

Habitat destruction:
Raven's seedbox is threatened by habitat loss from drainage or other hydrological alteration, and conversion of its habitat to timber plantations and agricultural uses. Populations in disturbed habitat (e.g., ditches, utility corridors) are vulnerable to continued disturbance, herbicide use, and excavation or other construction (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect the Raven's seedbox.

Other factors:
Because this plant is self-compatible and frequently autogamous, its long-term viability may be compromised by low genetic diversity (Peng 1984)

References:

Chafin, L. G. 2000. Field guide to the rare plants of Florida. Florida Natural Areas Inventory, Tallahassee.

Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed February 2, 2010).

Peng, C.I. 1984. Ludwigia ravenii (Onagraceae), a new species from the Coastal Plain of the southeastern United States. Systematic Botany. 9(2): 129-132.

Weakley, A.S. 1996. Flora of the Carolinas and Virginia: working draft of 23 May 1996. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Dept., Chapel Hill, North Carolina. Unpaginated.

Scientific Name:
Ludwigia spathulata
Common Name:
Spathulate Seedbox

G Rank:
G2

Range:
Also known as the spoon primrose-willow, L. spathulata is endemic to the southeastern United States and occurs in a small range in South Carolina, Georgia, Florida, and Alabama (NatureServe 2008). Natural heritage records place this species in Alabama's Covington, Geneva, Houston, and Mobile Counties, in Georgia's Baker and Meriwether Counties (extirpated from Decatur County), and in South Carolina's Aiken, Allendale, Barnwell, Richland, and Saluda Counties (NatureServe 2008).

Habitat:
This species is found in periods of low water in exposed habitat around sinkhole ponds, cypress-gum bogs, and depression meadows (NatureServe 2008, Godfrey and Wooten 1981).

Ecology:
This plant is perennial, reproduces vegetatively and probably self-pollinates (Chafin 2008).

Populations:
Five occurrences are known in Georgia, few in Alabama and Florida, and more in South Carolina's Aiken Plateau, but size of individual occurrences is not reported (NatureServe 2008).

Population Trends:
This plant is rare and declining across its range largely because of habitat loss and degradation (Chafin 2008)

Status:
NatureServe (2008) ranks this species as critically imperiled in Alabama and Florida, and imperiled in Georgia and South Carolina.

Habitat destruction:
Threats to L. spathulata include clearing, drainage, and filling of wetland habitat or other activities that alter local hydrological patterns, fire suppression, conversion of wetland habitat to timber plantations, fragmentation by agriculture and silviculture, and numerous other direct or incidental effects of human activity (Southeastern Species Viability Project 2002, Chafin 2008). Its Carolina bay habitat is especially vulnerable as a target for in-filling to support various land-use practices (B. Sorrie pers. comm. as cited in NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Chafin (2008) reports that four occurrences in Georgia are protected, but others are susceptible to the threats previously discussed. No existing regulatory mechanisms adequately protect the spathulate seedbox or its habitat.

References:

Chafin, L. G. 2008. Species account for Ludwigia spathulata for Georgia Department of Natural Resources website.
http://georgiawildlife.dnr.state.ga.us/georgiaanimalsandplants_conservation.aspx

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. Georgia Press, Athens. 933 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 15, 2010)

Sorrie, Bruce. Consultant, Longleaf Environmental. Whispering Pines, NC 28327

Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Weakley, A.S. 1996. Flora of the Carolinas and Virginia: working draft of 23 May 1996. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Dept., Chapel Hill, North Carolina. Unpaginated.

Scientific Name:
Lythrum curtissii
Common Name:
Curtis' Loosestrife

G Rank:
G1

Range:
Curtis' loosestrife is a rare plant endemic to the Florida panhandle and southwestern Georgia - it is confirmed from Liberty, Franklin, and Gadsden Counties and reported in Bay, Calhoun, and Levy Counties in Florida, and confirmed in Calhoun, Decatur, Early, and Miller Counties, Georgia. Total range size is likely less than 100 square miles (NatureServe 2008).

Habitat:
This plant is found in silt, fine sand, peat bogs, seeps, and clearings on the edges of acidic or calcareous swamps, karst ponds, floodplains, or streambanks (NatureServe 2008).

Ecology:
Curtis' loosestrife is a perennial herb with a shrub-like form that flowers from June to August (NatureServe 2008).

Populations:
Eight occurrence records exist for Florida, though one has not been confirmed since 1954, and 4 exist for Georgia. Populations at some sites were comprised of between 50 to 200 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this species is in severe decline as a result of habitat loss.

Status:
This species has a small range within which few occurrences are known, and is experiencing major decline because of extensive habitat loss. NatureServe (2008) reports that the species is critically imperiled in both Florida and Georgia.

Habitat destruction:
The severe decline of Curtis's loosestrife is attributed to extensive habitat loss: clearcutting, conversion of natural habitat to timber plantations, dams, diversions, or other anthropogenic alterations of regional hydrology, and agricultural and residential development are among the primary activities responsible for this loss (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species.

References:

Allison, J.R. 1991. The status of Cacalia diversifolia and Lythrum curtissii in southwestern Georgia. Unpublished report for the U.S. Fish and Wildlife Service, Jacksonville, Florida.

Clewell, A.F. 1985. Guide to vascular plants of the Florida panhandle. Florida State Univ. Press, Tallahassee, Florida. 605 pp.

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Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

Patrick, T.S., J.R. Allison, and G.A. Krakow. 1995. Protected plants of Georgia: an information manual on plants designated by the State of Georgia as endangered, threatened, rare, or unusual. Georgia Dept. Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program, Social Circle, Georgia. 218 pp + appendices.

Scientific Name:
Lythrum flagellare
Common Name:
Lowland Loosestrife

G Rank:
G2

Range:
This plant is restricted to an increasingly small range in peninsular Florida. It has been recently confirmed in Charlotte, Collier, Dade, DeSoto, Glades, Henry, Lee, Manatee, Okechobee, and Sarasota Counties (NatureServe 2008).

Habitat:
Lowland loosestrife is found in muck or sand-peat-muck soil along the margins of ponds and cypress depressions or other similar habitat (Kral 1983).

Ecology:
This plant is perennial.

Populations:
No comprehensive survey data are available for this species.

Population Trends:
Trend information is not available for this species, but it is likely in decline as a result of widespread habitat loss (NatureServe 2008).

Status:
NatureServe (2008) reports that L. flagellare is imperiled in Florida, where it is also listed as state-endangered.

Habitat destruction:
Much of the habitat used by L. flagellare has been destroyed by drainage or other alterations to regional hydrology, logging, and fire suppression (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in Florida, this designation offers L. flagellare no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species or its habitat.

References:

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: Dicotyledons. Univ. Georgia Press, Athens. 933 pp.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed December 17, 2009.

Scientific Name:
Macbridea caroliniana
Common Name:
Carolina Birds-in-a-nest

G Rank:
G2

Range:
Also known as the Carolina bog-mint, M. caroliniana ranges across the southern Coastal Plain from southeastern North Carolina to southern Georgia; reports from Florida, Alabama, and Missisippi are not confirmed (LeBlond 2002). Natural heritage records indicate it is present in Georgia's Berrien, Marion, McDuffie, and Richmond Counties, in North Carolina's Bladen, Brunswick, Columbus, Harnett, Johnston, Jones, Pender, Robeson, and Sampson Counties, and in South Carolina's Aiken, Barnell, Colleton, Dillon, Edgefield, Florence, Hampton, Jasper, Marion, Richland, and Williamsburg Counties (NatureServe 2008). It has been extirpated from some of its historical range.

Habitat:
Carolina birds-in-a-nest are found in wet longleaf pine (Pinus palustris) or pond pine (P. serotina) savannas, and in blackwater swamp forests with swamp blackgum (Nyssa sylvatica), red maple (Acer rubrum), and tulip poplar (Liriodendron tulipifera), in Atlantic wide cedar swamps, and in roadside ditches within the above habitats (NatureServe 2008).

Ecology:
This perennial herb flowers mid-July through September (or first frost) (NatureServe 2008). This species is not autogamous and is dependent on pollinators to set fruit (Weeks 2009).

Populations:
A 2001 USFWS survey (LeBlond and Sorrie 2002) found 36 occurrences, three in Georgia, 15 in South Carolina, and 18 in North Carolina; two more populations were found in South Carolina in 2003-2004 - one contained approximately 6,000 stems and the other close to 200 (DeGarady 2006). This species' rarity is particularly remarkable because its preferred habitat is so common (NatureServe 2008).

Population Trends:
NatureServe (2008) determined that many but not all populations of M. caroliniana are declining; the species was absent from several historical sites in recent surveys and up to one-third of rangewide populations may already have been lost to habitat loss (LeBlond and Sorrie 2002).

Status:
This species occurs sporadically across the southern Coastal Plain, and many populations are in decline as a result of habitat loss and degradation. NatureServe (2008) ranks the Carolina birds-in-a-nest as critically imperiled in Georgia, imperiled in North Carolina, and vulnerable in South Carolina. The species is listed as threatened in North Carolina, as a species of special concern in South Carolina, and rare in Georgia.

Habitat destruction:
Though its preferred habitat type (swamp forest) is extensive, human impacts are significant; logging and correspondent declines in water quality, silvicultural plantations, and fire suppression are cited as the primary threats to the Carolina birds-in-a-nest (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

Six populations, including the largest populations and highest-quality habitat, occur on federal lands (the largest is found in Congaree National Park), but may still be vulnerable to human activities if management for their viability is not the highest priority (NatureServe 2008, Weeks 2009). Though it is listed as threatened in North Carolina and as a species of special concern in South Carolina, these designations offer M. caroliniana no substantial regulatory protections.

Other factors:

Rooting activity by feral hogs may harm this species and/or its habitat in some areas (Weeks 2009).

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Scientific Name:
Macromia margarita
Common Name:
Mountain River Cruiser

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
This dragonfly is recorded from Alabama, Georgia, North Carolina, South Carolina, Tennessee and Virginia (Roble 1997).It was formerly thought to be endemic to the southern Appalachians (Carle in Terwilliger 1991), but several recent records exist for the Piedmont of North Carolina as well as west-central Tennessee and northwestern Alabama (Roble 1997). Morse et al. in Benz and Collins (1997) reported that this species is known from only 6 or 7 localities, but Roble (1997) listed twice that many recent records.

Habitat:
M. margarita lives in small streams to large rivers, usually rocky but with silt deposits. Typical habitat is small mountain streams but it is also recorded from several Piedmont localities in North Carolina. The eggs are scattered in water, larvae sprawl among bottom debris, and adults forage widely. This species is associated with forested watersheds and is an indicator of high water quality, being less tolerant of pollution than its congeners.

Populations:
NatureServe (2008) reports that there are fewer than 20 occurrences known, but more may be discovered. This dragonfly is abundant in appropriate habitat and is a fast-flying species that is difficult to capture.

Population Trends:
NatureServe (2008) reports that this species is probably declining as water quality is degraded. Exact population data are not available, but NatureServe reports a large to moderate long-term decline of 25-90 percent for this species.

Status:
NatureServe (2008) ranks this species as critically imperiled in Georgia and Virginia, imperiled in North Carolina and Tennessee, and not rated in Alabama or South Carolina. It was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
The Mountain River cruiser is more intolerant of pollution than its congeners and is an indicator of high habitat quality. Degradation of water quality is the primary threat to its survival and it is specifically threatened by siltation and pollution of rivers by logging, second home development, and pesticide runoff. This species is associated with forested watersheds and logging is thus a primary threat.

Individuals of M. margarita and its habitat were likely impacted by the Upper Creek Timber Sale on the Grandfather Ranger District of the Pisgah National Forest (USFS 2005). The same is true of the Old House Gap timber sale on the same Ranger District (USFS 2006).

Inadequacy of existing regulatory mechanisms:

This dragonfly occurs on National Forests, but occurrence on public lands does not necessarily protect this species from the impacts of logging and herbicide applications.

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Scientific Name:
Marshallia grandiflora
Common Name:
Large-flowered Barbara's-buttons

G Rank:
G2

Range:
The large-flowered Barbara's buttons is a perennial herb endemic to the central Appalachians (also known as the Monongahela Barbara's buttons, NatureServe 2008). It occurs in Kentucky, Maryland, Pennsylvania, Tennessee and West Virginia, and is considered extirpated from North Carolina. Its present range includes Fayette, Somerset and Allegheny Counties in Pennsylvania, Barbour, Nicholas, Preston, Randolph, Upshur, Greenbrier, Fayette, Webster, Summers, Marion, and Monongahela Counties in West Virginia, McCreary County in Kentucky, Morgan, Roane and Scott Counties in Tennessee, and Garrett County in Maryland (NatureServe 2008).

Habitat:
It is found along the flood-scoured banks of large, fast-flowing rivers or creeks, along lakeshores, and on bluffs or flood plains. It prefers moist sandy soil, sand or cobbled alluvial matter, and also grows in bedrock crevices (NatureServe 2008). It is somewhat shade-tolerant, but grows best in full sunlight (pers. comm. as cited in NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are up to 80 occurrences of this species across its range of 11 watersheds. Many remaining populations are considered marginally viable as they are isolated by 1.5 km or more of unsuitable habitat and comprised of only a few individuals.

Population Trends:
NatureServe (2008) reports that populations are generally considered stable, though many have not been evaluated recently.

Status:
NatureServe (2008) lists the Large-flowered Barbara's buttons as critically imperiled in Kentucky and Pennsylvania, imperiled in Tennessee and West Virginia, and possibly extirpated from North Carolina. Its status is under review in Maryland. This species is state-listed as threatened in West Virginia and endangered in Tennessee.

Habitat destruction:
The most significant threats to this species are changes to hydrological flow and flood regime: floods provide the necessary scouring and deposition of sand and gravel that maintains their preferred riverbank habitat (NatureServe 2008). Flood control projects threaten many major populations (NatureServe 2008). Protection from anthropogenic disturbance is essential, as the effects of recreation (particularly motorized recreation) can destroy these fragile populations. All historically documented populations in North Carolina have been extirpated (NatureServe 2008). This species is also threatened by mountaintop removal coal mining (EPA 2005). In mountaintop removal, over 1000 feet of mountain can be blown up and dumped into adjacent streams, which annihilates this plant and its habitat.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms afford adequate protection to Marshallia grandiflora. Though it

is listed as threatened or endangered in some states in which it occurs, these designations do not significantly protect the large-flowered Barbara's buttons from the activities that threaten it, particularly altered hydrologic regime.

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Scientific Name:
Marstonia agarhecta
Common Name:
Ocmulgee Marstonia

G Rank:
G1

IUCN Status:
EN - Endangered

Range:
The range of the Ocmulgee Marstonia is less than 100 square km in Georgia (NatureServe 2008). This species occurs in Bluff Creek, a tributary of the Ocmulgee River (Thompson 1969, Hershler 1994, Burch 1989) and at House Spring in Wilcox County, 30 km southeast of Bluff Creek (Watson 1999, 2000, Dillon et al. 2006).

Habitat:
This snail occurs on silt, diatomaceous ooze, or submerged logs and leaves (O'Connor 1975, Watson 2000).

Populations:
There are two populations of this species, and it is abundant within its limited range (NatureServe 2008).

Population Trends:
A new population of this species was recently detected, making the population trend for this snail increasing (Watson 2000).

Status:
The Ocmulgee Marstonia is critically imperiled (G1S1) (NatureServe 2008). It is classified as endangered by the IUCN.

Habitat destruction:
The Georgia Dept. of Natural Resources (2009) reports that the spring habitats this species is associated with are threatened by development and groundwater pumping. The Wilcox County Comprehensive Plan (2005) reports that sensitive habitat areas, such as the habitats which harbor this snail, are increasingly threatened by the encroachment of people and development, by the sale of riverfront acreage from timber companies to developers, and by improperly sited or improperly operated septic tanks. Sedimentation from logging in riparian areas also potentially threatens this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species, and no occurrences are appropriately protected and managed (NatureServe 2008).

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Scientific Name:
Marstonia castor
Common Name:
Beaverpond Marstonia

G Rank:
G1

IUCN Status:
DD - Data deficient

Range:
The total range of the Beaverpond Marstonia consists of less than 4 square km in a single creek in Georgia (NatureServe 2008). This snail is only known from the type locality, Cedar Creek in Crisp County in the Flint River drainage (Burch 1989, Watson 2000).

Habitat:
This snail's only known habitat is a quiet, clear, cold creek where it is found on aquatic plants (O'Connor 1975).

Populations:
There is only one known population of this species, and population size is unknown but low (NatureServe 2008). A survey of 22 sites on tributaries of the Flint River between Andersonville and Albany, Georgia were unsuccessful in detecting additional populations of this species (Watson 2000).

Population Trends:
NatureServe (2008) reports that this snail is very rapidly declining (decline of 50-70 percent) in the short term, and has experienced a long-term decline of 75 to over 90 percent.

Status:
This snail is critically imperiled (G1S1) (NatureServe 2008).

Habitat destruction:
Because the total known global range of this snail consists of less than four square kilometers, it is extremely vulnerable to habitat loss and degradation. The Georgia Dept. of Natural Resources (GDNR 2009) reports that this species' Southeastern Plains habitat is threatened by agriculture, withdrawal of ground and surface waters, development, recreation, and dams. Agriculture and other ground-disturbing activities result in erosion and degradation of water quality. Groundwater and surface water withdrawals for agriculture substantially reduce stream flow, and agriculture contributes to nutrient and silt loading which stresses aquatic organisms (GDNR 2009). Development increases sediment levels in streams (GDNR 2009). Unmanaged recreation and ATV use destabilizes streambanks, increases sedimentation, pollutes water with fuel, and crushes aquatic organisms outright (GDNR 2009). Dams and other structures which alter stream flows on the Southeastern Plains cause significant problems for high priority species such as this snail (GDNR 2009).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Beaverpond Marstonia. This snail is considered to be a high priority species for conservation by the state of Georgia, but this does not convey any regulatory protection.

Other factors:
This snail is threatened by water pollution from many sources. Because this species exists as a single population, it is vulnerable to extinction from stochastic genetic and environmental events.

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Scientific Name:
Marstonia ozarkensis
Common Name:
Ozark Pyrg

G Rank:
G1

IUCN Status:
DD - Data deficient

Range:
The range of this species is less than 100 square km on the Arkansas-Missouri border (Hershler 1994, NatureServe 2008). It survives in a single location on the North Fork of the White River above Norfolk.

Populations:
There is only one surviving population of this species and it occurs on the North Fork of the White River in Ozark County, Missouri (Wu et al. 1997, NatureServe 2008). This species has not been detected at other localities despite search efforts (MO NHP, pers. comm., November 2006 cited in NatureServe 2008). This snail has likely been extirpated from all former sites in Arkansas including the type locality (Wu et al. 1997).

Population Trends:
This species has severely declined in the short term, with a decline of more than 70 percent, and has declined by more than 90 percent in the long term (NatureServe 2008).

Status:
This snail is classified as critically imperiled in Arkansas (S1?) and not assessed in Missouri (SNA) (NatureServe 2008).

Habitat destruction:
With only one surviving population in Missouri, this snail is exceedingly vulnerable to habitat degradation. This snail has likely been extirpated from all former sites in Arkansas (Wu et al. 1997). The Missouri Dept. of Conservation (2001) reports that the North Fork of the White River watershed is threatened by water quality degradation due to high fecal coliform levels, nutrient loading, and sediment/gravel deposition. Activities such as gravel dredging, indiscriminate land clearing, livestock grazing in riparian zones, and contamination from septic systems and municipal discharges all threaten this species' habitat (Missouri Dept. of Conservation 2001). Mining is also a threat to the Arkansas Mudalia. The Missouri Department of Natural Resources, Division of Geology and Land Survey has identified 23 active mines and 137 past producers within the North Fork Watershed in Missouri, including gravel removal operations, limestone quarries, and iron mines, all of which threaten water quality (Missouri Dept. of Conservation 2010).
Recreational activities and developments also threaten this snail. The North Fork Watershed is heavily used for fishing and floating. Bank and shoreline development continues to occur in some areas on the major streams of the watershed, with housing construction on the North Fork River downstream of the Mark Twain National Forest being one example. Problems associated with recreational activities and developments include destabilization of stream banks and flood plains due to vegetation removal, increased sediment loading, and water quality impacts from poorly treated sewage (Missouri Dept. of Conservation 2010).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species.

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Scientific Name:
Medionidus conradicus
Common Name:
Cumberland Moccasinshell

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The total range of the Cumberland Moccasinshell encompasses 250-1000 square km in Kentucky, Tennessee, Alabama, Georgia, North Carolina, and Virginia (NatureServe 2008). This mussel occurs in the Tennessee River drainage in Virginia, Tennessee, and Alabama, and in Cumberland river drainages in Kentucky and Tennessee including the Duck River (Burch 1975, Johnson 1977, Parmalee and Bogan 1998). Johnson (1977) listed this species in the Powell River drainage in Virginia, Clinch River drainage in Virginia and Tennessee, Holston River drainage in Virginia and Tennessee, French Broad River drainage in North Carolina, Little River drainage in Tennessee, Little Tennessee River drainage in Tennessee, Hiwassee River drainage in Tennessee, Chickamauga Creek drainage in Georgia, Paint Rock River drainage in Alabama, Flint River drainage in Alabama, Elk River drainage in Tennessee, Blue Water Creek drainage in Alabama, Shoals Creek drainage in Alabama, Tennessee River drainage in Alabama, Duck River drainage in Tennessee, Rockcastle River drainage in Kentucky, Cumberland River drainage in Kentucky, South Fork drainage in Kentucky, Beaver Creek drainage in Kentucky, Obey River drainage in Tennessee, Roaring River drainage in Tennessee, Caney Fork drainage in Tennessee, Stones River drainage in Tennessee, and Red River drainage in Kentucky.

In the Cumberland drainage, this mussel occurs downstream of Cumberland Falls in Kentucky and Tennessee (Cicerello et al. 1991, Parmalee and Bogan 1998). In the Tennessee River drainage, it occurs from eastern Tennessee, southwest Virginia, and western North Carolina downstream to Muscle Shoals (Ahlstedt 1992, Parmalee and Bogan 1998). In the Alabama and Mobile Basin, Williams et al. (2008) state that this species probably occurred in the Tennessee River across northern Alabama, but that the only records are from Muscle Shoals and from tributaries to the Tennessee. In Alabama, it is known to be extant only in a tributary of Spring Creek in Colbert County, and in the Paint Rock River System (Williams et al. 2008).

Habitat:
This mussel inhabits sand and gravel substrates in small streams, generally in headwaters, and can be found under rocks or in cracks (Johnson 1977, Parmalee and Bogan 1998). Mirarchi et al. (2004) describe its habitat as "usually moderate to strong current, generally in small streams to medium rivers, and often under large, flat rocks (Parmalee and Bogan 1998). However, its presence at Muscle Shoals, prior to impoundment of Tennesseee River (Ortmann 1925) indicates ability to exist in large rivers under certain conditions" (p. 64).

Ecology:
This mussel is a long-term brooder which spawns in July, with females exhibiting slow, continual, long-term discharge. Females brood mature glochidia from September through late May. Glochidia are present in stream drift during every month but July and August. Fish hosts include rainbow, fantale, redline, and striped darters (Mirarchi et al. 2004).

Populations:
This mussel is known from Citico Creek, inside and adjacent to the Cherokee National Forest in Monroe County, Tennessee (Johnson et al. 2005). It occurs in Powell, Clinch, Holston, Emory, Watauga, Little Pigeon, Little Tennessee, Tellico, Duck, and Little Rivers, Conasauga Creek (Hiwassee River basin), main Tennessee River, and various small streams in upper east Tennessee, and in the Cumberland River basin in the Obey, Collins, Roaring, West Fork Stones, and Stones Rivers (Parmalee and Bogan 1998). It occurs occassionally to sporadically in the lower and upper Cumberland River below Cumberland Falls in Kentucky (Cicerello and Schuster 2003). In Alabama, it is known to be extant only in the Paint Rock River system, and Foxtrap Creek in Colbert County (Mirarchi et al. 2004). In Virginia, this mussel was recently detected in the upper Clinch (Jones et al. 2001) and in Copper Creek in the Upper Clinch drainage (Fraley and Ahlstedt 2000). Jones and Neves (2007) report its occurrence in the upper North Fork Holston River in Virginia as river kilometers 135.8 to 190.7. Total population size of this species is unknown.

Population Trends:
The Cumberland Moccasinshell is declining in the short term (decline of 10-30 percent), and moderately declining in the long term (decline of 25 - 50 percent). This bivalve was common in the upper and lower Tennessee and Cumberland River systems before impoundments including just below Cumberland Falls (1948) and Beaver Creek and the Rockcastle River as far up as Laurel Fork (Johnson 1977). This mussel is extirpated in Georgia and in North Carolina where it formerly occurred in Buncombe Co. in the French Broad River (LeGrand et al. 2006), and there is evidence of decline in some Tennessee River drainages (NatureServe 2008). Garner (2008) reports that the viability of the Foxtrap Creek population is questionable.

Status:
The Cumberland Moccasinshell is critically imperiled in Alabama, extirpated in Georgia and North Carolina, vulnerable in Tennessee and Virginia, and apparently secure in Kentucky, though Cicerello and Schuster (2003) describe its Kentucky distribution as occasional to sporadic (NatureServe 2008). It is ranked as Near Threatened by the IUCN. It is a Species of Greatest Conservation Need in Alabama and Kentucky. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Mirarchi et al. (2004) state that the Cumberland Moccasinshell is vulnerable to extirpation due to susceptibility to habitat degradation. Threats to this species' habitat include impoundment, sedimentation, and mining for gravel and coal (Parmalee and Bogan 1998, USFWS 2003). Impoundment acts as a barrier to dispersal, blocks recolonization following population extirpation, isolates populations, inundates habitat, and alters water quality. Sedimentation, resulting from agriculture, forestry, storm water runoff, and other factors, interferes with respiration and feeding and can smother populations. Gravel mining directly destroys mussel habitat and coal mining introduces sediment and pollutants (NatureServe 2008). Warren et al. (2001) report that in the Little South Fork this mussel is threatened by strip mining and additional impacts. Mussels in the Little South Fork are also threatened by oil extraction (Warren and Haag 2005). The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that this mussel is threatened by aquatic habitat degradation from gravel and sand quarrying and from point and non-point source pollution from acid mine drainage and agricultural runoff, and from siltation and increased turbidity resulting from coal mining, agriculture, road construction, urbanization, and recreation. The Alabama Natural Heritage Program (2003) identifies nonpoint source pollution as a

threat to aquatic species in the Paint Rock River watershed.

Disease or predation:
Neves and Odom (1989) cite muskrat predation as a threat to imperiled mussels in the North Fork of the Holston in Virginia.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect the Cumberland Moccasinshell, and it is unknown whether any occurrences are appropriately protected (NatureServe 2008). In Tennessee there is an occurrence of this mussel in Citico Creek, inside and adjacent to the Cherokee National Forest in Monroe Co., (Johnson et al. 2005), but this does not provide habitat protection. It is a Species of Greatest Conservation Need in Alabama and Kentucky, but this does not provide any regulatory protection. It has no special status in Tennessee or Virginia.

Other factors:
Mirarchi et al. (2004) state that the Cumberland Moccasinshell is vulnerable to extirpation due to limited distribution and rarity. Any factor which degrades water quality threatens this species including toxic pollution, altered pH, and heavy metals from mining waste, industry spills, urban runoff, and agriculture (Parmalee and Bogan 1998, USFWS 2003). The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996). This mussel is threatened by accidental chemical spills. In 2004, 657 individuals of this species were estimated to be killed in the Clinch River when a tanker trunk overturned and released 1,350 gallons of toxic liquid that killed wildlife for seven miles downstream (FWS 2004).

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Scientific Name:
Medionidus walkeri
Common Name:
Suwannee Moccasinshell

G Rank:	AFS Status:	IUCN Status:
G1	Threatened	EN - Endangered

Range:
The range of the Suwannee Moccasinshell is 100-250 square km in the Suwannee River system in Florida, with 11 historical occurrences in the Withlacoochee, Suwannee, and Santa Fe drainages (Johnson 1977). It is known from the lower Withlacoochee, from its confluence with the main channel downstream to approximately Levy County, and from above the sinks in the upper Santa Fe river system including both the main channel and New River sites. Its occurrence is sporadic, especially in the main channel of the Suwannee (NatureServe 2008).

Habitat:
This mussel is known from medium-sized creeks and rivers in areas of moderate current with mud, sand, muddy sand, or sand and gravel substrate (Johnson 1977, Heard 1979, Deyrup and Franz 1994). It occurs most often in coarser sediments in mid-channel habitats (J. Brim Box, pers. obs. cited in NatureServe 2008). This mussel requires high water quality (NatureServe 2008).

Populations:
There are fewer than five populations of this mussel. It is known from 11 historical occurrences-- four on the main stem of the Suwannee River, one on the Withlacoochee River, five in the Santa Fe River and one in the New River. This mussel has only been detected live recently only in the Santa Fe River in 1981, and in the New River in 1987 and 1994. In addition, a dead shell was located at the type locality in the Suwannee River in 1981. It may be extirpated from the Withlacoochee River and the main channel of the Suwannee River. Total population size of this species is estimated at 1-1000 individuals. In 1977 it was considered to be abundant only at the type locality in the mainstem of the Suwannee, and was uncommon at other sites. Of 14 historical records, only one site had over 20 specimens. In the late 1980's, the last location that harbored sizeable populations yielded only three specimens. Only one live mussel has been detected recently throughout this species' historic range (NatureServe 2008).

Population Trends:
The Suwannee Moccasinshell has declined by 75-90 percent (NatureServe 2008). It is "exceedingly rare and in significant decline," with only one individual having been detected alive recently (J. Brim Box, pers. comm. cited in NatureServe 2008).

Status:
This mussel is ranked by NatureServe (2008) as critically imperiled in Florida. It is classified as endangered by the IUCN. Its status was changed from threatened (1993) to endangered (2010) by the American Fisheries Society (Draft, in review). As only one mussel has been detected alive recently, this species is in dire need of Endangered Species Act protection. Its rank is being changed from threatened (Williams et al. 1993) to endangered by the American Fisheries Society (2010 draft, in review).

Habitat destruction:
This mussel is threatened by sedimentation due to agricultural and silvicultural activities, by phosphate mining on the upper Suwannee River main channel, by industrial pollution from a pulp mill in the Withlacoochee watershed, and by localized municipal pollution. It is also threatened by eutrophication from residential development (NatureServe 2008). The Florida Wildlife Conservation Commission (2005) reports that this species' stream habitat in Florida is threatened by chemical pollution, sedimentation, development, logging, mining, invasive species, agriculture, and eutrophication. The Florida Dept. of Environmental Protection (2002) reports that water quality in the Suwannee is threatened by large-scale chicken farming operations and by large-scale water withdrawals.

Overutilization:
Overutilization threatens the survival of this species. Only one individual has been detected alive recently, making this species exceedingly vulnerable to overutilization. NatureServe (2008) states, "Overharvest by shell collectors and biologists has been a distinct possibility; in the past 20 years, more than 20 specimens of this threatened species have been retained for collections at the GEXEMPSITE alone. Given already stressed populations throughout most or possibly all of its range, overcollecting can potentially contribute significantly to this species' decline."

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that currently protect this species.

Other factors:
This mussel is potentially threatened by competition from the Asiatic clam (NatureServe 2008).

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Scientific Name:
Megaceros aenigmaticus
Common Name:
A hornwort

G Rank:
G2

Range:
This hornwort species is found in Georgia, North Carolina, and Tennessee; natural heritage records indicate that it is present in Georgia's Fannin County, North Carolina's Cherokee, Clay, Graham, Haywood, Macon, and Swain Counties, and Tennessee's Blount, Cocke, Monroe, Polk, and Sevier Counties (NatureServe 2008). The largest populations are found in the Joyce Kilmer-Slickrock Wilderness in western North Carolina's Nantahala National Forest.

Habitat:
This species forms dense mats on rocks in small, clear, shaded streams, springs, or waterfall spray zones, often at river headwaters and generally within mixed hardwood forests (NatureServe 2008). Seasonal inundation is necessary for survival and reproduction, though colonies may be consistently submerged in 1-2 inches of water (Schuster 1992).

Ecology:
A dioecious species, M. aenigmaticus reproduces primarily by marginal fragmentation of the thallus (Hicks and Amoroso 1996). Seasonal inundation is necessary for reproduction and colonization of new habitat (Schuster 1992). It is the only species in the Megaceros genus known to occur north of Mexico.

Populations:
Populations are small, as is total global range (Schuster 1992).

Population Trends:
Populations are in decline as a result of anthropogenic habitat disturbance or destruction (Schuster 1992).

Status:
NatureServe (2008) reports that M. aenigmaticus is critically imperiled in Georgia, and imperiled in North Carolina and Tennessee. Remaining populations are small and geographically isolated (Schuster 1992).

Habitat destruction:
This species is very sensitive to changes in water quality resulting from sedimentation, agricultural or industrial runoff, and the increase in water temperature that accompanies canopy clearing within riparian zones (NatureServe 2008, Hicks and Amoroso 1996). Thriving populations are found in undisturbed waters, while the species is absent from ecologically similar streams in nearby developed areas.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this hornwort; though it is listed as a species of special concern in Tennessee, this designation offers it no substantial regulatory protections from the habitat destruction that threatens its persistence.

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Scientific Name:
Megaleuctra williamsae
Common Name:
Smokies Needlefly

G Rank:
G2

Range:
NatureServe (2008) states: "This stonefly is known from the highest elevations of Virginia (Mt Rogers National Recreation Area, Grayson Co.) and immediate vicinity of the Smoky Mt National Park (North Carolina: Graham Co., Haywood Co., Jackson Co., Macon Co., Yancey Co.) and Tennessee (Sevier Co.). LeGrand et al. (2006) cite UT Cullasaja River in Macon Co., Cove Creek in Haywood Co., Mull Creek in Jackson Co., Beech Flats Prong in Swain Co., North Carolina."

Habitat:
This stonefly is found in higher elevation springs, seeps, and creeks.

Populations:
Megaleuctra williamsae is known from fewer than 20 occurrences (NatureServe 2008). According to the Kondratieff, in SC Department of Natural Resources (2005), M. williamsae "occurs as small populations, usually less than 20 nymphs per site."

Population Trends:
Morse et al. (1993) report that this species is rare and vulnerable throughout its range.

Status:
NatureServe (2008) ranks the Smokies Needlefly as critically imperiled in North Carolina, Tennessee, and Virginia, and unranked in South Carolina. It was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
The springs and seeps required for survival of M. williamsae are all potentially impacted by logging, acid deposition and development (NatureServe 2008). Morse et al. (1993) report that this species is particularly vulnerable to habitat degradation, being restricted to isolated springbrooks that are subject to threats of drought and development.

M. williamsae and its habitat will be adversely impacted by the implementation of projects under the Jefferson National Forest Plan (USFS 2008). The Wet Face timber sale on the Nantahala Ranger District in North Carolina will adversely impact M. williamsae and its habitat (USFS 2009).

Kondratieff, in SC Department of Natural Resources (2005), states that "A major challenge to the Smokies needlefly is deforestation, which would result in opening of the canopy of seeps and springs, increasing water temperature and likely reducing food inputs. Acid deposition, primarily from precipitation, may alter pH conditions of the habitats, potentially eliminating populations. Diversions of surface waters or removal of ground water may alter below ground hydrological patterns of the seeps and springs."

Inadequacy of existing regulatory mechanisms:
M. williamsae occurs in the Great Smoky Mountains National Park (Parker et al. 2007), which

protects some occurrences of this species, but the species' lacks protection in the rest of its limited range.

Other factors:

The invasive Hemlock Woolly Adelgid may impact individuals of M. williamsae (USFS 2005).

This species is also vulnerable to drought (Morse et al. 1993).

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Scientific Name:
Minuartia godfreyi
Common Name:
Godfrey's Stitchwort
G Rank:
G1
Range:
Natural heritage records indicate that Godfrey's stitchwort is or was present in Pickens and Munroe Counties, Alabama, Madison and Taylor Counties, Florida, Craven and Jones Counties, North Carolina, Horry County, South Carolina, and Carter and Johnson Counties, Tennessee, though recent confirmation of existing populations is not available for all locations (NatureServe 2008, ANHP 2006). This rare plant is sporadically distributed throughout its range.
Habitat:
The stitchwort is found on moist creek banks, roadside ditches, freshwater tidal marshes, wet saline prairies, open mesic meadows, and Delta post oak (Quercus stellata) flatwoods (NatureServe 2008).
Ecology:
This perennial herb flowers in April (FNA 2005).
Populations:
This plant is known from very few widely scattered occurrences, and total number of populations and global population size are not known (NatureServe 2008, Kral 1983).
Population Trends:
This plant is in decline and has been extirpated from several historical occurrences (NatureServe 2008).
Status:
Godfrey's stitchwort is rare, in decline, and has been extirpated from several historical occurrences across its narrow range. NatureServe (2008) ranks this species as critically imperiled in Florida, Georgia, North Carolina, and Tennessee, and reports that it may be entirely extirpated from Alabama and South Carolina. It is listed as endangered in Florida, North Carolina, and Tennessee .
Habitat destruction:
Habitat destruction is the primary threat to Godfrey's stitchwort: the conversion of forests and wetlands to residential or agricultural development and replacement of natural forests with commercial forest plantations are major factors in this species' imperilment (Southern Appalachian Species Viability Project 2002).

Inadequacy of existing regulatory mechanisms:
Though M. godfreyi is listed as endangered in Florida, North Carolina, and Tennessee, these designations afford the species and its habitat no substantial regulatory protections; no existing regulatory mechanisms adequately protect the Godfrey's stitchwort.

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Weakley, A.S. 1996. Flora of the Carolinas and Virginia: working draft of 23 May 1996. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Dept., Chapel Hill, North Carolina. Unpaginated.

Scientific Name:
Moxostoma robustum
Common Name:
Robust Redhorse

G Rank:	**AFS Status:**
G1	Threatened

Range:
Historically, the robust redhorse likely occurred from the Piedmont and upper Coastal Plain areas of the Altamaha River drainage in Georgia through the Carolinas to at least the Pee Dee River (Oppermann 2000). Today the species is restricted to the Altamaha, Savannah, and Pee Dee river systems in North Carolina, South Carolina, and Georgia (Jenkins and Burkhead 1994, Rohde et al. 1994, Bryant et al. 1996, Menhinick and Braswell 1997, Straight and Freeman 2003, Grabowski and Isely 2007). There are four known extant wild populations found in a limited portion of the Oconee River between Milledgeville and Dublin, lower segment of the Yadkin-Pee Dee River system below Blewett Falls Dam (North Carolina/South Carolina), and in the Savannah River in the Fall Line Zone around and below Augusta, Georgia, and North Augusta, South Carolina (Straight and Freeman 2003). The Savannah River population is restricted to the lower 300-km reach below New Savannah Bluff Lock and Dam, the terminal dam located in Augusta, Georgia (Grabowski and Isely 2007). Populations of this fish have been introduced from Oconee stock into the Broad and Ogeechee rivers in Georgia, and refugial populations have been established in ponds at the Piedmont National Wildlife Refuge near Round Oak, Georgia, and several hatcheries in Georgia and South Carolina (Bryant et al. 1996, Jimmy Evans, pers. comm., 1998 cited in NatureServe 2008). In 2002, fish were released into the Ocmulgee River (Straight and Freeman 2003).

Habitat:
The redhorse spawns over gravel substrate in shallow flowing water (Grabowski and Isely 2007).

Adults in the Oconee River are associated with swift, moderately deep waters in areas of accumulated woody debris (Hendricks 2002). Radio-tracked fish in the Savannah River were consistently found along the outer edge of river bends in association with woody debris and gravel streambed sediments (Grabowski and Isely 2006).

Populations:
Prior to its rediscovery in 1991, the robust redhorse had not been recognized for 122 years. In 1994 a small population was detected in the Oconee River, then in 1998, 5 fish were discovered in the Savannah River (Oppermann 2000). There are four extant native populations (Hendricks 2002). Total adult population size is unknown, but based on the small numbers of adults that have been observed, it is very likely quite small (RRCC 2001, Hendricks 2002, NatureServe 2008, RRCC Yadkin-Pee Dee 2009). The largest known population occurs in the Oconee River and is estimated to consist of fewer than 500 adults (RRCC 2001). Other populations are estimated to be considerably smaller. The population in the Pee Dee for example, is estimated to include fewer than 50 adults (RRCC Yadkin-Pee Dee 2009). The few number of populations and the small size of these populations suggests the robust redhorse is critically endangered.

Population Trends:
The robust redhore's overall range and populations are presumed to be greatly reduced from

Status:

The robust redhorse now exists in remnant low abundance populations in a restricted range which faces multiple threats. NatureServe (2008) ranks this species as critically imperiled in Georgia and North Carolina and unrated in South Carolina. The American Fisheries Society (Jelks et al. 2008) rank the Pee Dee, Altamaha, and Savannah River populations of this fish as endangered due to habitat loss and degradation and narrow range. The redhorse is listed as endangered by the states of Georgia and North Carolina. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the robust redhorse is endangered (SFC and CBD 2010).

Habitat destruction:

Dams were a primary contributor to the decline of this species and pose an ongoing threat to its survival. In all three drainages where the redhorse survives, hydroelectric dams have destroyed and degraded habitat, restricted range, and disrupted spawning migrations (Straight and Freeman 2003). Altered flows caused by dams negatively effect the growth and survival of larvae (Weyers et al. 2003). In the Savannah River, more than half of the observed nest sites in a main-channel gravel bar were either completely dewatered or left in near zero-flow conditions for several days due to dam operations (Grabowski and Isely 2007). Decreased flow reduces the amount of available spawning habitat, and increases the risk of disturbance of preexisting nest sites by spawning adults (Grabowski and Isely 2007).

The habitat of the redhorse is also threatened by several other factors. Channel straightening has resulted in fewer channel bends and caused the loss of spawning habitat (Meyer et al. 2003). Sedimentation from agriculture and deforestation likely contributed to the early decline of this species and is an ongoing threat (Hendricks 2002). Urbanization is a threat within the restricted remaining habitat (Bryant et al. 1996). Kaolin mining also threatens this species (Lasier et al. 2004). The proposed construction of two new nuclear reactors at Plant Vogtle on the Savannah River also threatens the redhorse due to dredging impacts to allow the barging of construction materials, flow alterations and thermal pollution that would result from operation of the reactors, and the cumulative impact of having four operating reactors on the Savannah River in conjunction with water withdrawals for other uses (Barczak and Young 2009).

Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Overutilization:

Historical overfishing by settlers during spawning migrations likely contributed to the decline of this species (Hendricks 2002).

Disease or predation:

The introduction of non-indigenous, predatory fish species likely contributed to the decline of this species (Hendricks 2002). Most rivers in the redhorse's historical range are now inhabited by flathead catfish, and predation by flathead catfish and blue catfish poses an ongoing threat (Marcy 2005).

Inadequacy of existing regulatory mechanisms:

The redhorse is listed as endangered by the states of North Carolina and Georgia, but this designation does not provide meaningful regulatory protection for the species' habitat.

In 1995, a voluntary partnership called the Robust Redhorse Conservation Committee (RRCC) was created through a Memorandum of Understanding (MOU) between state and federal resource agencies, private industry, and the conservation community to improve the status of the redhorse. Under the auspices of the RRCC, captive rearing programs have been established and attempts have been made to reintroduce the species into new habitats (Lawrence et al. 2007). It is likely to early to determine if these efforts will be successful. There have also been efforts to change dam management to benefit the species by, for example, limiting the practice of load following through daily fluctuations in flow (SFC and CBD 2010).

Although we applaud these efforts, they have to date not been effective in recovering the species. Moreover, the formation of the committee and the MOU do not provide regulatory protection for the species or its habitat and thus cannot be relied on by the Service to deny the species listing. Participation on the committee is voluntary, and actions taken or funds expended to implement the agreement are contingent upon appropriations, priorities, and other constraints. A Candidate Conservation Agreement with Assurances has been developed for this species, but this collaborative effort has not effectively prevented the ongoing degradation of redhorse habitat, which is already severely reduced from historical levels. In 2005, for example, 50 percent of observed nest sites of the redhorse were completely or nearly dewatered for several days at a time (Grabowski and Isely 2007). Given the magnitude of the decline of this species, the ongoing threats to its survival, and the uncertainty of implementation and effectiveness of voluntary agreements, Endangered Species Act protection is necessary to ensure the survival of the redhorse.

Other factors:

Several other factors threaten the robust redhorse. Water pollution from sedimentation and contaminants is a primary threat to this species. Five major tributaries draining urban and agricultural watersheds carry permitted municipal and industrial effluents into the Oconee River, and sediments in the river have elevated levels of chromium, copper, mercury, and zinc. Lasier et al. (2004) state, “Sediments in the lower Oconee River appear to be impaired due to metal contamination and could pose a threat to organisms, such as the robust redhorse, that are closely associated with this matrix during their life cycle.” Fine sediment particles settle in gravel and can entrap and suffocate eggs and larvae (Marcy 2005). Jennings et al. (2010) report that fine sediment pollution of gravel substrates threatens eggs and larvae in the Oconee River. They found that eggs incubated in gravel substrates infested with varying levels of fine sediment experienced severe reductions in survival when fine sediment levels were greater than 15 percent in the laboratory. Fine sediment concentrations in spawning substrates at known spawning locations in the Oconee River are well above this level (Jennings et al. 2010). Lazier et al. (2004) state: “Soil erosion and sedimentation contribute a major stress to the (Oconee) system. Early-life stages of the robust redhorse may be particularly affected because fine sediments clog gravel bars occupied during early development reducing the availability of dissolved oxygen and providing a route of exposure to sediment-associated contaminants. Sediments are repositories for contaminants released to the environment (Lee and Jones, 1984, Salomons et al. 1987), and fine materials within the sediment matrix tend to accumulate the majority of contaminants by virtue of the chemical and physical characteristics inherent to their large surface areas (O'Conner 1990). Robust redhorse eggs are deposited and develop in gravel bars that receive significant amounts of fine sediment. Exposure of the earlylife stages to these sediments and associated contaminants may be limiting recruitment of this species.”

The redhorse is particularly vulnerable to extinction due to limited range, low abundance, skewed population age toward older individuals, and little evidence of substantial recruitment in any surviving population (Hendricks 2002, Marcy 2005). Predation from invasive catfish is also a threat (NatureServe 2008).

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Scientific Name:
Moxostoma sp. 2
Common Name:
Sicklefin Redhorse

G Rank:
G2

Range:
The sicklefin redhorse once inhabited the majority of rivers and streams in the Blue Ridge portion of the Hiwassee and Little Tennessee River systems in North Carolina, Tennessee, and Georgia (Jenkins 1999, FWS 2009). Currently, there are only two metapopulations of the sicklefin redhorse known to survive – one in the Hiwassee River system and one in the Little Tennessee River system (Jenkins 1999, FWS 2009). In total, the species is estimated to be eliminated from nearly 60 percent of its historic range (FWS 2009).

Habitat:
The sicklefin redhorse occupies riffles, runs and flowing pools with gravel, cobble, boulder and bedrock substrates with little to no silt in rivers and creeks with moderate velocities (Jenkins 1999, FWS 2009). During early life stages, the sicklefin redhorse has also apparently adapted to near shore areas of reservoirs (Ibid.)

Populations:
The sicklefin redhorse still occurs in the main stem of the Hiwassee River between Mission Dam and Hiwassee Lake in North Carolina (approximately 9.0 miles), in Brasstown Creek (approximately 16.9 miles), a tributary to the Hiwassee River in North Carolina and Georgia, the main stem of the Valley River, between the community of Buffalo and backwaters of Hiwassee Lake (approximately 22.3 miles) in North Carolina, in Hanging Dog Creek (approximately 3.0 miles), a tributary to Hiwassee River (at Hiwassee Lake) in North Carolina and a short reach of the Nottley River (approximately 2-3 miles) between the cold water discharge from Nottely Reservoir and the backwaters of Hiwassee Reservoir in North Carolina (References cited in FWS 2009). In total, the species is found in only roughly 53 river miles of the Hiwassee River system and 42 river miles of the Little Tennessee River system, as well as in some reservoirs (FWS 2009).

Population Trends:
The sicklefin redhorse has undergone substantial long-term decline (Jenkins 1999, FWS 2009).

Status:
The sicklefin redhorse is considered critically imperiled in both Georgia and North Carolina (NatureServe 2008), threatened by the American Fisheries Society (Jelks et al. 2008), a candidate species for listing by the U.S. Fish and Wildlife Service (FWS 2009), threatened by the state of North Carolina and endangered by the state of Georgia (Albanese 2008).

At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the sicklefin redhorse should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
The sicklefin redhorse has been severely impacted by impoundments, as well as urban sprawl, agriculture, logging and other activities that contribute sediment and other pollutants to streams where

the species occurs (Jenkins 1999, Albanese 2008, FWS 2009). Albanese (2008), for example, concluded:

"Historically, impoundments have destroyed a large amount of adult feeding and breeding habitat throughout the range of the sicklefin redhorse. Impoundments also fragment populations, which eliminates opportunities for gene flow, colonization after local extinction, and migration to upstream spawning habitats. Failure to follow agricultural best-management practices results in sedimentation and bank destabilization in Brasstown Creek. Commercial and residential development in the North Georgia mountains is also a significant threat."

Likewise, FWS (2009) concluded:

"Many populations of the species were apparently extirpated when large portions of suitable habitat in the upper Tennessee River system were destroyed as a result of impoundments created when dams were constructed (Jenkins 1999, p. 26). These impoundments also resulted in fragmentation and isolation of the remaining populations, making them more vulnerable to extirpation from other environmental impacts. In addition to impoundments, other factors contributing to habitat destruction and modification that resulted in population losses and curtailment of the range of this species are believed to include inadequate erosion/sedimentation control (Jenkins 1999, p. 27) during agricultural, timbering, and construction activities; run-off and discharge of organic and inorganic pollutants (Jenkins 1999, p. 27) from industrial, municipal, agricultural, and other point and nonpoint sources; habitat alterations associated with channelization and instream dredging/mining activities; and other natural and human-related factors that adversely modify the aquatic environment. As described below, many of these factors continue to threaten the surviving populations."

Disease or predation:

FWS (2009) identify introduction of blueback herring as a potentially serious threat to the sicklefin redhorse, stating:

"Recently, non-native blueback herring (Alosa aestivalis) were introduced to Hiwassee Reservoir, presumably by angler bait release. NCWRC biologists have documented a collapse of natural reproduction of walleye (Sander vitreus) and white bass (Morone chrysops), concurrent with increases in blueback herring densities. Heavy predation of drifting eggs and early juveniles of both walleye and white bass by blueback herring has been observed in the transition zone between the free-flowing Hiwassee and Valley rivers and Hiwassee Reservoir. Blueback herring have been observed several miles upstream in Valley River and have unobstructed access to the Hiwassee River, Mission Dam, and lower Brasstown Creek. Blueback herring have also been observed congregating at the mouths of other tributaries to Hiwassee Reservoir in March and April (above is condensed from personal observations by A.P. Wheeler, D.L. Yow, and S.J. Fraley NCWRC 2005-2006). The presence of large numbers of known predators of drifting fish eggs and larvae at or near the time of spawning and hatching of sicklefin redhorse poses a potentially significant threat. Further investigation is required to determine the degree of threat posed to sicklefin redhorse survival and recruitment in the Hiwassee River system. To date, no Blueback herring have been collected from Fontana Reservoir or elsewhere in the Little Tennessee River system upstream from Fontana Dam."

Inadequacy of existing regulatory mechanisms:

FWS (2009) concluded that the sicklefin redhorse is not adequately protected by existing regulatory mechanisms, stating:

"The sicklefin redhorse does not currently have any official status in North Carolina; however, the North Carolina Non-Game Advisory Committee has recommended that the species be state-listed as threatened. It is anticipated that the listing will become official in the coming year. In Georgia, the sicklefin redhorse is state-listed as endangered. Both states prohibit the collection of the fish for scientific purposes without a valid State collecting permit. However, this requirement does not protect the species from 'incidental' harm, injury, death (impacts resulting from activities not specifically intend to the harm the species) or provide any protection to the species' habitat except on state-owned lands."

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Najas filifolia
Common Name:
Narrowleaf Naiad

G Rank:
G1

Range:
The narrowleaf naiad occurs in peninsular Florida and the Florida panhandle, as well as in parts of southwestern Georgia. It was once reported in Mississippi, but that report is now considered a misidentification (Kartesz 1998 as cited in NatureServe 2008). Natural heritage records exist for Alachua, Highlands, Lake, Leon, Marion, and Santa Rosa Counties, Florida, and Decatur County, Georgia, but as of 2000, extant populations were reported only from Santa Rosa and Leon Counties, Florida, and Decatur County, Georgia (FNA 2000).

Habitat:
The naiad is found in freshwater lakes, rivers, and basin marshes, generally in blackwater habitats which contain a high concentration of leached organic acids (NatureServe 2008, FNAI 2009).

Ecology:
This submerged annual flowers in late summer (FNA 2000).

Populations:
This species is known from just four locations-- two in Florida and two in Georgia (FNA 2000). Population sizes are not reported.

Population Trends:
Population trend has not been reported for this species, but the decline in reported locations suggests a rangewide decline.

Status:
Known from just four populations throughout its apparently contracting range, this species is widely threatened by hydrological alterations. NatureServe (2008) ranks the narrowleaf naiad as critically imperiled in both Florida and Georgia. It is listed as threatened in Florida.

Habitat destruction:
This species is threatened primarily by damming, diversion, and other anthropogenic alterations to hydrology that imperil its habitat and allow encroachment by woody upland species (FNAI 2009).

Disease or predation:
The naiad may be threatened by the grass carp (Ctenopharyngodon idella), which was introduced to parts of the Southeast as part of an aquatic weed control program but is now considered an invasive species in many states (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as threatened in Florida, this designation offers N. filifolia no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Necturus alabamensis
Common Name:
Black Warrior Waterdog

G Rank:
G2

IUCN Status:
EN - Endangered

Range:
The Black Warrior Waterdog occurs above the Fall Line in the Black Warrior River Basin in Alabama (NatureServe 2008). This salamander is patchily distributed in the Appalachian portions of the Black Warrior drainage (Bart et al. 1997, Bailey 2005).There are known populations in Sipsey Fork and Brushy Creek in Winston County, in Locust Fork and Blackburn Fork in Blount County, in Mulberry Fork, Blackwater Creek, and Lost Creek in Walker County, in the North River and in Yellow Creek in Tuscaloosa County (USFWS 1999, Bailey and Moler 2003).

Habitat:
This benthic salamander occurs in medium to large permanent streams with logs, submerged ledges, rocks, and other features which provide cover (Ashton and Peavy 1986). It uses semipermanent leaf beds where they are available. Its historical range likely included streams 10 meters or more wide, with moderate flows and alternating rapids and pools (Ashton and Peavy 1986, Bailey 1992).

Populations:
There are from 9-14 surviving populations of this species. Bailey and Moler (2003) and Bailey (2005) report this salamander from 9 stream segments. Bailey and Guyer (2004) state that the species is "presently known from 14 scattered locations." Guyer (1997) sampled 120 sites for this salamander from 1990-1997, including all localities within its range that approached or intersected roads and had appropriate habitat, with only an 8 percent success rate. Based on a statistical analysis of the data, Guyer concluded that waterdogs were unlikely to have been missed if they were present. Waterdogs were detected at only ten sites in four counties in surveys conducted in 1990, 1991, 1992, 1994, 1996, 1997, and 1998 (Bailey 1995, Guyer 1997, 1998).

The total population size of Black Warrior Waterdog is unknown. This species is now rare and occurs sporadically within its range (Guyer 1997). Population density is low even at the best localities (Bailey and Guyer 2004). A 1990-1992 survey detected only a few individuals in four localities, including six adults and one larva in Sipsey Fork, one adult in Lost Creek, one larva in North River, and one subadult in Yellow Creek (Bailey 1992). During a 1996-1997 survey, 18 individuals were detected in Sipsey Fork and 11 individuals were detected in Brushy Creek (Guyer 1997).

Population Trends:
Even though this salamander was extensively surveyed from 1990 to 1997, population abundance was too low to determine short-term population trend. Guyer and Durflinger (1999) report that abundance may fluctuate from year to year, but only low numbers of this species were detected throughout the 1990's. Over the long-term, this species has declined by 50-75 percent (NatureServe 2008). This salamander has been reduced or extirpated over much of its historic range due to habitat degradation (Bailey 1992).

Status:
The Black Warrior Waterdog is imperiled in Alabama (G2S2) (NatureServe 2008). It is ranked as Endangered by the IUCN. It is a federal candidate for ESA listing and is in dire need of full ESA protection.

Habitat destruction:
Habitat degradation has resulted in population reduction or extirpation over much of the historical range of this salamander (Bailey 1992). The Black Warrior Waterdog now exists only in highly fragmented populations where it occurs at low densities and is extremely vulnerable to further habitat degradation (NatureServe 2008). Habitat conditions are expected to worsen for this species (NatureServe 2008). Pollution and sedimentation from mining, forestry, agricultural (especially poultry farms and cattle feedlots), and industrial and residential sewage effluent have contributed to the extirpation of this species over much of its range and pose an ongoing threat to its survival (Bailey 1995, Bailey and Guyer 2004).

There are widespread and numerous sources of point and nonpoint source pollution in this species' habitat. Most of the streams which once supported this species now show evidence of deteriorated water quality and many appear biologically depauperate (Bailey 1992, 1995, Guyer 1997). Industrial plants, landfills, sewage treatment plants, and drain fields from private residences are known sources of pollution in this salamander's habitat (FWS 1998), as are poultry and cattle feedlots (Deutsch et al. 1990). Urban runoff from Birmingham, Tuscaloosa, and Jasper also threatens this species (Mettee et al. 1989, U.S. Fish and Wildlife Service 1990).

The Black Warrior Waterdog is also threatened by surface mining for coal, which causes erosion, sedimentation, hydrological alteration, declining groundwater levels and general water quality degradation (Bailey 1995, FWS 1998). Logging also threatens this salamander (Dodd et al. 1986, Hartfield 1990, FWS 1998). Waterdogs are vulnerable to sedimentation and pollution because they spend virtually all of their lives on the stream bottom and are in contact with any toxic sediments that are present (Bailey 1995).

Impoundments also threaten this species. Impoundments in the Black Warrior basin have flooded thousands of hectares of previously suitable habitat and fostered populations of predatory fishes. There are no records of Black Warrior waterdogs occurring in impoundments (Bailey, pers. comm., 1999 cited in NatureServe 2008). Hartfield (1990) reported that the entire main channel of the Black Warrior River has been affected by impoundments, as have reaches of the Locust Fork, Mulberry Fork, Sipsey Fork, and North River. The Sipsey Fork is perhaps the best remaining locality for the Waterdog (Guyer 1998), but habitat quality there is known to be declining (Bailey and Guyer 1998).

Remaining Waterdog populations are isolated from each other by unsuitable habitat caused by impoundments, pollution, and other factors. Habitat fragmention causes surviving isolated populations to be vulnerable to catastrophic events including floods, droughts, or chemical spills. Even if stream quality improves within portions of the basin, impoundments and polluted segments will act as barriers that prevent population rescue and reestablishment (NatureServe 2008).

Overutilization:
Due to its increasing rarity and the low abundance of surviving populations of this species,

overutilization by herpetological collectors increasingly threatens the survival of this salamander.

Inadequacy of existing regulatory mechanisms:

Despite this species' status as a federal candidate for Endangered Species Act protection, NatureServe (2008) reports that no occurrences are appropriately protected and managed. The State of Alabama provides no protection for this endemic species, categorizing it only as a Species of Greatest Conservation Need. The Federal Surface Mining Control and Reclamation Act of 1977 and the Clean Water Act of 1972 have been ineffective in preventing the continued decline of this salamander in the Black Warrior basin (Dodd et al. 1986, Mettee et al. 1989, Hartfield 1990, Bailey and Guyer 1998, U.S. Fish and Wildlife Service 1998). This species occurs on Bankhead National Forest, with the remaining 90 percent of occurences being on private land. Due to ongoing habitat degradation, the Black Warrior Waterdog needs full Endangered Species Act protection before it is driven to extinction while waiting on the candidate list.

Other factors:

Water pollution threatens the Black Warrior Waterdog. Guyer (1997) found that this salamander is associated with substrates that lack silt and that have increased abundance of snails and Desmognathus salamanders, both of which are sensitive to water quality degradation. Guyer (1997) also found that this salamander occurs more often in sites with decreased abundance of invasive Corbicula clams, indicating that the spread of this invasive clam may somehow threaten the Waterdog via unknown mechanisms.

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Scientific Name:
Necturus lewisi
Common Name:
Neuse River Waterdog

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
Neuse River Waterdogs (Necturus lewisi) only occur in the Neuse and Tar river systems in the Piedmont and Coastal Plain regions of North Carolina (AmphibiaWeb 2009).

Habitat:
Neuse River Waterdogs are permanently aquatic stream dwellers that require relatively high water quality and high levels of dissolved oxygen (Ashton 1990). They occur in areas of submerged leaf liter in eddies and backwaters (Bury et al. 1980 in NatureServe 2008). Juveniles have been encountered sheltering under granite boulders on sand/gravel substrate and in leaf beds (Petranka 1998 in AmphibiaWeb 2009). This salamander constructs retreats under cover objects, and construct retreats entrances on the downstream side of rocks (Ashton 1985 in AmphibiaWeb 2009).

AmphibiaWeb (2009) provides the following description of Neuse River Waterdog habitat: "While Bishop (1943) notes animals generally are found in backwaters off the main current, where substrates are sandy or muddy, Braswell and Ashton (1985) found animals to be most abundant in streams greater than 15 m wide and 1 m deep, with flow rates of greater than 10 cm/s. Further, Braswell and Ashton (1985) found more animals associated with clay or hard soil substrates, while Brimley (1924) and Martof et al. (1980) found animals associated with leaf beds (see also Petranka, 1998). Neuse River waterdogs are distributed from larger headwater streams in the Piedmont to coastal streams up to the point of saltwater intrusion (Braswell and Ashton, 1985)."

Ecology:
AmphibiaWeb (2009) provides the following details on the ecology of Neuse River Waterdogs:

Adults are active at night, and daytime activity is limited, as is activity when water temperatures are greater than 18˚C. Adults remain active at temperatures as low as 0˚C (Braswell and Ashton, 1985; Petranka, 1998). Home range size was determined to be 16–19 m2 for two females, and 49–90 m2 for three males (Ashton, 1985), with males also moving greater distances between captures. Eggs are attached to the underside of cover objects such as large rocks in the water in moderate currents in water depths of 25-41 cm. Breeding occurs in the spring. Detected nest sites were in areas that received only a few hours of direct sunlight per day. Clutch size has been reported at 19-35 eggs. Nests are guarded by females and potentially by males. Larvae feed on leaf-litter invertebrates (Braswell and Ashton, 1985; see also Petranka, 1998). Females and males defend their retreat sites. In the spring and fall activity levels are highest and activity increases following moderate rainfall, when barometric pressure is low or falling, and during the new moon. In spring adults move from winter shelters in leaf beds, river banks, and under rocks to boulders or outcrops in fast currents with high dissolved-oxygen content to nest and spend the summer. This salamander becomes sexually mature at about 100 SVL (Cooper and Ashton, 1985; see also Petranka, 1998). Age at maturity is estimated at 5.5 yr for males, 6.5 yr for females (Cooper and

Ashton, 1985; see Petranka, 1998). Adult waterdogs eat lampreys, ostracods, copepods and cladocerans, snails, annelids, fishes, other species of salamanders, adult eastern worm snakes (Carphophis amoenus amoenus), isopods, slugs, spiders, crayfish, centipedes, millipedes, and insects such as mayflies, true flies, beetles, dragonfly and damselfly naiads, hellgrammites, caterpillars, and caddisflies (Braswell and Ashton, 1985; Petranka, 1998).

Populations:
Number of populations and overall population size are unknown for this species (NatureServe 2008). This salamander may be locally abundant at certain sites (Bury et al. 1980).

Population Trends:
The Neuse River Waterdog is known to be declining due to water quality degradation, but quantitative data are unavailable. Some populations are known to have been eliminated due to water population. AmphibiaWeb (2009) states: "Historical versus current abundance is unknown, but if high levels of pollution eliminate populations (Braswell and Ashton, 1985; see also Petranka, 1998), low levels of pollution may reduce abundances within remaining populations."

Status:
The Neuse River Waterdog is vulnerable in North Carolina (NatureServe 2008). It is ranked as Near Threatened by the IUCN. It lacks legal protective status.

Habitat destruction:
Habitat destruction is a major threat to the Neuse River Waterdog. Dodd (1997) lists habitat alteration as a threat to this species. This salamander is threatened by water development projects such as channelization and impoundments, and by industrial and urban development (Bury et al. 1980; Braswell and Ashton 1985; Braswell 1989; H. LeGrand, pers. comm., 1997 in NatureServe 2008). Bury et al. 1980 state, "Extensive plans for dams above the fall line threaten nearly all of the localities where this species is abundant. It is threatened by both habitat destruction and pollution" (p. 16). NatureServe (2008) reports that a significant portion of the habitat in the upper Neuse drainage has been destroyed or degraded (Braswell 1989), and that ongoing development threatens this species. Aquatic habitats in the Neuse River basin have been extensively degraded by pollution from confined animal feeding operations and runoff from ongoing development (North Carolina Office of Environmental Education 2008). The North Carolina Wildlife Resources Commission (2005) reports that aquatic species in the Neuse Basin are threatened by agriculture, forestry, impoundments, water withdrawals for irrigation, development, wastewater discharges, and increasing human population. The human population within the basin is expected to grow by more than 867,000 by 2020 to almost 3 million people.

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: “The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous” (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: “There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations” (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: “Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species” (p. 178).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: “Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)” (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007). Dodd (1997) states: “In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers” (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: “Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park" (p. 180).

Overutilization:
Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: "Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available" (p. 183).

Disease or predation:
Native amphibians in the Southeast potentially face predation pressures from introduced species of fishes and from cattle egrets, armadillos, and wild hogs (Dodd 1997). Amphibian populations can also be negatively affected by increases in populations of native predators such as raccoons (Dodd 1997) and corvids (Liebezeit 2002). In conjunction with other threats, natural predation could negatively impact populations.

New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and it is imperative that equipment be disinfected so that research efforts to protect species do not inadvertently introduce this fungus or other pathogens to imperiled amphibian populations.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that no occurences of this species are appropriately protected. Neuse River Waterdogs are considered a Species of Special Concern in North Carolina, but this designation does not provide the species with any regulatory protection.

Other factors:
The Neuse River Waterdog is threatened by factors which degrade water quality, including pollution from agricultural runoff, hog farm wastes, pesticides, and industrial and urban development (Bury et al. 1980; Braswell and Ashton 1985; Braswell 1989; H. LeGrand, pers. comm., 1997 in NatureServe 2008). AmphibiaWeb (2009) reports that severely polluted streams are known to have lost their populations (Braswell and Ashton, 1985; see also Petranka, 1998). Hall et al. (1985) found metabolites of DDT and PCBs in Neuse River Waterdog tissue from the Tar and Neuse Rivers in North Carolina-- DDE, DDD, dieldrin, cis-chlordane, trans-nonachlor, and PCP 1254 were detected (in AmphibiaWeb 2009). The North Carolina Wildlife Resources Commission (2005) reports that aquatic species in the Neuse Basin are threatened by non-point source pollution from agriculture, forestry, animal waste byproducts, bank erosion, and development. Point source pollution also threatens aquatic species. There are over 400 point source waste discharge permits in the Neuse basin.

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations” (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians.
Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: "Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Notropis ariommus
Common Name:
Popeye Shiner

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
Historically, the popeye shiner occurred in most of the principal drainages of the Ohio River basin and in the western part of the Lake Erie drainage (Maumee River, Ohio) (Burkhead and Jenkins 1991). It is now spottily distributed in the Ohio River basin including the Tennessee River drainage. It has been extirpated from much of its former range (Boschung and Mayden 2004).

Habitat:
This fish occurs in warm, relatively clear flowing waters of large creeks and small to medium rivers, and is closely associated with gravel substrate (NatureServe 2008). It is typically found in runs, backwaters near appreciable current, and the head of pools (Burkhead and Jenkins 1991).

Populations:
NatureServe (2008) estimates that there are probably between 21 and 100 extant occurrences of this fish, but this needs to be verified. Some of the best remaining populations occur in the Clinch and Duck rivers in Tennessee (Boschung and Mayden 2004). Outside Kentucky and Tennessee, it is only known from a few sites, and some of these populations have been extirpated. This fish is seldom very common (Lee et al. 1980).

Population Trends:
NatureServe (2008) reports that this fish is declining throughout much of its range, and estimates a decline of up to 30 percent.

Status:
The American Fisheries Society (Jelks et al. 2008) ranks the popeye shiner as vulnerable due to habitat loss and degradation and limited range. NatureServe (2008) ranks this species as extirpated in Alabama, Indiana, and Pennsylvania, critically imperiled in Georgia, and Ohio, imperiled in Virginia and West Virginia, and vulnerable in Kentucky and Tennessee. This species is spottily distributed and much of its habitat has been degraded or destroyed by siltation, pollution, and impoundment (Burkhead and Jenkins 1991). Some peripheral occurrences have been extirpated.

Habitat destruction:
Several occurrences of the popeye shiner have been extirpated due to habitat loss and degradation, and remaining populations are threatened by ongoing habitat degrading activities. In the upper Tennessee River drainage, habitat has been degraded or destroyed by siltation, pollution, and impoundment (Burkhead and Jenkins 1991). Boschung and Mayden (2004) state, “It owes its demise in Alabama to siltation resulting from the inundation of large, gravel-bottomed creeks by impoundment of the Tennessee River." This species was impacted by a toxic spill into the Clinch River in 1967, from which it has not recovered well (NatureServe 2008). It has also been negatively impacted by toxic pollution in the North Fork of the Holston (Burkhead and Jenkins 1991).

Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

EPA (2002) reports that coal mining activities and agricultural practices, past and present, are having adverse impacts on stream habitats in the Clinch watershed, where some of the best populations of this species remain (Boschung and Mayden 2004). The popeye shiner is threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which adequately protect this species, and NatureServe (2008) reports that it is unknown whether any occurrences are appropriately protected.

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Scientific Name:
Notropis ozarcanus
Common Name:
Ozark Shiner

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
This fish occurs in the Ozark Uplands in southern Missouri and northern Arkansas. Most localities are in the White and Black river systems in the White River drainage (Robison and Buchanan 1988, Pflieger 1997). This species was formerly known from the headwaters of the St. Francis River in southeastern Missouri. A survey in Arkansas in the mid-1990s indicated that populations still occur in the Buffalo, Spring, and Strawberry river systems, but this species is possibly extirpated from the upper White River above or below Beaver Reservoir, War Eagle Creek, North Fork of the White River below Lake Norfork, Eleven Point River, and the Current River (Robison 1995).

Habitat:
This fish occurs in high-gradient small to medium clear rivers with permanent strong flow. It is associated with riffles, runs, and flowing pools in slight to moderate current over firm silt-free substrates. In midwater, it occurs in schools. It has been eliminated from many impounded areas (NatureServe 2008).

Populations:
In Missouri, this species was historically known from 5 principal drainages (Pflieger 1997). Currently large numbers exist in only one drainage, and there are an estimated 6-20 extant occurrences. Pflieger (1997) mapped 19 pre-1945 collection sites and 23 post-1945 sites. Lee et al. (1980) mapped 54 collection sites. This fish is extant in a least a few river systems in Arkansas, where Robison and Buchanan (1988) mapped 33 collection sites for 1960-1987 and 9 pre-1960 sites.

Total population size is unknown. This fish can be locally common, especially in the upper Current River, but typically occurs in low abundance (Page and Burr 1991, Robison 1995). In Arkansas, an extensive status survey with 104 collection samples from 1994-1995 resulted in the collection of 91 individuals, 67 of which were taken from the Buffalo River (Robison 1995). Robison (1995) summarized the number of individuals in museum collections that were taken from Arkansas by decade: 242 individuals during 1938-1939; 121 individuals during 1950-1959; 143 individuals during 1960-1969; 426 individuals during 1970-1979; 13 individuals during 1980-1989; and 201 individuals during 1990-1995.

Population Trends:
The Ozark shiner is declining in Missouri, with large numbers now occurring in only one of its 5 historically occupied drainages (J. Sternburg, pers. comm., 1997 cited in NatureServe 2008). In the White River, which was a former stronghold for this fish, it is now on the verge of extirpation. It may be declining in the St. Francis River, and it is probably extirpated in the Eleven Point and Black rivers (Robison 1995, Pflieger 1997, J. Sternburg, pers. comm., 1997 cited in NatureServe 2008). This fish has also declined in range and abundance in Arkansas, where it has been extirpated from several streams. The Buffalo River continues to support a rather large and

widespread population (Robison 1995). In the short-term this species has declined by up to 30 percent, and it has experienced a long-term decline of 25-75 percent (NatureServe 2008).

Status:
This fish is spottily distributed in small populations, is declining in some areas and has been extirpated from numerous locations. It is ranked by NatureServe (2008) as imperiled in Arkansas and Missouri. The American Fisheries Society (Jelks et al. 2008) classifiy this species as vulnerable due to habitat loss and degradation.

Habitat destruction:
The primary threat to the Ozark shiner is impoundments. Impoundments destroyed habitat for this species and their operation continues to threaten this fish through siltation and releases of cold water (Robison and Buchanan 1988, Pflieger 1997). This fish was extirpated from a number of stream reaches that have been impounded and also from downstream reaches miles downstream which are affected by cold water releases (Robison and Buchanan 1988). The shiner is also threatened by increased turbidity and siltation from surrounding land practices such as clearcutting, farming, development, and road building (NatureServe 2008). Gravel removal operations and increased resource demands driven by human population growth also threaten this fish (NatureServe 2008). The Arkansas Game and Fish Commission (2005) report that this fish is threatened by habitat destruction from dams, resource extraction, and road construction, and by sedimentation from forestry, grazing, and resource extraction. The Missouri Dept. of Conservation (2010) reports that fish in the White River watershed are threatened by urbanization, livestock grazing, gravel mining, and reservoir operations. Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which adequately protect this species. NatureServe (2008) reports that few to several occurrences may be appropriately protected, because much of Jack's Fork and the Current River are part of the Ozark National Scenic Riverways (J. Sternburg, pers. comm., 1997), and the Buffalo River is protected by the National Park Service (Robison 1995).

Other factors:
The Ozark shiner is threatened by water pollution from nutrient enrichment from poultry and swine operations, and by siltation from impoundments and a variety of land use activities (Arkansas Game and Fish Commission 2005, NatureServe 2008, Missouri Dept. of Conservation 2010).

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Scientific Name:
Notropis perpallidus
Common Name:
Peppered Shiner

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The peppered shiner is patchily distributed within its narrow range in tributaries of the Red and Ouachita rivers in southeastern Oklahoma and southern Arkansas. In the Red River drainage, it is known from the Little and Kiamichi rivers. In the Ouachita drainage, it is known from the Saline, Ouachita, Caddo, and Little Missouri rivers (Page and Burr 1991, Lee et al. 1980). Despite extensive surveys, Robison (2006) did not detect this species in Oklahoma, and only detected it in the Ouachita mainstem and the Saline River system in Arkansas.

Habitat:
This fish occurs in pools and slow runs of warm, clear, small to medium rivers with gravel substrate, frequently near aquatic plants. It is associated with lees of islands and other obstructions out of the main current (Lee et al. 1980, Page and Burr 1991), and with deeper (more than 50 cm), slower (less than 0.3 cm/sec) areas (Wagner et al. 1987).

Populations:
Lee et al. (1980) mapped 19 collection sites for this species. As of 1981, there were 26 documented occurrences in Arkansas, and 38 collection sites in Oklahoma, but Robison (2006) did not detect this fish at all in Oklahoma, and only detected it in two river systems in Arkansas. Despite 81 collection efforts, Robison (2006) did not document any extant populations in Oklahoma or in the Little Missouri River, Caddo River, Kiamichi River, Mountain Fork River, or Glover River in Arkansas. Robison (2006) states: "After careful review of all of the major museum holdings of the peppered shiner available, 2 years of intensive field work collecting peppered shiners, review of all pertinent literature, and discussions with virtually all of the major collectors of peppered shiners in Arkansas, it is apparent that the peppered shiner has declined in abundance throughout its historical range in Arkansas. No specimens of the peppered shiner were collected in Oklahoma."

Total population size is unknown. This fish was historically rare and occurs in small populations at low densities (Wagner et al. 1987). Robison (2006) captured only 17 peppered shiners in 81 sampling efforts in Oklahoma and Arkansas.

Population Trends:
NatureServe (2008) reports that this species has declined by up to 30 percent, but Robison (2006) did not find this species at any of its historical occurrences in Oklahoma or in the Little Missouri River, Caddo River, Kiamichi River, Mountain Fork River, or Glover River in Arkansas. This fish has never been common and has declined over the past 30 years in both Arkansas and Oklahoma (Robison 2006).

Status:
This fish has a narrow range, occurs in low densities, and has been extirpated from many historical locations (Robison 2006). NatureServe (2008) ranks this fish as imperiled in Arkansas and Oklahoma. Robison and Buchanan (1988) categorized this fish as threatened in their discussion of

rare and endangered fishes in Arkansas. The peppered shiner is classified as vulnerable the American Fisheries Assoication (Jelks et al. 2008) due to habitat loss and degradation.

Habitat destruction:

The peppered shiner is very susceptible to environmental disturbance (Robison and Buchanan 1988). Jester et al. (1992) consider the peppered shiner to be intolerant to degradation in habitat and water quality. Much of the shiner's habitat has been destroyed and modified by impoundments and reservoir construction (Arkansas Game and Fish Commission 2005, NatureServe 2008). Cold water releases from the dams are an ongoing threat (Robison 2006). This fish is also threatened by increases in turbidity and siltation which have occurred in the upland streams it inhabits due to poor land use practices such as road building, farming, clearing of land for pasture, clearcutting, destruction of riparian buffer strips and other human perturbations which continue in these watersheds (Robison 2006). In a number of streams, the shiner is also threatened by gravel removal operations (Filipek and Oliver 1994) and by intensive silviculture (C. Taylor 1997 pers. comm. cited in NatureServe 2008). Jelks et al. (2008) list habitat loss and degradation as a threat to this species.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect the peppered shiner, and no occurrences are protected (NatureServe 2008).

Other factors:

The peppered shiner is threatened by pollution from nutrient enrichment from the enormous increase in poultry and swine operations surrounding its habitat, and from siltation from impoundments and from a variety of land use activities (Robison 2006).

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Scientific Name:
Notropis suttkusi
Common Name:
Rocky Shiner

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
The rocky shiner is endemic to the Ouachita Uplands, including tributaries of the Red River in southeastern Oklahoma and southwestern Arkansas (Humphries and Cashner 1994, Wood et al. 2002, Miller and Robison 2004). Populations are known from the Blue, Kiamichi, Little and Muddy Boggy rivers (Humphries and Cashner 1994).

Habitat:
The rocky shiner is found in clear rivers and creeks of moderate to high gradient with gravel and rubble substrates (Humphries and Cashner 1994).

Populations:
Humphries and Cashner (1994) documented 19 sites in four drainages. More recent information is not available.

Population Trends:
There is no information on population trends in the rocky shiner.

Status:
According to Humphries and Cashner (1994), "the restricted range" of the rocky shiner is cause for concern over the long-term survival of its populations. Jelks et al. (2008) list the species as vulnerable.

Habitat destruction:
Humphries and Cashner (1994) identify impoundment of rivers, farmland runoff, gravel operations, and stream channelization as factors in the diminishment of habitat for gravel dependent species like the rocky shiner. Jelks et al. (2008) identify the present or threatened destruction, modification or reduction of habitat or range as a factor in the rocky shiner being vulnerable.

Inadequacy of existing regulatory mechanisms:
There is no legal or regulatory protection for the rocky shiner.

Other factors:
Jelks et al. (2008) identify a narrow, restricted range as a factor in the rocky shiner being considered vulnerable.

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Scientific Name:
Noturus fasciatus
Common Name:
Saddled Madtom

G Rank:	**AFS Status:**
G2	Vulnerable

Range:
The saddled madtom has a very small range in the Duck River system and adjacent western tributaries of the Tennessee River in Hardin and Wayne counties, Tennessee (Burr et al. 2005). It was historically recorded in additional areas, including a few records from the mainstem Duck River in Bedford, Henry, and Marshall counties, five localities in the Indian Creek system and one locality in Rogers Creek (Burr et al. 2005).

Habitat:
Burr et al. (2005) state that "critical habitat for Noturus fasciatus includes second and third order streams with clear water, dark gravel and slabrock substrates, and abundant riffle habitat." During the day, the species is typically found buried in gravel, cobble, rubble, or slate substrates in riffle habitats, whereas at night the species is thought to forage in pools or pool margins (Burr et al. 2005).

Populations:
Burr et al. (2005) extensively sampled for the saddled madtom from 1992-1994 and found the species at "few sites" and a "low number of specimens per site (mean= 2.1)," leading the authors to conclude that either the madtom had "declined dramatically in abundance and range over the past 10-20 years; or our seasonal timing, collecting techniques, and efforts differ significantly relative to those of previous collectors." They further speculated that one reason they may have undersampled the madtom was that they had sampled during the day, rather than at night when the species is easier to capture (Burr et al. 2005). Despite this limitation, however, Burr et al. (2005) state that "repeated diurnal collections by BMB have consistently yielded ten or more N. fasciatus from several localities in the previous 15 years," indicating that their surveys do accurately document that "the species has disappeared from some sites over the past 10-20 years."

Population Trends:
NatureServe (2008) concludes that the saddled madtom has experienced a long-term, moderate decline of 25-50 percent, consistent with findings of Burr et al. (2005) that the species has dissapeared from some sites.

Status:
NatureServe (2008) lists the saddled madtom as imperiled in Tennessee because of its "restricted range in the Duck River drainage, Tennessee," because it is "known from only 13 sites since 1992," and because "numbers very low where found." Jelks et al. (2008) list the madtom as vulnerable because of the present or threatened destruction, modification, or reduction of habitat or range and because of a narrow, restricted range.

Habitat destruction:
Jelks et al. (2008) classify the species as vulnerable in part because of the present or threatened destruction, modification, or reduction of habitat or range. Burr et al. (2005) identify "channelization, removal of riparian vegetation, and agricultural runoff" as potential threats to the

saddled madtom, which they note are "all common occurrences in eastern North American streams," and moreover that "these disturbances have the greatest impact on small, high quality streams, critical habitat of Noturus fasciatus."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) determines that "few occurrences" are "appropriately protected and managed." Tennessee lists the species as threatened. This designation, however, provides no regulatory protection for the madtom's habitat.

Other factors:

Other threats to the continued existence of the saddled madtom include a narrow restricted range, drought, and organic pollution (Burr et al. 2005, Jelks et al. 2008, NatureServe 2008). Recognizing that factors contributing to range decline of Noturus fasciatus were not investigated, Burr et al. (2005) observed that "severe drought in the late 1980s could have contributed to local extirpation" because "peak spawning for N. fasciatus is probably in June and July," when low flows "might have disrupted nesting and reduced recruitment, especially in smaller tributaries lacking permanent spring input." This indicates the saddled madtom is potentially threatened by future droughts and increasing water demands from a growing human population.

Burr et al. (2005) also cited organic pollution as a potential threat, stating: "the wide variety of complex organic chemicals added to streams may interfere with the highly developed olfactory sense of madtoms, disrupting behavioral patterns important for survival."

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Scientific Name:
Noturus furiosus
Common Name:
Carolina Madtom

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	DD - Data deficient

Range:
The Carolina madtom occurs in the Neuse and Tar river drainages in North Carolina in the Piedmont and inner Coastal Plain. Most records are from the vicinity of the Fall Line (Lee et al. 1980). It has been severely reduced in the Tar drainage and is mostly eliminated from the Neuse.

Habitat:
Lee et al. (1980) report that this fish usually occurs over fine to coarse sand substrate in very shallow water with little or no current. Page and Burr (1991) describe its habitat as sand-, gravel-, and detritus-bottomed riffles and runs in small to medium rivers. Midway (2008) reports that it is found under cover in moderately flowing, sand and gravel-lined streams and rivers, with cobble being the most frequent cover structure. Burr et al. (1989) report that nests have been found in cans and bottles in pools and runs (Burr et al. 1989).

Populations:
The Carolina madtom was detected at 42 distinct localities during the early 1980's, 33 of which have been recollected since 1982. The madtom is difficult to detect during high water conditions, and may not have been detected at some sites where it was present (Burr and Lee 1985). More recent surveys have revealed fewer occurrences of this species (Starnes 2002). Total population size is unknown. Lee et al. (1980) describe this species as generally uncommon or rare. Page and Burr (1991) state that it can be locally common, but is disappearing from some localities. Population densities are, for the most part, unknown and assumed to be low (Midway 2008). Burr and Stoeckel (1999) note that, Noturus spp. densities never reach those associated with most other stream-dwelling fishes. This species is mostly eliminated from the Neuse Basin.

Population Trends:
The Carolina madtom has declined by up to 30 percent in the short-term and has undergone a long-term decline of 25-75 percent (NatureServe 2008). Midway (2008) did not detect this species at 2 of 3 sampled reaches in the Neuse Basin, and reports that the Neuse population has shown recent significant decline. Recent work by the North Carolina Wildlife Resources Commission found Carolina madtom abundance in the Neuse Basin to be much lower than historical records indicate, suggesting local extirpations (Midway 2008). NatureServe (2008) states, “It appears that this madtom has severely declined in the Neuse basin and thus may be effectively extirpated from over half of its overall range.”

Status:
The Carolina madtom is declining within its very limited range. It is ranked as imperiled by NatureServe (2008). The Southeastern Fishes Council (2007) recommends threatened status for this fish due to limited overall range and impending threats. The American Fisheries Society (Jelks et al. 2008) rank the Carolina madtom as threatened due to habitat loss and narrow range. This fish is listed as threatened by the state of North Carolina. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the Carolina Madtom should be listed as endangered (SFC and CBD 2010).

Habitat destruction:

The Carolina madtom is particularly sensitive to habitat loss and degradation because of its restricted range and small clutch size (Angermeier 1995, Burr and Stoeckel 1999). Within its limited range, this species faces many threats.

Populations in the Neuse drainage have been negatively affected by the construction of Falls Lake, which has significantly altered water temperatures below the dam. Thermal alteration and general pollution problems around Raleigh have reduced habitat in the upper Neuse River (NatureServe 2008). The Neuse is routinely considered to be an endangered basin (American Rivers Foundation 2007) with impacts such as urban wastewater, fertilizer, industrial development and animal operations all contributing to eutrophication (Pinckney et al. 1997, Paerl et al. 1998). In-stream habitat in the Neuse Basin has been lost and degraded by forestry, urban and residential development, impoundments, and effluent (North Carolina Department of Environment and Natural Resources 2002). Agriculture and farming operations have contributed to habitat degradation, and development is rapidly increasing (Midway 2008). The North Carolina Wildlife Resources Commission (2005) reports that aquatic species in the Neuse Basin are threatened by agriculture, forestry, impoundments, water withdrawals for irrigation, development, wastewater discharges, and increasing human population. The human population within the basin is expected to grow by more than 867,000 by 2020 to almost 3 million people.

Development, confined animal feeding operations, and forestry also threaten aquatic species in the Tar River basin, but to a lesser extent than the Neuse (Starnes 2002). Aquatic species in the Tar River basin are threatened by erosion, sedimentation, channelization, agriculture, irrigation withdrawals, confined animal feeding operations, and increasing human population growth and development pressure (North Carolina Wildlife Resources Commission 2005b).

Jelks et al. (2008) list habitat loss as a threat to this species.

Disease or predation:

In conjunction with habitat loss and degradation, the Carolina madtom is increasingly threatened by predation from the introduced flathead catfish (Pylodictis olivaris) (Guier et al. 1981, Thomas 1993, Brewster 2007, Pine et al. 2007, Midway 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect the Carolina madtom. This fish is listed as threatened by the state of North Carolina, but this designation does not provide the species with substantial regulatory protection. NatureServe (2008) reports that no occurrences are appropriately protected and managed.

Other factors:

This fish is threatened by point and non-point source pollution from a variety of sources, especially poultry and hog farms, rampant development, and forestry (North Carolina Wildlife Resources Commission (2005a, 2005b). Braswell (1989) did not detect this fish in a historical location that has been impacted by municipal and industrial effluents. Midway (2008) suggests that increasing predation from introduced flathead catfish may also be threatening the Carolina madtom, stating: “[A] second potential cause of Carolina madtom decline in the Neuse Basin is the recent introduction of flathead catfish Pylodictis olivaris. North Carolina Wildlife Resource Commission biologists working in these systems have noted Carolina madtom declines in the basin's larger river segments that have historically held populations. Flathead catfish typically inhabit these large rivers and have been documented to forage on Noturus spp. (Guier et al. 1981; Brewster 2007); in some cases near eradication of native ictalurid species have been recorded (Thomas 1993). Further, simulation modeling suggests that flathead catfish suppress native fish abundance in streams by 5–50% through predatory and competitive interactions (Pine et al. 2007)."

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Scientific Name:
Noturus gilberti
Common Name:
Orangefin Madtom

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The orangefin madtom occurs in the Ridge and Valley and upper Piedmont regions of the upper Roanoke River drainage, including the Roanoke River proper and the Pigg, Mayo, and Dan systems, in Virginia and North Carolina (Burkhead and Jenkins 1991).

Habitat:
This fish occurs in swift riffles with small cobble substrate. Because it occupies the interstitial spaces among the cobbles, it is not found in areas with large amounts of sand and silt (Simonson and Neves 1992). Burkhead and Jenkins (1991) describe this species' habitat as medium-sized, moderate gradient, montane and upper Piedmont streams, with the largest populations in streams that are clear. Eggs are presumably deposited under loose rubble.

Ecology:
The orangefin madtom consistently co-occurs with the Roanoke darter (Percina roanoka) (Simonson and Neves 1992).

Populations:
Lee et al. (1980) mapped 13 collection sites for this fish. Butler (2002) reports 5 sites for this species in North Carolina, all in the Little Dan River, 23 sites from the upper Roanoke River system in Virginia, and 13 sites in the upper James River system, where this fish was likely introduced. Burkhead and Jenkins (1991) list viable populations as those in the Roanoke River from Salem upstream, through the South Fork of the Roanoke River, into the lower Bottom and Goose creeks; lower Big Chestnut Creek and a nearby Pigg River site; the Dan River from its gorge in the Blue Ridge downstream into North Carolina; and the South Mayo River and North Fork of South Mayo River within or just above Stuart.

Total population size is unknown. Jenkins & Burkhead (1991) state that this fish is rare to uncommon in portions of the Roanoke River drainage, and uncommon to common in Craig Creek in the James River drainage.

Population Trends:
North Carolina's Wildlife Action Plan (2005) reports that this species is declining in North Carolina. Butler (2002) reports that it is declining in its native range, but expanding in the area where it has been introduced. Most populations apparently are stable, but Jenkins and Burkhead (1994) report significant changes in abundance and distribution in recent decades. The orangefin madtom is apparently extirpated in the heavily silted lower North Fork of the Roanoke River and in the lower Roanoke River below Salem, lower Little Dan River, and upper Smith River (Burkhead and Jenkins 1991).

Status:
This species is ranked as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and limited range. Etnier (1997) states that it warrants federal protective status. It is

listed as endangered by the state of North Carolina, and as threatened by the state of Virginia. NatureServe (2008) ranks it as critically imperiled in North Carolina and imperiled in Virginia.

Habitat destruction:

Within its limited range, this species faces multiple threats. Habitat suitability for this fish is marginal in the South Mayo River and the upper Roanoke River system, particularly in the North Fork of the Roanoke River (Simonson and Neves 1992). The orangefin madtom is threatened by channelization, impoundment, and dewatering (NatureServe 2008). In North Carolina, this fish is restricted to the upper Dan River drainage where it is threatened by cold water releases from dams, which could disrupt its reproductive cycle (North Carolina Wildlife Resources Commission 2005). Fish in the Roanoke Basin are threatened by sedimentation from agriculture, forestry, and construction. Fish and other aquatic species in the basin are also threatened by increasing human population growth and demand for fresh water. Demand for water is expected to increase as much as 55 percent by 2020 (North Carolina Wildlife Resource Commission 2005). Fish in Virginia's Northern Ridge and Valley province are threatened by siltation, mine wastes, industrial and municipal effluent pollution, and agricultural and urban runoff (Virginia Department of Game and Inland Fisheries 2006). Jelks et al. (2008) list habitat loss as a threat to this species.

Overutilization:

Burkhead and Jenkins (1991) report bait-seining as a threat to the orangefin madtom.

Inadequacy of existing regulatory mechanisms:

This fish is listed as endangered by the state of North Carolina, and as threatened by the state of Virginia but these designations do not convey substantial protection to the species or its habitat. It is a federal Species of Concern, but this category carries no regulatory protection.

Other factors:

The orangefin madtom is threatened by pollution from sedimentation, various forms of chronic pollution, and catastrophic chemical spills (NatureServe 2008). There are fish consumption advisories in the Roanoke Basin due to contamination from dioxin, selenium, and mercury from coal ash ponds and other sources (North Carolina Wildlife Resource Commission 2005). Elevated selenium concentrations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Fish in the basin are also threatened by pollution from municipal wastewater treatment plants, industrial facilities, and stormwater runoff.

Populations of orangefin madtom are particularly susceptible to extirpation due to this species' low reproductive rate and short life span (Simonson 1997, Simonson and Neves 1992, Simonson 1987).

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Scientific Name:
Noturus gladiator
Common Name:
Piebald Madtom

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
The piebald madtom is a recently described species that is limited to the coastal plain of Tennessee and Mississippi (Thomas and Burr 2004). The species historically occurred in seven river systems, but is now limited to the Wolf, Hatchie and Obion River systems (Thomas and Burr 2004). It is likely extirpated from the Loosahatchie River (last record, 1954), Yazoo River drainge (last record, 1978), and Big Black River drainage (last record, 1983) (SFC and CBD 2010).

Habitat:
According to Thomas and Burr (2004), the piebald madtom is found in the mainstem of small to medium sized rivers and the lower reaches of their tributaries. They state, "[i]n our sampling experience, we have observed that the species is most commonly associated with moderate velocities, moderate depth (about 60 cm), clean sand or clay substrata, and cover in the form of leaf packs, brush, and log jams."

Populations:
Thomas and Burr (2004) determine that "[m]ost collections have been from the relatively less disturbed portions of the Hatchie, Wolf, and Obion River drainages. Although never locally abundant, it has been taken with greatest consistency in the middle and upper Hatchie and Wolf River drainages."

Population Trends:
The piebald madtom has been extirpated from four of the seven river systems it is historically known from (Thomas and Burr 2004).

Status:
Jelks et al. (2008) list the piebald madtom as vulnerable because of habitat loss and a small range. NatureServe (2008) lists it as vulnerable in Tennessee and critically imperiled in Mississippi, further noting that the species has been "extirpated in some areas" and that a "significant portion of historical range has degraded habitat conditions." It is state listed as endangered by the Kentucky Nature Preserves Commission and is a species of "greatest conservation need" in Kentucky's SWG Wildlife Action Plan. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was support for listing this species as threatened (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) list the piebald madtom as vulnerable because of the present or threatened destruction, modification or reduction of habitat or range. NatureServe (2008) cites Rakes and Shute (2001) as concluding that the Tuscumbia River and lower Hatchie River sites are "severely degraded by poor agricultural and forestry practices." The species has been extirpated from four of the seven river systems in which it formerly occurred likely because of degradation of watershed conditions.

Primary threats are channelization and removal of riparian vegetation that results in increased sedimentation and decrease in instream woody debris cover. Primary activities associated with this disturbance are poor agricultural and forestry practices (SFC and CBD 2010). Watersheds in Mississippi where this madtom occurs are tremondously degraded from erosion and headcutting and heavily altered stream hydrology related to impoundments, channelization and other factors

Inadequacy of existing regulatory mechanisms:
The Piebald Madtom is listed as a species "Deemed in Need of Management" by the Tennessee Natural Heritage Program and endangered by the state of Kentucky, but these designations do not require a recovery plan, critical habitat designation, or agency consultation. Apart from the Hatchie National Wildlife Refuge, lands containing habitats throughout the species' range are under private ownership (SFC and CBD 2010).

Other factors:
Jelks et al. (2008) list the piebald madtom as vulnerable because of a narrow, restricted range. Simlarly, Thomas and Burr (2008) conclude that "[b]ecause N. gladiator has a relatively small geographic range, exists in naturally low population numbers, and there has been deterioration in significant portions of its habitat, we recommend a conservation status of vulnerable, based on national and global criteria." Thomas and Burr (2004) further observe that the species is vulnerable to local extinctions because of poor environmental quality in the lower reaches of streams it inhabits, and because its 'equilibrium' life history strategy (small clutch sizes, large eggs, extreme parental care, and small body size) makes it susceptible to sudden changes in flow regimes, spates of siltation in potential nesting reaches, and a concomintant loss in recruitment from the relatively few large males that nest and reproduce.

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Scientific Name:
Noturus lachneri
Common Name:
Ouachita Madtom

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Ouachita madtom has a very small, discontinuous range in the upper Saline River system and a small unnamed tributary of the Ouachita River below Remmel Dam, in central Arkansas (Robison and Harp 1985, Robison and Buchanan 1988).

Habitat:
The madtom occurs in clear, cool, moderate- to high-gradient creeks and small rivers with gravel-rubble-sand substrates, and alternating pools and riffles. This fish is usually found in gravel/cobble or debris in shallow pools, but also occurs in very shallow riffles under large rocks (Robison and Allen 1995). Spawning likely occurs in smaller tributaries, as juveniles have been detected over shale bedrock in small tributaries (Robison and Harp 1985).

Populations:
Robison and Harp (1985) mapped 17 collection sites for this madtom which probably represent not more than 15 distinct occurrences. Total adult population size is unknown and is difficult to estimate due to difficulty of detection. This species is not abundant at any locality (Robison and Harp 1985).

Population Trends:
Trends are not well documented for the Ouachita madtom, but this species may be declining (NatureServe 2008).

Status:
The Ouachita madtom has a very restricted range where it faces multiple threats. It is categorized as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and degradation and narrow range. It is ranked as imperiled by NatureServe (2008). The Arkansas Department of Planning (1974) described the madtom as endangered, stating, "N. lachneri is not abundant at any locality. Because of its small numbers, the constant threat of damming or channelization activities in the area, and the nearby construction of a massive new planned community in the Saline River watershed (Hot Springs Village), this species is endangered."

Habitat destruction:
The Ouachita madtom is threatened by degradation and loss of habitat from logging, commercial gravel operations, housing developments, and bridge and road building (NatureServe 2008). The construction and repair of bridges has decimated local populations (NatureServe 2008). Habitat has been degraded by stream channelization, gravel mining, and clearcut logging (Robison and Buchanan 1988). Potential impoundments to supply water for Benton and Little Rock are also a threat (Robison and Buchanan 1988). The Arkansas Dept. of Planning (1974) reported damming, channelization, and residential development as threats to the madtom. The Arkansas Game and Fish Commission (2005) reports that this species is threatened by habitat destruction from dams, diversions, resource extraction, and forestry. Jelks et al. (2008) list habitat loss as a threat to this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. It is a designated Species of Concern in Arkansas, but this does not provide any regulatory protection.

Other factors:
The madtom is threatened by water pollution from sedimentation resulting from forestry, gravel mining, and urbanization (Arkansas Game and Fish Commission 2005).

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Scientific Name:
Noturus munitus
Common Name:
Frecklebelly Madtom

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Vulnerable-Endangered	NT - Near threatened

Range:
The frecklebelly madtom now occurs as four isolated populations found in the upper Tombigbee River in Alabama and Mississippi, upper Coosa River in Georgia and Tennessee, upper Alabama and Cahaba in Alabama, and Pearl River in Mississippi and Louisiana (Boschung and Mayden 2004). It was historically known from the Pearl, Bogue chitto, and Strong Rivers in Mississippi and Louisiana, the Tombigbee River and several of its major tributaries, upstream of the junction with the Warrior River, the Cahaba River downstream of the Fall line at Centreville, and from the main channel of the Alabama River, and in the upper Coosa River system in the Conasauga River and the Etowah River upstream of Allatoona Reservoir in Georgia (SFC and CBD 2010).

Habitat:
The frecklebelly madtom occurs in free-flowing riffles and rapids of medium to large rivers often in areas where there is an abundance of river-weed (Boschung and Mayden 2004). It does not occur in areas of chronic siltation and sedimentation or in impounded rivers (Boschung and Mayden 2004, NatureServe 2008).

Populations:
Based on a comprehensive review of all population surveys to date, museum records, and new field work, Bennet et al. (2008) conclude:

"Nofurus munitus was once fairly abundant in appropriate habitat throughout its range, with night-time collections on large-river gravel shoals before the late 1960s regularly producing large collections of specimens in the hundreds (Supplementary Table 1, available only online at http://dx.doi.Org/10.1656/S593.s!; Pilleret al. 2004). One of the most extensive analyses of historic population trends was conducted by Piller et al. (2004) using museum collection data from the Pearl River from 1950 to 1988. They found a precipitous decline in the N. munitus population in the Pearl River after 1964, coinciding with many human-induced river modifications, despite the fact that sampling effort (number of samples per year) was higher after 1964. While this study focused only on the Pearl River, the same decline in abundance of N. munitus associated with river modification has occurred across its range, as the surveys discussed above document. Examination of available museum records reveals a similar pattern in the Alabama and Tombigbee rivers (Table I), with few collections after 1970 producing specimens, in contrast to the Cahaba River collections, in which A, munitus seems to have remained fairly common. While these museum datasets undoubtedly omit some records, a general trend similar to the findings of Piller et al. (2004) is apparent."

A complete discussion of the available information on the status of populations of the madtom in all of the four major systems in which it occurs can be found in Bennett et al. (2008). On balance, these data show the species to be exceedingly rare in places where it was once abundant. For example, Bennett et al. (2008) observe that the species was not found in the mainstem of the Pearl River and only eight specimens were found in tributaries in 1999 (Piller et al. 2004), was found only at 47 of 113 sites in the Mobile Basin in 1996 and 1997, half of which were in the Cahaba River (Shepard et al. 1997), and is extirpated from the Alabama River (Shepard et al. 1997). These data lead the authors to conclude, "Our review indicates that N. munitus is currently greatly reduced from its former range, and is in decline in most of the drainages it still inhabits. We recommend federal protection for the species under the Endangered Species Act."

The following detailed summary was provided by the Southeastern Fishes Council at a meeting of the Gulf Slope Group with CBD:

"There are records of the frecklebelly madtom from four major tributaries of the upper Tombigbee River in Alabama and Mississippi: Sipsey River, Luxapallila Creek, Buttahatchie River, and Bull Mountain Creek. The lower section of Sipsey River is characterized by high-quality gravel shoals, and the population there is apparently stable. Although the lower reach of Luxapallila Creek has produced several large series of N. munitus, the portion of the stream downstream of Columbus, MS was channelized for flood control in 1995, eliminating the stable gravel shoal habitat needed by the species. The area upstream of the Alabama state line is channelized and has not produced the species. N. munitus is now probably limited to a short unchannelized stretch of Luxapallila Creek near Steens, MS. The strongest remaining population of frecklebelly madtoms in the upper Tombigbee River system in the Buttahatchee River where the species has been collected from the first shoal upstream of the embayment Columbus Lock and Dam upstream to Hamilton, AL in most stable gravel shoals. In-stream gravel mining in the lower section of the river has disrupted some shoals eliminating frecklebelly madtoms. Bull mountain Creek produced N. munitus in 1980-81 at several stations, however, repeated sampling recently at numerous localities throughout the creek has failed to produce additional specimens, and it may now be extirpated. The population may have been adversely effected when the lower section of the creek was cut off by construction of the Tennessee-Tombigbee Waterway. In the Cahaba River, frecklebelly madtoms have recently been documented from four miles downstream of the Highway 80 bridge in Dallas County upstream to near the Fall Line at Centreville in Bibb County. Abundance in the Cahaba River is closely related to the condition and stability of the gravel shoals. Shoals which are embedded with sand and silt are typically not inhabited by the species. Frecklebelly madtoms were collected at 7 stations in the main channel of the Alabama River in Wilcox and Monroe counties in the 1960's before the completion of Jones Bluff, Millers Ferry, and Claiborne Locks and Dams. The species has now apparently been eliminated there due to sedimentation, gravel removal, and altered flow regimes."

Population Trends:

NatureServe (2008) classifies the frecklebelly madtom as "severely to rapidly declining" at a rate of 30 to more than 70 percent, stating: "This species has declined precipitously in recent years, particularly in Mobile Bay drainage where it is approaching extirpation (Lee et al. 1980). Habitat modifications have apparently eliminated or greatly reduced abundance throughout much of former range (Shephard et al. 1996). Declining in Louisiana, possibly rapidly (S. Shively, pers. comm., 1997). Declining rapidly; Tennessee-Tombigbee waterway construction in the early 1980s probably destroyed much of the habitat in the Tombigbee River; majority of extant populations may occur in Mississippi (P. Shute, pers. comm., 1997). Apparently extirpated from Bull Mountain Creek in the Tombigbee River System and the Alabama River (Shephard et al. 1996)."

Although Noturus munitus was once widespread and abundant on the expansive gravel shoals that characterized the main channel of the upper Tombigbee River, the species has now been eliminated there by channelization and impoundment to create the Tennessee-Tombigbee Waterway (SFC and CBD 2010).

Status:

This summary clearly demonstrates that the frecklebelly madtom has been lost from many This species is spottily distributed in Louisiana, Mississippi, Alabama, and Tennessee, has historic locations because of habitat degradation, including in the recent past.significantly declined in the Mobile Bay drainage, and is threatened by various alterations to its habitat. It is ranked by NatureServe (2008) as critically imperiled in Georgia and Tennessee, and imperiled in Alabama, Mississippi, and Louisiana. Jelks et al. (2008) list the populations in the Tombigbee and Coosa as endangered and the populations in the Cahaba and Pearl as vulnerable. It is listed as threatened by the state of Tennessee, endangered by the states of Mississippi and Georgia, and as a species of greatest conservation need in Alabama. Bennett et al. (2008) conclude that this species warrants listing under the federal Endangered Species Act as threatened, stating: "While it remains widely distributed across the southeastern US, it has declined precipitously from historic abundance since the late 1960s and is currently found in abundance in only the Cahaba and Buttahatchee rivers. Further, its dependence on large-river gravel shoal habitat makes it vulnerable to river modification that will likely continue into the foreseeable future." At a meeting of the Southeastern Fishes Council and CBD there was general support for listing this species as threatened (SFC and CBD 2010).

Habitat destruction:

The frecklebelly madtom occurs in main channel shoal habitats, and is very intolerant of sedimentation (Shepard 2004, SFC and CBD 2010). Its habitat requirements make it very vulnerable to practices which disturb substrate integrity such as in-stream gravel mining, channelization, and sedimentation due to nonpoint source pollution (Ibid.) Jelks et al. (2008) list the species as vulnerable or endangered, depending on which system, because of the present or threatened destruction, modification, or reduction of habitat or range.

The freckleberry madtom is considered to be very threatened by several factors including impoundment, channelization, gravel mining, altered flow regimes, agriculture, and logging (Mettee et al. 1996, Shephard et al. 1996, Piller et al. 2004, Bennett et al. 2008, NatureServe 2008). Piller et al. (2004), for example, conclude: "the Pearl River experienced numerous human caused disturbances since the 1950s, and it is difficult to attribute the decline of the frecklebelly madtom to any one of these factors. Rather, it is likely that all of the disturbances contributed to the widespread problem of geomorphic instability in the river, and this in turn is depressing populations of gravel-dependent species such as the frecklebelly madtom." Likewise, Bennett et al. (2008) list impacts to the species in most watersheds where it historically occurred. For example, they specifically list construction of the Tennessee-Tombigbee Waterway with 10 lock and dam structures, which led to the "probable extirpation" of the species in the main channel, contruction of three dams on the Alabama River, which led to the extinction of the species in this river, construction of one dam on the Etowah River, which "likely affected" the frecklebelly madtom, and poor land-use practices in the Conasauga, leading to the frecklebelly madtom being "greatly reduced from their former extent and perhaps extirpated" (Bennett et al. 2008). With a growing population in the region, new dams are continuing to be planned. A dam, for example, is being planned on Shoal Creek, which is a tributary to the Etowah (see http://www.dawsonnews.com/news/archive/2321/). There are also plans for a large coal mine on the Buttahatchee River (SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) concludes that none to few occurrences of this fish are appropriately protected. They note, however, that the "most of the headwaters of the Conasauga River are protected by high quality watershed management in the Cherokee National Forest" (NatureServe 2008). The frecklebelly madtom is state-listed inTennessee, Georgia and Mississippi, and is a species of greatest conservation need in Alabama, but none of these designations provide regulatory protection to the madtom or its habitat.

Other factors:

Jelks et al. (2008) cite narrow restricted range as a threat to this species. The madtom is threatened by water pollution, primarily from siltation (NatureServe 2008).

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Scientific Name:
Noturus taylori
Common Name:
Caddo Madtom

G Rank:	AFS Status:	IUCN Status:
G1	Threatened	VU - Vulnerable

Range:
This endemic fish has a small range in the upper Ouachita, Caddo, and Little Missouri rivers of the Ouachita River drainage in southwestern Arkansas (Lee et al. 1980, Robison and Buchanan 1988, Page and Burr 1991). The majority of occurrences are in the Ouachita and Caddo rivers. This fish was known from a single locality in the Little Missouri River, but during recent surveys was not detected there (Turner and Robison 2006).

Habitat:
This headwater stream specialist uses shallow, gravel-bottomed pools or shoals near the shoreline of clear, small to medium-sized upland rivers. It is associated with well-compacted gravel areas below riffles, and also occurs under rocks, beneath large gravel, or among rubble (Robison and Harris 1978, Lee et al. 1980, Robison and Buchanan 1988, Page and Burr 1991, Robison and Allen 1995, Turner and Robison 2006).

Populations:
In 1988, 15 coarse-scale collection sites were mapped for this species (Robison and Buchanan 1988). Turner and Robison (2006) surveyed the majority of the known range of this fish but detected it at only two localities each in the Ouachita and Caddo drainage, and did not detect it in the Little Missouri despite extensive sampling effort. Total adult population size is unknown. Page and Burr (1991) stated that this species is locally common, but Robison and Buchanan (1988) categorized it as rare. Turner and Robison (2006) surveyed most of the known range of the Caddo madtom yet obtained relatively small numbers of individuals at each locality (8.75 individuals, on average).

Population Trends:
The Caddo madtom has declined by up to 30 percent (Robison and Buchanan 1988, Turner and Robison 2006, NatureServe 2008). The population in the Little Missouri may no longer be extant (Turner and Robison 2006).

Status:
The Caddo madtom is restricted to a few rivers in Arkansas where it is rare and apparently declining. Because of their specific habitat requirements and limited occurrence, Caddo madtoms are considered critically imperiled both statewide and globally (Throneberry 2010, NatureServe 2008). Robison (1974) describes this species as rare and endangered. Warren et al. (2000) categorize this species as threatened. The American Fisheries Society (Jelks et al. 2008) categorize this species as threatened due to habitat loss and degradation and narrow range.

Habitat destruction:
The Caddo madtom is particularly vulnerable to habitat loss and degradation due to its limited range. Robison and Buchanan (1988) stated that "this rare species should be considered threatened due to loss of habitat." This fish appears to be vulnerable to local extirpation by small scale disturbances (Turner and Robison 2006). Because this fish is a headwater specialist, it is

particularly vulnerable to local extirpation because natural recolonization from adjacent rivers is unlikely (Turner and Robison 2006). Williams et al. (1999) report that aquatic habitats in this region are negatively impacted by local human activities such as development, logging, and gravel mining. The Arkansas Wildlife Action Plan (2005) reports that this species is threatened by dams, resource extraction, forestry, road construction, sedimentation, and hydrological alteration. Throneberry (2010) reports that this species is threatened by hydrologic alteration and sedimentation. Jelks et al. (2008) list habitat loss as a threat to this species.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. NatureServe (2008) reports that no occurrences are appropriately protected and managed.

Other factors:
The Caddo madtom is threatened by pollution, particularly by sedimentation from a variety of activities (Arkansas Wildlife Action Plan 2005, Throneberry 2010).

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Scientific Name:
Nuphar lutea ssp. sagittifolia
Common Name:
Cape Fear Spatterdock

G Rank:
T2

Range:
The Cape Fear spatterdock, also known as the yellow pond lily, is an aquatic plant endemic to the Coastal Plains of North Carolina, South Carolina, and Virginia. Natural heritage records show this species is present in Charles City, James City, and New Kent Counties in Virginia - records for North and South Carolina are not available (NatureServe 2008). North Carolina had 24 reported occurrences at last inventory (1987), and the species is reportedly rare in both South Carolina (present in one county), and Virginia (present in the Chickahominy River estuary) (NatureServe 2008).

Habitat:
This lily is primarily found in coastal-plain blackwater streams or tidal estuaries, but also occasionally in lakes or brownwater streams. It is often found co-occurring with cypress (Taxodium) (NatureServe 2008).

Ecology:
This plant may hybridize with N. lutea advena in the Chickahominy River estuary (Fernald 1950).

Populations:
Global population size is not know for this species, but approximately 26 occurrences have been reported in the last two decades (NatureServe 2008). This species is locally abundant at some sites, but total range is small, and occurrences are sparse throughout its range.

Population Trends:
NatureServe (2008) reports that the Cape Fear spatterdock is declining across its range, largely as a result of habitat loss.

Status:
NatureServe (2008) ranks this species as critically imperiled in Virginia, imperiled in North Carolina, and its status is under review in North Carolina. This species has a narrow range throughout which it is sparsely distributed, and populations are being extirpated by residential development along river shores.

Habitat destruction:
Degradation in water quality as a result of pollution or siltation from industry, development, and other anthropogenic activities threaten this species, as does recreational boating, and on-shore development (NatureServe 2008). Several occurrences in Virginia have already been lost to development along river shorelines.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Cape Fear spatterdock or its habitat.

Other factors:
The spatterdock is threatened by siltation from a variety of sources (NatureServe 2008).

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Scientific Name:
Nuphar lutea ssp. ulvacea
Common Name:
West Florida Cow-lily

G Rank:
T2

Range:
This water lily is reported from Escambia, Santa Rosa, Okaloosa, Washington, Jackson, and Calhoun Counties, Florida, Baldwin County, Alabama, and possibly from sites in southern Mississippi, though these are not confirmed (Kral 1983, NatureServe 2008, Godfrey and Wooten 1981).

Habitat:
The cow-lily is found in a variety of flow regimes, in shallow, clear, or tannic-acid tinted (blackwater) waters, and is often rooted in sandy substrate (NatureServe 2008).

Ecology:
This plant exhibits both floating and submerged leaves.

Populations:
This species is poorly known, it has not been extensively sampled and is rarely collected in surveys. Neither the number of occurrences nor total population size are known (NatureServe 2008).

Population Trends:
Trend has not been reported for this rare species.

Status:
NatureServe (2008) ranks the West Florida cowlily as critically imperiled in Alabama and imperiled in Florida.

Habitat destruction:
The West Florida cow-lily is extremely sensitive to changes in hydrology and water quality and is threatened by logging and wetland conversion to grazing, agriculture, and development (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
This species occurs on Eglin Air Force Base where it is protected from some threats. No existing regulatory mechanisms adequately protect this species or its habitat.

References:

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Scientific Name:
Nyssa ursina
Common Name:
Bear Tupelo
G Rank:
G2
Range:
Also known as dwarf blackgum, the bear tupelo is a small flowering shrub endemic to a small portion of the Apalachicola River Delta in Florida (Small 1933, Clewell 1985). Natural heritage records indicate this species' presence in Bay, Franklin, Gulf, and Liberty Counties (NatureServe 2008).

Habitat:
This species is found in fire-prone savannas, open herb bogs, and along the wet edges of pineland swamps (Nelson 1996).

Ecology:
This species is small in stature (seldom greater than 1.5 m tall), individuals are dioecious, and fruits are approximately 10-15 mm long (Clewell 1985, Nelson 1996).

Populations:
The Florida Natural Areas Inventory reports 28 occurrences of this species (FNAI 2001 as cited in NatureServe 2008). Global population size is not known, but where found this species is common to abundant (FNAI 2001).

Population Trends:
Though the precise level of decline is not reported, it is believed that habitat loss is driving the decline of this species across its already small range (NatureServe 2008).

Status:
NatureServe (2008) ranks the bear tupelo as imperiled in Florida. This species has an extremely restricted range; further reductions in the extent or quality of habitat may be expected to cause local extirpations.

Habitat destruction:
Habitat loss is the primary threat to this species: logging in pine flatwoods outrightly destroys habitat, and siltation from upstream logging, agriculture, or development alters wetland habitat, making it unsuitable for species like the bear tupelo.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the bear tupelo from habitat destruction or other threats. NatureServe (2008) reports that few occurrences are appropriately protected or managed: the species has been observed on Tyndall Air Force Base, in the Apalachicola National Forest, Tates Hell State Forest, and other public lands, but protections on these lands are minimal.

Other factors:
Siltation from a variety of activities threatens this plant (NatureServe 2008).

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Small, J.K. 1933. Manual of the southeastern flora. Two volumes. Hafner Publishing Company, New York.

Scientific Name:
Obovaria subrotunda
Common Name:
Round Hickorynut

G Rank:	AFS Status:	IUCN Status:
G4	Special Concern	NT - Near threatened

Range:
This freshwater mussel species is present in Alabama, Arkansas, Georgia, Illinois, Indiana, Kentucky, Michigan, Mississippi, Ohio, Pennsylvania, Tennessee, West Virginia, and Ontario. Only 100 occurrences have been reported since 1970, the majority of which were from Indiana (NatureServe 2008). In Indiana, it is found in the Muscatatuck, Tippecanoe, and St. Joseph drainages (Harmon 1989, Cummings and Berlocher 1990, Pryor 2005). In Ohio, it is found in many high quality rivers, including Lake Erie (Watters 1992, 1995, Lyons et al. 2007), in Tennessee, it occurs in the Obey, Stones, Harpeth, and Red Rivers, and the main stem of the Cumberland River, thought it was once more widespread (Parmalee and Bogan 1998). In Alabama, it is restricted to the Paint Rock River system and Bear Creek (Mirarchi et al. 2004, Williams et al. 2008), and in Mississippi, it occurs in the Mississippi River South, Big Black, and Yazoo drainages (Jones et al. 2005). The round hickorynut occurs occasionally in Tennessee's lower Cumberland drainage, including the Middle Green and South Fork Kentucky (Cochran and Layzer 1993, Evans 2008). Though it was once considered extirpated in Pennsylvania, it is likely still extant in the Shenango River (Bursey 1987). It is currently thought to be extirpated from New York (Strayer and Jirka 1997). In West Virginia, it is found in the Upper Ohio/Kanawha and Mud Rivers (Zeto et al. 1987, Schmidt and Zeto 1986). Michigan's populations are confined to the Pine and Belle River drainages (Badra and Goforth 2003). In Canada, specimens were most recently found Ontario's East Sydenham River and the St. Clair Delta in Lake St. Clair (Metcalfe-Smith et al. 2003).

Habitat:
This species is found in large streams and medium-sized to large rivers with sand and gravel substrate, typically in areas of moderate flow at depths of less than six feet (Cummings and Mayer 1992, Parmalee and Bogan 1988). It also occurs in Lake Erie and Lake St. Clair (COSEWIC 2003).

Ecology:
Females discharge glochidia in early to mid-summer; glochidial hosts are not known. Little other data on this species' life history is available (NatureServe 2008).

Populations:
Just over 100 occurrences of the round hickorynut have been reported since 1970, and total population size is thought to number at least 100,000 (NatureServe 2008). Numerous historical occurrences have been extirpated, and many remaining populations are small and isolated.

Population Trends:
Though this species was formerly wide-ranging and comprised of large, healthy populations, it has disappeared from several historical locations, and remaining populations continue to decline, with changes particularly evident in populations in Canada, where it has lost approximately 90 percent of its historical range, and in western Pennsylvania and New York (NatureServe 2008, COSEWIC 2003). NatureServe (2008) reports that the round hickorynut has experienced a long-

term decline of up to 50 percent, and that it has continued to decline by up to 30 percent in the short-term.

Status:

NatureServe (2008) reports that the round hickorynut is critically imperiled in Arkansas, Indiana, Michigan, Pennsylvania, and Ontario, imperiled in Alabama, Mississippi, and Tennessee, and vulnerable in West Virginia. It is listed as endangered in Illinois, Michigan, and Canada. Its rank is being changed from special concern (Williams et al. 1993) to threatened by the American Fisheries Society (draft 2010, in review).

Habitat destruction:

Numerous historic populations of round hickorynut have been extirpated by habitat loss and degradation, and threats to the species are ongoing. The round hickorynut is threatened by impoundments, dredging and channelization, gravel and sand quarrying, urban and industrial development, agriculture, forestry, oil and gas drilling, and coal mining (Carman 2001, Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the round hickorynut from the threats it faces across its range. It is listed as endangered by several states, but these designations do not protect the species habitat from destruction, which is the greatest threat to its survival.

Other factors:

Invasive aquatic species, such as the zebra mussel, Dreissena polymorpha, and Asian clam, Corbicula fluminea, have wreaked havoc on native mussel populations in the Eastern and Central United States. Roughly 64 percent of historical records for O. subrotunda are from waters now infested with zebra mussels; some sources suggest this is the greatest threat to the round hickorynut (e.g., COSEWIC 2003).

The round hickorynut is threatened by any factor which threatens the host fishes on which it depends for reproduction.

This mussel is also threatened by altered sediment loads, pesticides, herbicides, fertilizers, urban, municipal and industrial pollution, acid mine drainage, waste water discharge, and accidental chemical spills (Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006, NatureServe 2008).

Habitat fragmentation and small population size also limit gene flow and threaten this species (Kentucky Department of Fish and Wildlife Resources 2005, Michigan Dept. of Natural Resources 2006, NatureServe 2008).

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Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. Freshwater Mussels of Alabama & the Mobile Basin in Georgia, Mississippi & Tennessee. University of Alabama Press: Tuscaloosa, Alabama. 908 pp.

Scientific Name:
Obovaria unicolor
Common Name:
Alabama Hickorynut

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	NT - Near threatened

Range:
The Alabama Hickorynut occurs in Alabama, Louisiana, Mississippi, and possibly Oklahoma (NatureServe 2008). This mussel is found in eastern Gulf Coast drainages from the Mobile Basin west to the Lake Pontchartrain drainage of Louisiana and Mississippi (Williams et al. 2008). This mussel is found primarily below the Fall Line in the Alabama, Coosa, Cahaba, Tombigbee, and Black Warrior River drainages (Williams et al. 2008). There is some confusion regarding the range of this species, as it is easily confused with Obovaria jacksoniana, and both species are reported from the Pascagoula, Pearl, and Amite River systems in Mississippi and Louisiana (Mirarchi et al. 2004). Mirarchi et al. (2004) question occurrences in the Coosa and in Oklahoma.

Habitat:
This mussel occurs in medium to large streams below the Fall Line, generally in areas with sandy substrate and low flow, but individuals have been detected in many habitat types in appropriate streams including gravel-bottomed swift shoals, deep gravel and sand-bottomed runs, the silty margins of streams, pools, backwater sloughs, and high-water side channels (Mirarchi et al. 2004). USFS (2007) states that this mussel requires habitat stability, including substrate and water quality.

Ecology:
The Alabama Hickorynut is a long-term brooder with females releasing glochidia from April to June. Glochidial hosts include naked sand, southern sand, and red spotted darters, with marginal hosts including Johnny, Gulf, blackbanded, and dusky darters (Haag and Warren 2003).

Populations:
It is estimated that there are from 21-80 populations of Alabama Hickorynut (NatureServe 2008). Williams et al. (1992) report that the species was recently collected from the Black Warrior River in Tuscaloosa and Greene/Hale counties, and in the upper Tombigbee River in Sumter and Greene counties prior to impoundment. Vidrine (1993) reports this mussel from a few drainages in eastern Louisiana including the Pearl, Tangipahoa, Ticfaw, and Amite rivers. Brown and Banks (2001) report 1990s records for the Amite and Tangipahoa rivers, and historical occurrences in the Pearl River. Johnson and Ahlstedt (2005) report this mussel from the Luxapallila drainage on the Mississippi/Alabama border. Jones et al. (2005) report the Mississippi distribution as the Pearl, Pascagoula, and Tombigbee River drainages. Kennedy and Haag (2005) report specimens from the Sipsey River in Alabama.

This species is common only in the Sipsey River in Alabama (Mirarchi et al. 2004) and is generally uncommon or rare throughout the remainder of its range (NatureServe 2008).

Population Trends:
Although this mussel has a fairly wide distribution, it is in decline. The Alabama Hickorynut is declining in the short term (decline of 10-30 percent) and moderately declining (decline of 25 - 50 percent) in the long-term (NatureServe 2008). USFS (2007) states that this species is

currently declining globally and is generally uncommon. Williams et al. (2008) report that the distribution of this mussel has declined since the mid-1900s, and that in the Alabama and Mobile Basin, it is only extant in a few tributaries of the upper Tombigbee.

Status:

NatureServe (2008) ranks the Alabama Hickorynut as critically imperiled in Louisiana and Oklahoma,, imperiled in Alabama, and vulnerable in Mississippi. This mussel is a Species of Greatest Conservation Need in Alabama and Mississippi. Although this species still maintains a fairly wide range, declines are evident rangewide. Over 100 occurrences probably still exist but some have questionable viability (NatureServe 2008). This species is ranked as near threatened by the IUCN. In 1993, the American Fisheries Society classified this mussel as Special Concern (Williams et al.), but its status is being changed to Endangered (draft, in review).

Habitat destruction:

This mussel is threatened by impoundment, siltation, channelization of large stream habitat, and declining water quality (NatureServe 2008). Stream impoundments, channelization, and water quality degradation have extirpated this species from most of its historical range. Habitat loss and degradation is the greatest threat to the survival of mussels in the southeastern United States (Neves et al. 1997). The Alabama Hickorynut is sensitive to water quality degradation and sedimentation from ground-disturbing activities within a watershed (USFS 2007). This species occurs in the Bankhead National Forest and is thus threatened by silvicultural and recreational activities. USFS (2007) cites heavy recreational use of habitat as a threat to this species. The Alabama Hickorynut is also threatened by habitat inundation, alterations in the timing and duration of flow, blocked dispersal, and interrupted connectivity due to the operation of the Martin Hydroelectric Project (Takats 2009).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Alabama Hickorynut, and no occurrences are appropriately protected and managed (NatureServe 2008). NatureServe (2008) states: "No protected sites are known. The species is protected from harvest in most areas but generally there is no protection from upstream siltation or pollution sources." This mussel is a Species of Greatest Conservation Need in Alabama and Mississippi, but these designations do not confer regulatory protection. It has no state status in Oklahoma or Louisiana.

Other factors:

Any factor which degrades water quality is a threat to the Alabama Hickorynut. This species is also threatened by population isolation, reduced abundance, and questionable viability of some populations. The Hickorynut is also threatened by any factor which threatens host fish populations.

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Scientific Name:
Oecetis parva
Common Name:
Little Oecetis Longhorn Caddisfly

G Rank:
G1

IUCN Status:
NE - Not evaluated

Range:
Historically this rare caddisfly had been collected only from Alabama where it is known from one male that was collected in Wright's Creek, and from three sites in Florida-- near Gainesville in Alachua County, near Kissimmee in Osceola County, and from Lucas Lake in Washington County (Floyd 1995). Prior to 1991, there were no records of this species since 1907. It is possibly extirpated from Alabama. Rasmussen et al. (2008) report that recent light-trapping surveys have recovered O. parva at a number of lakes and ponds in Florida, as well as the Wekiva River in Seminole County. It is now known from 8 new sites including the Apalachicola, Choctawhatchee, Kissimmee, Oklawaha, St. Johns (upper) and St. Marks Rivers in Alachua, Jackson, Lake, Leon, Marion, Osceola, Putnam, Seminole, and Washington Cos.

Habitat:
This species is restricted to natural lakes, ponds, and spring runs (NatureServe 2010).

Populations:
Rasmussen et al. (2008) report 8 new ocurrences of O. parva, which brings known occurrences to approximately 12. Data on population size are not available. In healthy habitats, this species can be abundant.

Population Trends:
Rasmussen et al. (2008) report this species as stable. It is likely extirpated from Alabama.

Status:
This caddisfly is critically imperiled in Florida and state historical in Alabama (NatureServe 2008). It was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
Rasmussen et al. (2008) believe O. parva is an excellent bioindicator of lake health in Florida, as it is abundant in the healthiest lakes. This indicates that this species is threatened by any factor which negatively affects water quality.

The Florida Wildlife Conservation Commission (2005a, b) reports that this species' freshwater marsh and wet prairie habitat is highly threatened by altered hydrologic regime, altered water quality, and altered species dominance, and that this species' seepage habitat is highly threatened by altered hydrologic regime. Marsh, seepage, and lake habitats are all threatened by agriculture, urban development, forestry, recreation, water withdrawals, and nutrient loading (FWCC 2005).

Inadequacy of existing regulatory mechanisms:
Rasmussen et al. (2008) indicate that populations of O. parva are especially abundant in some of the lakes and ponds within the Ocala National Forest, but this provides no regulatory habitat protection. No existing regulatory mechanisms protect this species. Rasmussen et al (2008) state that "[p]rotection of Florida's natural lakes is essential to ensuring the long-term health of this species."

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Scientific Name:
Oncidium undulatum
Common Name:
Cape Sable Orchid
G Rank:
G4
Range:
The Cape Sable orchid is rare and sparsely distributed across southern Florida, and though its range outside the U.S. has not been formally estimated, it is reportedly found in parts of the Caribbean, Mexico, and Central America (Luer 1972, NatureServe 2008). Natural heritage records show this species to be present in Florida's Collier County, and other accounts also report infrequent occurrences in remote sloughs within Big Cypress National Park (NatureServe 2008).
Habitat:
This orchid is found in buttonwood (Platanus spp.) stands and also reported occasionally from remote cypress sloughs in Big Cypress National Park (NatureServe 2008).
Ecology:
This orchid is epiphytic and somewhat frost-tolerant (NatureServe 2008).
Populations:
Total population size is not known for the Cape Sable Orchid, nor is a precise number of occurrences available, though the species is reportedly locally abundant in small buttonwood (Platanus spp.) strand communities (Wunderlin 1998, NatureServe 2008).
Population Trends:
Trend information is not available for this species.
Status:
The orchid has a highly rare and localized distribution in south Florida where it is vulnerable to overcollection by orchid enthusiasts. NatureServe (2008) reports that this species is critically imperiled (N1) in Florida.
Overutilization:
Overcollection is the primary threat to this rare orchid. It is highly threatened by orchid collectors in south Florida as specimens are of great economic value (NatureServe 2008).
Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Cape Sable orchid from overcollection, and NatureServe (2008) reports that few populations are appropriately protected, though some occur in Everglades or Big Cypress National Parks. Collectors are a consistent threat, and location in remote, inaccessible areas is the only form of protection currently afforded to this species.

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Scientific Name:
Ophiogomphus australis
Common Name:
Southern Snaketail

G Rank:
G1

Range:
This dragonfly is known from eastern Louisiana and western Mississippi (Mauffray, 1997; Carle, 1992). Specimens from Eglin AFB, Okaloosa County, Florida, were previously misidentified as O. incurvatus, but are in fact O. australis (Jerrell Daigle, pers. comm. to Dave Almquist, 2008). NatureServe (2008) estimates the total range to be 100-250 square km (less than about 40 to 100 square miles). Ophiogomphus australis could be a subspecies of O. incurvatus, and the Center thus requests the Service to recognize this petition for either the species or the subspecies, should it be validated.

Habitat:
The Southern snaketail is found near gravel-bottomed streams (NatureServe 2008). It requires "good water quality and stable stream flow" (NatureServe 2008).

Populations:
The Southern snaketail is known from three rivers and streams in eastern Louisiana and adjacent Mississippi (Mauffray 1997) and also from Eglin Air Force Base. It is known from about 50 miles of stream, with probably thousands in each of the three streams (NatureServe 2008). According to Frank Carle (cited in IUCN 2010) there is much negative survey data.

Population Trends:
According to NatureServe (2008), the Southern snaketail is undoubtedly declining in the short term because of susceptibility of Ophiogomphus larvae to flood scouring and pollution. NatureServe estimates a decline of 10-30 percent.

Status:
O. australis has a limited range, with susceptibility to both pollution and perturbation of stream flow. (NatureServe (2008) ranks this species as critically imperiled globally, but it has not been ranked in FL, LA, or MS. IUCN (2010) now classifies O. australis as Endangered, stating that it might be in danger of extinction due to habitat degradation.

Habitat destruction:
O.australis faces threats from gravel mining, siltation, pesticides, and clear cutting/deforestation that impact water quality (NatureServe 2008). There are probably other threats related to flood scour. The scope of threat could be higher than "moderate".

IUCN (2010) reports that "the pristine nature of the streams inhabited by this species were so degraded that the species might be in danger of extinction. The habitat of this species is being rapidly reduced by gravel removal and farm water run-off."

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

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Paulson, D.R. and S.W. Dunkle. 1999. A Checklist of North American Odonata. Slater Museum of Natural History University of Puget Sound Occasional Paper Number 56:86 pp.

Scientific Name:
Ophiogomphus edmundo
Common Name:
Edmund's Snaketail

G Rank:
G1

IUCN Status:
EN - Endangered

Range:
Edmund's snaketail is currently known from four rivers and streams in eastern Tennessee, adjacent areas of North Carolina, and Georgia. The one Pennsylvania record is based on a female collected in Dauphin County and is thought to be the common O. Aspersus instead (NatureServe 2008).

Habitat:
This species lives near clear moderately flowing mountain streams and rivers (NatureServe 2008).

Populations:
According to NatureServe (2008) there are fewer than 5 populations with up to 10,000 total individuals of this species. It is currently known from four rivers and streams in five counties. Within its limited range and in appropriate habitat, this species is abundant, and there are probably hundreds to thousands in each stream.

Population Trends:
NatureServe (2008) indicates that this species is declining in the short term by up to 30 percent, undoubtedly because of a general sensitivity of Ophigomphus larvae to flood scouring and pollution.

Status:
NatureServe (2008) ranks this species as critically imperiled globally and in Georgia, North Carolina, and Tennessee. It is a Tennessee Tier 2 Species of Greatest Conservation Need, in North Carolina it is Significantly Rare, and in Geogia it is state listed as Endangered. It was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
NatureServe (2008) reports threats to this species form deforestation and clear cutting, silation, pesticides, and development.

Individuals of O. edmundo and its habitat were likely impacted by the Tsali Forest Health Project on the Cheoah Ranger District of the Nantahala National Forest (USFS 2001). This is also true of the Upper Creek Timber Sale on the Grandfather Ranger District of the Pisgah National Forest (USFS 2005). O. edmundo may be in the area of and affected by the Armuchee Ridges Timber Sale on the Consuaga Ranger District of the Chattahoochee National Forest (USFS 2007).

According to Vogt (1995), "[t]he most vulnerable life stage from a conservation perspective is that of the nymph. Odonata nymphs are vulnerable to a wide variety of threats directly or indirectly affecting their aquatic habitats. Examples include impoundments, channelization, siltation, and water pollution. Because the nymphs live in highly aerated riffles, they may be especially vulnerable to low dissolved oxygen levels".

Inadequacy of existing regulatory mechanisms:

According to NatureServe (2008), the two known North Carolina streams are in Pisgah National Forest, and the species is a Regional forester's Sensitive Species. This designation provides only discretionary protection for this species, however, and logging is a primary threat to this species. This species is state-listed in Georgia, but this designation provides no habitat protection.

References:

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Carle, F.L. 1981. A new species of OPHIOGOMPHUS from eastern North America, with a key to the regional species (Anisoptera: Gomphidae). Odonatologica 10(4):271-278. December 1,1981.

Needham, James G., and Minter J. Westfall, Jr. 1954. A Manual of the Dragonflies of North America (Anisoptera). University of California Press, Berkeley, California. 615 p.

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U.S. Forest Service. 2001. Decision Notice for the Tsali Forest Health Project. Available online at http://www.cs.unca.edu/nfsnc/nepa/cheoah/tsali_dn.pdf. Last accessed March 8, 2010.

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Scientific Name:
Ophiogomphus incurvatus
Common Name:
Appalachian Snaketail

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
This species occurs in the foothillls on either side of the Appalachian Mountains: it is found in Alabama, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia (NatureServe 2008). It is known from only 20 streams within this range. In North Carolina, it occurs in Alexander, Burke, Cabarrus, Caldwell, Caswell, Catawba, Cleveland, Davidson, Forsyth, Gaston, Guilford, Iredell, Lincoln, McDowell, Mecklenburg, Richmond, Rockingham, Rutherford, Stokes, Union, Wilkes and Yadkin Counties. In Pennsylvania, it occurs in York County. In West Virginia, it occurs in Monroe County. In Virginia, it occurs in Russell, Giles, Floyd, Charlotte, and Bedford Counties. In Tennessee, it occurs in Sevier County. In South Carolina, it occurs in Aiken and Barnwell Counties. In Maryland, it occurs in Anne Arundel, Baltimore, and Howard Counties. In Georgia, it occurs in Talbot and White Counties. In Alabama, it occurs in Blount, Clay, Cleburne and Tuscaloosa Counties (OdonataCentral 2008 as cited in NatureServe 2008).

Habitat:
O. incurvatus prefers clear stream habitat with sand or gravel riffles (NatureServe 2008).

Ecology:
This dragonfly breeds in May and June (NatureServe 2008).

Populations:
Though this species has a wide range, it is restricted to only 20 streams in eight states. It is widespread in distribution, but sparse in abundance. The Appalachian snaketail is globally rare and characterized as "uncommon" by Dunkle (2000). No estimates of total population size are available, and it is likely that some occurrences are not viable (NatureServe 2008).

Population Trends:
This dragonfly has declined by up to 90 percent in the long-term, primarily due to land-use changes in the Piedmont portion of its range. The Appalachian snaketail is also declining in the short-term because the larval stage is unusually susceptible to flood scouring and pollution.

Status:
NatureServe (2008) lists the Appalachian Snaketail as critically imperiled in Virginia, imperiled in Maryland, and vulnerable in North Carolina. It is not ranked in Alabama, Georgia, Kentucky, South Carolina, or West Virginia. It is classified as near threatened by the IUCN.

Habitat destruction:
Habitat loss and degradation is a primary threat to the Appalachian Snaketail, as larvae are highly sensitive to changes in stream flow and water quality caused by impoundment, deforestation, agriculture, and residential or commercial development. Threats are particularly severe in the Piedmont portion of this species' range, where agriculture has greatly changed the landscape in the past century (NatureServe 2008). Population viability of for this species requires connectivity of healthy riparian and terrestrial habitats, due to the distinct habitat requirements of larvae and

adults. Thus fragmentation or degradation of either aquatic or forested habitat may threaten this species (Dunkle 2000).

Overutilization:

This species is sought by dragonfly collectors, as evidenced by this blog account of a collector actively seeking this species:

"Weather is always a major factor in any dragonfly collecting trip and this one was no different as I zigged and zagged trying to get behind storm fronts and into the sun. Giff gave me a location for Appalachian Snaketail, Ophiogomphus incurvatus, in Georgia and Jerrell gave me one in North Carolina. I got to Giff's on midday Thursday, but large cumulus clouds kept the temperature down and I saw little but a few Ashy Clubtails, Gomphus lividus. The next day I was at Country Line Creek in NC but found neither Skillet Clubtails, Gomphus ventricosus, along the power line cut or Appalachian Snaketails along the creek" (Accessed March 31, 2010 at: http://homepage.mac.com/edlam/dragonflyroad/5_07SE.html).

The extent to which collecting affects populations has not been assessed, but given the rarity of this species, and in conjunction with other threats such as pollution and habitat loss, collecting could increasingly threaten this dragonfly.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that few occurrences of this species are appropriately protected as they occur on lands at least partially under the jurisdiction of wildlife management agencies: the Pisgah National Forest, Patuxent Wildlife Research Center,and a Clemson University research area. However, these protections do not cover enough of this species' range to constitute substantial regulatory protection. Other populations have no regulatory protection whatsoever.

Other factors:

Siltation and contamination by pesticides, fertilizers, and other anthropogenic polllutants are primary threats to this species, as they are intolerant of pollution and insecticides (Corbet 1999, NatureServe 2008). Chemical control of gypsy moth outbreaks threatens this dragonfly when Dimilin is used (NatureServe 2008). The snaketail is vulnerable to flood scouring and is thus threatened by severe storm events. The snaketail may also be threatened by limited gene flow as populations are increasingly isolated.

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Scientific Name:
Orconectes blacki
Common Name:
Calcasieu Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	VU - Vulnerable

Range:
All sites confirmed to have Orconectes blacki are found in Beauregard and Calcasieu Parishes, Louisiana according to NatureServe (2008).

Habitat:
NatureServe (2008) indicates that this species is found in moderately flowing, small or medium-sized streams with detritus.

Populations:
The species is known from only six localities and according to Walls (1972: 455), intergrading occurs with O. d. hathawayi "in Calcasieu River drainage of Allen, Beauregard, Calcasieu, and Vernon Parishes, Louisiana." In his revision of the genus Orconectes, however, Fitzpatrick (1987) recognized no geographic races of Orconectes (H.) difficilis, according Walls' subspecies specific rank. NatureServe (2008) estimates total population size at 1000-2500 total individuals.

Status:
NatureServe (2008) ranks this species as imperiled. The IUCN ranks it as vulnerable. The American Fisheries Society considers this species to be threatened due to habitat loss and limited range.

Habitat destruction:
According to NatureServe (2008), Orconectes blacki is threatened by habitat loss and direct take of the species from the rapidly developing oil industry in SW Louisiana and SE Texas. These impacts could seriously endanger this species.

The Lousisana Department of Wildlife and Fisheries (2005) reports that this species is threatened by degradation or alteration of habitat and chemical pollution, and is especially sensitive because of a limited distribution.

Inadequacy of existing regulatory mechanisms:
This species occurs on the Kisatchie National Forest, where it is a USFS Sensitive Species, but this designation does not provide regulatory protection for ths species or its habitat (USFS 2005). The Nature Conservancy has adopted O. blacki as an Animal Conservation Target with a goal of 7 viable occurrences in its land portfolio (TNC 2003).

References:

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Scientific Name:
Orconectes burri
Common Name:
Blood River Crayfish

G Rank:
G1

Range:
This species is endemic to the Blood River drainage, a Tennessee River tributary in western Kentucky and northwest Tennessee (Taylor and Schuster 2004).

Habitat:
It prefers sand and gravel substrate im medium and small size streams (Williams and Bivens 2001). Taylor and Sabaj (1998) report that O. burri occurs in lowland stream habitat with minimal gradient. It is found in small to medium-sized streams with substrates of gravel and sand, only in flowing water. It was captured from under tree roots and in accumulated woody debris piles or wood vegetation, or in sand and gravel substrate, sand in slow-flowing runs and pools, and gravel in shallow riffles. The stream banks were usually steep and vegetated.

Populations:
This rare species occurs in a single drainagae. No estimates of population size or trend are available (NatureServe 2008).

Status:
NatureServe (2008) ranks this species as imperiled in Kentucky and Tennessee. The State of Kentucky lists Orconectes burri as Threatened. In Tennessee, the Blood River crayfish is a Species of Greatest Conservation Need. The American Fisheries Society lists Orconectes burri as Endangered due to habitat loss and restricted range (Taylor et al. 2007).

Habitat destruction:
NatureServe (2008) states: "Suitable habitat has been lost in the lower part of the drainage due to impoundment. . . There is heavy recreational fishing pressure in the area and the nearby Kentucky Lake is a popular destination for fishing. Further, there is a lot of channelization in Kentucky and if the decision was taken to rechannelize this drainage, there could be negative impacts on the species."

Inadequacy of existing regulatory mechanisms:
This crayfish is listed as threatened in Kentucky, but this designation provides no habitat protection.

Other factors:
Orconectes burri is potentially threatened by the introduction of invasive species which are used as bait for fishing in the area where it occurs (NatureServe 2008).

References:

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Scientific Name:
Orconectes eupunctus
Common Name:
Coldwater Crayfish

G Rank:	**AFS Status:**
G2	Special Concern

Range:
Orconectes eupunctus has a range less than 100-250 square km (less than about 40 to 100 square miles) according to NatureServe (2008). It is restricted to the Spring and Eleven Point Rivers in southeastern Missouri and northeastern Arkansas (Pfleiger 1996). It occurs in two small drainages that cross the state line between Missouri and Arkansas (NatureServe 2008). Each state may be counting extensions of the same populations as occurrences, causing a cumulative error in estimating the number of rangewide occurrences. The Eleven Point River and Spring River drainages are fed by Greer Spring and Mammoth Springs, two of the largest Ozark springs. In Eleven Point River, it does not inhabit tributaries and does not ascend the river itself much above Greer Spring. In the Spring River drainage it occurs in the Greer Spring Branch and West Fork of Spring Rvier (Pflieger 1996). The Missouri Natural Heritage Program has recorded seven extant occurrences from two watersheds. These occurrences are all believed to be in good condition (although last surveyed in late 1980's).

In Missouri Orconectes eupunctus is found in Oregon and Howell Counties (Missouri Fish and Wildlife Information System 2009) and it is very localized where found. The species is considered the most abundant crayfish in the Eleven Point River and most common crayfish in the Greer Spring Branch and West Fork of Spring River (Pfleiger 1996). It has a highly restricted range with large local populations.

Habitat:
The Coldwater crayfish is found in rivers in coarse gravel and rock substrates in swift, shallow water (Pflieger 1996).

Populations:
According to NatureServe (2008), Orconectes eupunctus has as many as 6-20 populations with a total of 2500-10,000 individuals. Crandall (pers. comm. 1998 cited in NatureServe 2008) feels the population size is probably smaller then 10,000 individuals.

Population Trends:
In the short term, this species is declining by 10-30 percent (NatureServe 2008). Recently abundance has declined to the point of near extirpation from the West Fork Spring River (Black) in Arkansas. It is also declining in Missouri where it was once (circa 1984) a dominant portion of the crayfish community, due to invasion of Orconectes neglectus into the system (Magoulick and DiStefano 2007).

Status:
NatureServe (2008) ranks this species as critically imperiled in Arkansas and imperiled in Missouri. It is ranked as Special Concern by the American Fisheries Society. It is listed as rare in Missouri, indicating a narrow distribution and restricted habitat specificity (Crandall 1998).

Habitat destruction:

This species requires clean, cold streams which are becoming increasingly rare in its range (Missouri Natural Heritage Program 2009).

Allert et al (2005) studied metal contamination of crayfish habitat in Missouri. O. eupunctus was found in one stream used as a reference. Allert found that "mining-derived metals represent a significant threat to functionally important crayfish communities in areas downstream of lead-zinc mines." Furthermore, "Crayfish were absent or had significantly lower densities at mining affected sites. Crayfish survival was also lower at mining-affected sites in both laboratory and in-situ toxicity tests, and was negatively correlated with metal concentrations in detritus and crayfish tissue."

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms protect this species.

Other factors:

This crayfish is highly threatened by invasive crayfish. It is nearly extirpated from the West Fork Spring River (Black) in Arkansas and Missouri due to invasion of Orconectes neglectus into the system (Magoulick and DiStefano 2007). Displacement of this species by Cambarus neglectus chaenodactylus has been well studied (Rabalais and Magoulick 2006; Magoulick and DiStefano 2007; Larson and Magoulick 2008, 2009). Rabalais and Magoulick suggests that microhabitat competition may be at work, while Larson and Magoulick (2009) suggest differential predation or reproductive interference.

Due to a highly restricted range, this species could also be eliminated by catastrophic events (NatureServe 2008).

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Scientific Name:
Orconectes hartfieldi
Common Name:
Yazoo Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Yazoo crayfish is found in the Yazoo River basin in Calhoun, Carroll, Panola, Tallahatchie, and Yalobusha counties, Mississippi (Fitzpatrick and Suttkus 1992).

Adams (2008) reports "In 2007, I collected a female O. hartfieldi from the Yocona River drainage, the first record for Lafayette County, MS. The Mississippi Museum of Natural Science database indicates a female collected in 1997 from the extreme headwaters of the Yockanookany River in the Pearl River basin in Choctaw County, MS, which, if valid, is a considerable range extension."

Habitat:
O. Hartfieldi inhabits small creeks with moderate flow and a firm bottom; it seems to prefer pools (NatureServe 2008). Adams (2008), citing Fitpatrick and Suttkus (1992), indicates that: "Orconectes hartfieldi has been collected from streams with sand/silt or compacted clay substrates in channels up to 15 m wide. Streams were shallow (several cm) to deep (>1 m) with wetted widths of 2 - 10 m at low flows and slow to moderate velocities. At least two stream sites where the species lived were used by cattle, with water temperatures at one site as high as 28 C, suggesting the species can tolerate somewhat degraded conditions. Some individuals were collected under ledges in plunge pools formed on the downstream side of road bridges"

Populations:
NatureServe (2008) roughly estimates fewer than 20 populations with 1000-2500 total individuals of O. hartfieldi, based principally on its wide geographic range. There are only 5 known sites, but probably more can be found. It is known from only 11 specimens and is rare where it does occur.

Status:
NatureServe (2008) ranks Orconectes hartfieldi as imperiled. The State of Mississippi classifies O. hartfieldi as a Tier 1 Species in Need of Immediate Conservation Action. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
Concerning threats to this species, NatureServe (2010) states: "It seems to be able to tolerate somewhat degraded conditions, as two of the streams it inhabits are used by small holder livestock farming and have water temperatures up to 28C (Fitzpatrick and Suttkus 1992). It is likely to be affected by row-crop agriculture, deforestation, roads, channelization, and headcutting. Large reservoirs currently fragment the species range, however it occurs throughout a primarily rural area."

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that no occurrences are appropriately protected and managed.

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Scientific Name:
Orconectes incomptus
Common Name:
Tennessee Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
Although previously observed in only 4 caves, Orconectes incomptus is now known from 12 caves with a fragmented range in Jackson, Putnam, and Smith counties in Tennessee (Buhan and Crandall 2008).

Habitat:
The Tennessee Cave crayfish is found in shallow pool areas in subterranean streams (NatureServe 2008).

Populations:
This species is known from 12 locations and occurs in small populations (Buhay and Crandall 2008).

Population Trends:
NatureServe (2008) reports that this species faces a short term decline of 10-30 percent, and that it is stable to moderately declining in the long term (25 percent change to 50 percent decline).

A recent study by Buhay and Crandall (2005) showed this species exhibited little difference between historical and current genetic diversity estimates but there is inferred decline in quality of cave habitat (Buhay and Crandall 2008).

Status:
NatureServe ranks this species as critically imperiled. The State of Tennessee lists it as Endangered. It is also ranked as endangered by the American Fisheries Society.

Habitat destruction:
NatureServe (2010) states: "Orconectes incomptus is threatened due to its severely restricted habitat and the fragmentation of the habitat. Few individuals were found in the survey and they occur on both sides of the Cumberland River. The restricted cave environment presents a number of potential threats. Caves are often subject to surface runoff and can easily bring in contaminants such as sewage or fecal contamination, pesticides or herbicides, and hazardous materials via accidental spills or deliberate dumping such as road salting (Lewis 2001). Sedimentation resulting in habitat alteration is a common threat caused by construction, farming, logging, and other development that disturbs the groundcover. It can block recharge sites in caves and alter flow velocity and volume (Lewis 2001). Flooding can be a serious threat to cave dwelling species as it changes stream flow. Stream back-flowing is another source of contamination introduction into cave habitats, as is local exploration for oil, water or gas, which may encounter cave passages (Lewis 2001)."

Inadequacy of existing regulatory mechanisms:
This species is listed as endangered by the state of Tennessee, but this designation does not convey habitat protection.

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Scientific Name:
Orconectes jonesi
Common Name:
Sucarnoochee River Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	VU - Vulnerable

Range:
The Sucarnoochee River crayfish is found in the Sucarnoochee River drainage in west central Alabama and east central Mississippi. More populations may be detected, expanding the range (Fitzpatrick 1996).

Habitat:
O jonesi is found in moderate to swiftly flowing streams, usually in riffle areas with emergent aquatic vegetation and sandy bottoms (NatureServe 2008).

Populations:
NatureServe (2008) crudely estimates 21 - 80 populations with 1000-2500 indivudiuals of Orconectes jonesi. In Alabama it is known only from the Sucamoochee River drainage in Sumter Co. (Mirarchi et al., 2004; appendix 1.2 pub. separately; Schuster and Taylor, 2004).

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as vulnerable in Mississippi and not ranked in Alabama. The State of Mississippi classifies it as a Tier 2 Species of Greatest Conservation Need, while Alabama calls it a Priority 2 GCN Species. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
Concerning threats to this species, NatureServe (2010) states: "Orconectes jonesi is threatened by the extensive agricultural land use which occurs in the Sucarnooche river basin. This has caused there to be high levels of sedimentation, chlorophyll and nitrogen present in the water (Schuster et al., 2008). O. jonesi are smaller, with lower fecundity and smaller eggs than most other species from the subgenus. At one site, several ovigerous females carried empty eggshells and one male had deformed gonopods, suggesting possible water quality problems."

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that no occurrences of this species are protected.

Other factors:
This crayfish is threatened by water pollution from agriculture.

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Scientific Name:
Orconectes maletae
Common Name:
Kisatchie Painted Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Kisatchie Painted crayfish is known from only seven localities in Natchitoches and Sabine parishes, Louisiana, and Upshur County, Texas. Specimens from Coal County, Oklahoma, were intrepreted by Walls (1972) as intergrades between this crayfish and Orconectes (H.) difficilis. The freshwater crayfish, Orconectes difficilis, formerly had four subspecies (O. difficilis blacki, O. difficilis maletae, O. difficilis hathawayi, O. difficilis difficilis) (Walls, 1985), all of which have been elevated to full species status (see Fitzpatrick, 1987; Hobbs, 1989). Texas records are O. maletae and Louisiana records are O. blacki and O. hathawayi.

Habitat:
O. malatae is found in streams of varying sizes and bottoms, almost always with leaf litter.

Populations:
NatureServe (2008) estimates that there are 6-20 total populations of O. maletae with 1000-2500 total individuals. It is not uncommon where found, and is known from 7 localities.

Population Trends:
Trend is unknown, but site level extirpation has occurred in Louisiana (NatureServe 2008).

Status:
This species is critically imperiled in Texas and imperiled in Louisiana (NatureServe 2008). The State of Louisiana has classified O. maletae as a Rare Animal of Conservation Concern. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
According to NatureServe (2008), historical stresses to this species include clear-cutting practices and the conversion of forests to agricultural use. Current stresses include clear-cutting and the resulting increase in silt and loss of shade, and impoundments for recreational use. NatureServe (2008) states: "This species has a relatively restricted and disjunct range . . . There is a clear deterioration in habitat quality in the Louisiana portion of its range, where site level extirpation has occurred." NatureServe states that this species' habitat also needs to be monitored for industrial development.

The Louisiana Natural Heritage Program (2005) reports that threats to this species include conversion of forests to agricultural uses, practices that lead to increased sediment loads in streams, practices that lead to loss of shade in the water, and impoundments.

Inadequacy of existing regulatory mechanisms:
This species is found on the Kisatchie National Forest in Louisiana and is a Forest Service Sensitive Species (USFS 2005) but this designation provides only discretionary levels of protection. The Nature Conservancy has adopted O. maletae as an Animal Conservation Target with a goal of 1 viable occurrence in its land portfolio (TNC 2003). No existing regulatory

mechanisms protect this species.

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Scientific Name:
Orconectes marchandi
Common Name:
Mammoth Spring Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
The Mammoth Spring crayfish is known from 20 locations in 8 sub-watersheds of the Spring River watershed in southwest Missouri and two northwest Arkansas counties (Flinders and Magoulick 2005).

Habitat:
Warm Fork in Missouri is a medium-sized, clear Ozark stream with well defined riffles and runs (Pflieger, 1996). Flinders and Magoulick (2005) found this species almost exclusively in smaller moving tributary streams of the Spring River, predominantly in shallow, slow-moving water in gravel and pebble substrates compared to previous studies that found it in faster moving riffle habitats. Flinders and Magoulick (2007) found small individuals were more broadly distributed across pools, backwaters, stream margins, and vegetated habitats. Small individuals also strongly selected vegetated, backwater and stream margin habitats at all sites and times even though these habitat types comprised only 15 percent of the available habitats.

Populations:
This species is known from 20 locations in a single watershed.

Population Trends:
NatureServe (2008) indicates that this species is increasing in the short term, and relatively stable to increasing in the long term.
Several new localities were recently found in slower moving tributaries in Spring River drainage (Flinders and Magoulick 2005).

Status:
NatureServe (2008) ranks O. marchandi as imperiled in Arkansas and critically imperiled in Missouri. It is ranked as threatened by the American Fisheries Society (Taylor et al. 2007). It is listed as endangered in Missouri. The primary threat to this species is displacement by an invasive crayfish.

Habitat destruction:
The Arkansas Wildlife Action Plan (2008) reports that this species faces threats from chemical alteration and sedimentation of habitat due to recreation, and riparian habitat destruction from channel alteration.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that at least one locality occurs in a state park. Though this species is listed by the state of Missouri, this designation conveys no habitat protection.

Other factors:
This species occurs in a single watershed, and the greatest threat to its survival is the spread of an invasive crayfish species. NatureServe (2008) states: "An invasive species O. neglectus is reported to be in western part of the drainage in south fork Spring River, entering the system some time

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Scientific Name:
Orconectes packardi
Common Name:
Appalachian Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
NatureServe (2008) reports that this species is found in 16 caves in the Cumberland River basin in southeastern Kentucky. Hobbs Jr. (1989) reports that the species is found intergraded with the nominate subspecies in Wayne County, Kentucky, and Fentress County, Tennessee, but no "pure" packardi forms have been found in Tennessee yet (Taylor and Schuster, 2004). This "intergrade" has now been afforded species status, Orconectes barri (Buhay and Crandall, 2008).

Habitat:
According to NatureServe (2008), the Appalachian Cave Crayfish inhabits quiet pools of subterranean streams.

Populations:
NatureServe (2008) indicates that this species has between 6 and 20 populations in 16 caves in the middle Cumberland River drainage (on both sides of the Cumberland River) in McCreary, Pulaski, Rockcastle and Wayne Cos. It is likely that there are more populations to be found (Taylor and Schuster, 2004). Buhay and Crandall (2005; 2008) list only Rockcastle, Pulaski, and Wayne Cos., Kentucky because individuals at the other locations have been reassigned to a new species, O. barri.

Status:
This crayfish is listed as threatened by the American Fisheries Society and by the state of Kentucky. It is ranked as imperiled by NatureServe (2008) and as vulnerable by the IUCN.

Habitat destruction:
The subterranean cave habitat used by this species is susceptible to groundwater contamination from agriculture (NatureServe 2008). According to Buhay and Crandall (2008), major road construction is an imminent threat to many populations of this species.

Taylor et al. (2007) state that this species is threatened by habitat degradation and loss, as well as limited range.

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species, and no populations are appropriately protected. Although it is listed as threatened by the state of Kentucky, this designation provides no protection for the species' habitat.

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Scientific Name:
Orconectes sheltae
Common Name:
Shelta Cave Crayfish

G Rank:
G1

Range:
Orconectes sheltae is endemic to a single location, Shelta Cave in Huntsville, Alabama (Cooper and Cooper 1997).

Habitat:
This species lives in subterranean pools in a single cave (Cooper and Cooper 1997).

Ecology:
This crayfish may be dependent on nutrient input from gray bats.

Populations:
There is only one population of this species. J.E. and M.R. Cooper estimate population size to be 96-102 individuals, based on 942 plus person-hrs of study in the cave (Cooper 1975, Cooper and Cooper 1997). Prior to 1975 only 17 individuals had ever been collected and later 97 individuals were examined and released.

Population Trends:
NatureServe (2008) reports a severe short-term decline of greater than 70 percent for this species (Cooper and Cooper 1997, Buhay and Crandall 2008). Over the long-term the species has declined by 75 to over 90 percent.

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of Alabama has classified it as a Priority 1 Species of Special Concern. AFS lists it as Endangered (Taylor et al. 1997). The National Speleological Society owns the single cave where this species occurs, and in erecting a gate to prevent vandalism, incidentally cut off nutrient input from bats. This crayfish is highly threatened by the loss of bat guano, disturbance from school groups, and pollution from residential run-off.

Habitat destruction:
Concerning threats to this species, NatureServe (2010) states: "This species is impacted by a variety of factors namely land development and vandalism, cave abandonment by Gray Bats, insecticides and water level fluctuations. In the 1960s there was extensive vandalism in the cave and the surrounding land was developed with residential housing (Cooper and Cooper, 1997). In 1967, the cave was purchased by the National Speleological Society which owns the entrances and controls access to the cave. The Headquarters of the NSS has been built above the cave. In an attempt to curb vandalism, cave gates were built at the entrances to the caves in 1968, but these were not conducive for Gray Bats. By 1970, the bats had abandoned the cave, reducing the amount of nutrients available for O. sheltae. Overall cave biodiversity has declined since the Gray Bats left the cave (Cooper and Cooper, 1997). In 2002, a fence was erected 20 feet around the cave to encourage the bats to return, but to continue to deter vandalism (Cooper and Cooper, 1997). Some water chemistry analysis has been conducted at the cave and indicated high levels of insecticide heptachlor epoxide in 1989 presumably from surrounding residential gardens.

Additionally, this area of Alabama due to geological circumstances is prone to having high levels of radon gas. Levels in the cave were very high at 400-500 pCi/L which must be having an adverse impact on this species. Finally, the species is sensitive to water level fluctuations as a result of droughts . . . Attempts have been made to encourage the bats to return, but so far these attempts have proved unsuccessful. A cave fence has been erected to reduce vandalism, which has been successful. The NSS is controlling the number of visitors to the cave, but still allowing school groups to visit, thus continuing to cause disturbance to O. sheltae's habitat. However, no attempts have been made to improve the water quality of the cave, by reducing insecticide run off from nearby gardens."

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) reports that access to Shelta Cave is strictly controlled by the owner (National Speleological Society, managed by Huntsville Grotto). NSS has also a specific management plan for the cave. Yet private ownership of the cave has not succeeded in protecting the crayfish. School tours are still authorized in the cave, causing ongoing disturbance. Erection of a fence to prevent vandalism blocked bats from the cave, fundamentally altering its ecology and threatening this crayfish. Private ownership also does not protect the crayfish from on-going chemical pollution from surrounding residential runoff.

Other factors:

This species is threatened by residential run-off and by the loss of gray bats.

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Scientific Name:
Orconectes virginiensis
Common Name:
Chowanoke Crayfish

G Rank:	**AFS Status:**
G3	Currently Stable

Range:
Orconectes virginiensis is restricted to the Chowan River drainage in southeast Virginia (Fitzpatrick 1967) and extreme northeast North Carolina, plus three localities in the Roanoke drainage in Martin, Bertie, and Halifax counties, North Carolina (NatureServe 2008).

Habitat:
The Chowanoke crayfish is found in sluggish streams flowing through woodlands on sandy or gravelly substrates. Vegetation may be sparse (NatureServe 2008).

Populations:
LeGrand et al. (2006) cite streams and rivers in the Chowan and Roanoke drainages of Bertie, Granville, Halifax, Hertford, Martin, and Northampton Cos., North Carolina. Cooper and Braswell (1995) report it to be one of North Carolina's rarest crayfish. Abundance and range in Virginia are unknown, according to NatureServe (2008).

Status:
According to NatureServe (2008), this species has a status of vulnerable in North Carolina and imperiled in Virginia based on limited range. North Carolina Natural Heritage Program recognized this species as "Special Concern." Orconectes virginiensis was a C2 species under the Federal ESA until that list was abolished. It is now a Federal Species of Concern. It is ranked as stable by the American Fisheries Society.

Habitat destruction:
Orconectes virginiensis occurs within 6 miles of an Outlying Landing Field proposed by the U.S. Navy, and its habitat may be affected by increased runoff from this air field (Allie 2009).

Other factors:
This species is potentially threatened by invasive crayfish. According to the South Carolina Department of Natural Resources (2006): “The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from a native crayfish have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the coastal plain and eastern piedmont plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b) and the risk to our native species is great if further introductions or extensive spread on non-indigenous crayfish occurs.”

According to the North Carolina Wildlife Resources Commission (2000): “Nonindigenous crayfishes can affect natives via competition, predation, genetic dilution, and by serving as disease vectors. Further, introductions of nonindigenous crayfishes can enhance the negative effects of environmental change on native species because non-natives are often more tolerant to environmental degradation. Lodge et al. (2000a) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide. In Europe, nonindigenous crayfishes have contributed to serious declines and even local extinctions of its 5 native species. In several areas of North America, combinations of environmental degradation and introductions of non-native crayfishes have led to declines in native species, and to the extinction of at least one native crayfish in northern California (Lodge et al. 2000a). During recent decades, at least 3 exotic crayfish species have been introduced into North Carolina; therefore, we are concerned about potential impacts to our ecosystems and native crayfish species."

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Scientific Name:
Orconectes wrighti
Common Name:
Hardin Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Endangered	VU - Vulnerable

Range:
Known from only four historical sites prior to 1995, the Hardin crayfish has recently been confirmed at 19 streams (including two of the four historic sites) in Hardin and McNairy Cos., Tennessee (Rohrbach and Withers 2006). NatureServe (2008) reports its range as 100-250 square km (about 40-100 square miles).

Habitat:
The bottom of Robinson Creek is red clay and gravel with a few rocks forming riffles and flow is very slow with large pools of quiet water. Streams are 10-15 feet wide, heavily shaded, with some wayside vegetation and some exposed gravel bars are present. The species occurs in streams dominated by deposits of alluvial gravel. Substrate varies from sand to cobble but sand is never more than co-dominant (Rohrbach and Withers 2006).

Populations:
This species is known from 19 streams in two counties, and total population size is crudely estimated at 1000 - 2500 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports a short-term increasing trend and a long-term stable trend for this species.

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of Tennessee has listed the species as Endangered. It is ranked as vulnerable by the IUCN and as endangered by the American Fisheries Society.

Habitat destruction:
Rohrbach and Withers (2006) note that many streams in this species' habitat appear potentially and severely impacted by poor agricultural practices, limited riparian buffers, and improper ATV use.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species. Though it is listed by the state of North Carolina, this designation provides no habitat protection. Rohrbach and Withers (2006) report that despite extensive surveys, this species was not found on the Shiloh NMP, although it was expected. They also report that the Robinson Creek population is only marginally protected by Pickwick Landing State Park and TVA Pickwick Reservoir Reservation, and that the same is true for the Chambers Creek population (Rohrbach and Withers 2006).

References:

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Scientific Name:
Oryzomys palustris pop. 1
Common Name:
Pine Island Oryzomys

G Rank:
T1

Range:
The total range of the Pine Island Oryzomys is less than 250 square km on Pine Island and the adjacent mainland near Ft. Myers in Florida (NatureServe 2008).

Habitat:
The Pine Island oryzomys has been detected in marsh habitat with dense emergent vegetation (Spartina patens), and in a garbage dump adjoining the wetland (NatureServe 2008). It has also been detected using runways with cotton rats (Layne 1978).

Populations:
The Pine Island oryzomys is known from only two elemental occurrences, and has possibly been extirpated from one of the two (NatureServe 2008).

Population Trends:
Populations of the Pine Island oryzomys have decreased due to elimination of habitat (NatureServe 2008).

Status:
This mammal is critically imperiled (T1S1) (NatureServe 2008). It is known from only two elemental occurrences, has possibly been eliminated from one of them, and occurs in a habitat and area subject to human population growth and habitat destruction (NatureServe 2008).

Habitat destruction:
This mammal is threatened by habitat destruction from the filling and draining of wetlands for development (NatureServe 2008). Its habitat is also threatened by the invasion of woody plants (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. It occurs on Charlotte Harbor State Reserve.

Other factors:
This mammal is threatened by the spread of woody plants into its marsh habitat (NatureServe 2008). It is also potentially vulnerable to predation from the spread of giant constrictors (Reed and Rodda 2009).

References:

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Scientific Name:
Oryzomys palustris pop. 2
Common Name:
Sanibel Island Oryzomys

G Rank:
T1

Range:
This mammal occurs only on Sanibel Island in Lee County, Florida (NatureServe 2008).

Habitat:
The Sanibel Island Oryzomys occurs near the water's edge in swales and cattail stands in freshwater swamps of artesian origin (NatureServe 2008).

Populations:
All of the elemental occurrences for this mammal are on one barrier island, but there may be several small populations (NatureServe 2008).

Population Trends:
Abundance information is not available for this mammal. Its population has declined by an unknown extent due to habitat destruction.

Status:
This critically imperiled population (T1S1) is known from only one Florida island that is being extensively developed (NatureServe 2008). It is considered to be a Species of Special Concern by the state of Florida.

Habitat destruction:
Habitat destruction is the greatest threat to this mammal which is threatened by the draining and filling of marshes for development and by groundwater withdrawal for human consumption (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect this species. It is unknown whether any occurrences are appropriately protected and managed (NatureServe 2008). This mammal might occur on Ding Darling National Wildlife Refuge.

Other factors:
The Sanibel Island oryzomys is threatened by woody plant invasion of its habitat (NatureServe 2008). It is also potentially threatened by the spread of invasive giant constrictors (Reed and Rodda 2009).

References:

Reed, R.N., and G.H. Rodda. 2009. Giant constrictors: biological and management profiles and an establishment risk assessment for nine large species of pythons, anacondas, and the boa constrictor: U.S. Geological Survey Open-File Report 2009–1202, 302 pp.

Scientific Name:
Oxyethira setosa
Common Name:
Setose Cream and Brown Mottled Microcaddisfly

G Rank:
G2

Range:
The setose cream and brown mottled microcaddisfly is a rare invertebrate endemic to the southeastern United States. It is known from Florida, Alabama, Georgia, and was recently discovered in New Jersey (NatureServe 2008, Cosgrove 2004 as cited in NatureServe 2008). Natural heritage records indicate this species is present in Florida's Liberty, Santa Rosa, and Walton Counties, though Rasmussen (2004) collected just one specimen from a single site in Eglin Air Force Base, in Alabama's Autanga, Covington, Lauderdale, Lowndes, Marion, Mobile, Monroe, and Tuscaloosa Counties, and from an unspecified location near Georgia (NatureServe 2008).

Habitat:
It is found in small streams with high water quality and moderate stream flow gradients, often found below small impoundments (NatureServe 2008).

Populations:
There are an estimated 6-80 occurrences of this species, and total population size is thought to be at least 1000 individuals (NatureServe 2008). The species is considered to be extremely rare in Florida and Georgia, and uncommon in Alabama (NatureServe 2008).

Population Trends:
Population trends are unknown.

Status:
NatureServe (2008) reports that this species is critically imperiled in Florida, but not ranked in Alabama, Georgia, or New Jersey.

Habitat destruction:
Loss and degradation of this species' aquatic habitat are the primary threats to its persistence – pollution and siltation from various anthropogenic sources destroys water quality, and dams and diversions alter hydrological patterns, rendering habitat unsuitable (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), few occurrences are appropriately protected or managed: one population occurs on Eglin Air Force Base, but is not formally protected (Harris et al 1982).

No existing regulatory mechanisms adequately protect this microcaddisfly from the habitat loss that imperils its persistence; though it is considered a species of special conservation concern and is admittedly very rare, this recognition affords the setose cream and brown mottled microcaddisfly no substantial protections.

Other factors:
This microcaddisfly is threatened by water pollution (NatureServe 2008).

References:

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Rasmussen, A.K. 2004. Species diversity and ecology of Trichoptera (caddisflies) and Plecoptera (stoneflies) in ravine ecosystems of northern Florida. Unpublished PhD. Dissertation, University of Florida. 130 pp.

Scientific Name:
Percina bimaculata
Common Name:
Chesapeake logperch

AFS Status:
Endangered

Range:
The Chesaapeake logperch was historically distributed in the lower Susquehanna River Basin of Pennsylvania and Maryland and the middle to lower Potomac River Basin of Maryland, Virginia and the District of Columbia, USA, but is currently found only in the lower Susquehanna River Basin (Near 2008).

Habitat:
The Chesapeake logperch is found in large rivers or the mouths of tributaries flowing into large rivers. Neely and George (2006) observed the Chesapeake logperch near the mounth of Conowingo Creek, Maryland, where the species was found in a riffle with a steep gradient with large and small boulders over a bedrock substrate.

Populations:
The Chesapeake logperch has been collected in the lower Susquehanna River basin in Pennsylvania and Maryland, including Conowingo, Deer, Broad and Octoraro creeks, as well as Winters Run and the Northeast River, which flow into the Chesapeake Bay (Near 2008). Near (2008) observed that "the species has been sporadically collected in tributaries and the main stem of the lower Susquehanna River in Maryland and Pennsylvania."

Population Trends:
The Chesapeake logperch formerly occurred in the middle and lower Poptomac River basin, including frequently in the District of Columbia, but has not been observed in this system since the 1930s (Near 2008). Near (2008) observed that the failure to observe the species in the Potomac since the 1930s "contrasts sharply with Smith and Bean's (1899:186) statement that the species is common 'in gravely streams' that flow through the District of Columbia."

Status:
Near (2008) concluded that "[g]iven the restricted distribution of the species and the apparent extirpation from a substantial portion of its historical distribution, P. bimaculata would be a worthy candidate for protection under the United States Endangered Species Act of 1973." Jelks et al. (2008) classify the Chesapeake logperch as threatened. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the Chesapeake logperch should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) consider the Chesapeake logperch to be threatened based on the present or threatened destruction, modification or reduction in range.

Inadequacy of existing regulatory mechanisms:
The Chesapeake logperch was only recently redescribed (Near 2008) and thus is not afforded regulatory protection. Supporting this conclusion, Near (2008) concluded

"The lack of a sustained concern for the extirpation of P. bimaculata from the Potomac River and limited action from state and federal agencies are clearly the result of the species being considered a synonym of P. caprodes for over 130 years. Percina bimaculata is appropriately regarded as a species driven to obscurity by a taxonomic oversight. This status had removed the species from the working lexicon of ichthyologists and evolutionary biologists working with the diverse North American freshwater fish fauna, as well as appropriate governmental agencies that can initiate important protection and conservation measures."

Other factors:
The Chesapeake logperch has a restricted range in a heavily developed portion of the country.

References:

Jelks, H.J., S.J. Walsh, N.M. Burkhead, S. Contreras-Balderas, E. Díaz-Pardo, D.A. Hendrickson, J. Lyons, N.E. Mandrak, F. McCormick, J.S. Nelson, S.P. Platania, B.A. Porter, C.B. Renaud, J.J. Schmitter-Soto, E.B. Taylor, and M.L. Warren, Jr. 2008. Conservation Status of Imperiled North American Freshwater and Diaddromous Fishes. Fisheries, V. 33(8): 372-407.

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Scientific Name:
Percina brevicauda
Common Name:
Coal Darter
G Rank:
G2
Range:
The coal darter was historically distributed in the Coosa, Cahaba, and Black Warrior river systems in the eastern part of the Mobile Bay basin in Alabama (Suttkus et al. 1994). The darter's stronghold is now the main channel of the Cahaba River, primarily above the Fall Line. The coal darter was last collected in the main channel of the Coosa River in 1950 and presently occurs in that system only in Hatchet Creek where it is very rare (Boschung and Mayden 2004). The coal darter has not been seen in the Black Warrior River at Tuscaloosa since 1889, and the only remaining populations in the Black Warrior River system occur in the upper Locust Fork (Boschung and Mayden 2004).

Habitat:
This darter's habitat consists of shallow gravel bars which are commonly blanketed with aquatic plants such as river-weed (Podostemum ceratophyllum) and water-willow (Justicia americana). It also occurs in shoots and troughs worn in bedrock at the foot of rapids (Boschung and Mayden 2004).

Populations:
This species is known from three river systems, which may represent three separate occurrences. Only the Cahaba River system seems to support a robust population. Populations from the Black Warrior River may be extirpated, but there may be extant populations in the upper Locust Fork (Boschung and Mayden 2004). There are only a few records from the Coosa River, and the status of this population is unknown (Bernie Kuhajda, pers. comm., 1998 cited in NatureServe 2008). The coal darter was last collected in the main channel of the Coosa River in 1950 and presently occurs in that system only in Hatchet Creek where it is very rare (Boschung and Mayden 2004).

A summary provided by the Southeastern Fishes Council for a meeting with Center for Biological Diversity concluded (SFC and CBD 2010): "In a 2001 status survey in Locust Fork by the GSA, Coal darters were found at 11 stations from the first shoal upstream of Bankhead Lake upstream to the new Nectar bridge, and at three stations in Blackburn Fork for a total range of 65 river miles. In a 1998 biological assessment of Locust Fork, coal darters were relatively common at several stations, with up to 40 individuals collected at one station in Locust Fork, at Warrior-Kimberly Road, in 30 minutes. Far fewer coal darters were collected at sampling stations in the 2001 survey. The highest number collected was six taken at Deans Ferry Bridge in 30 minutes."

Population Trends:
Trend is unknown, but this species is extirpated or nearly extirpated from the Black Warrior and Coosa River systems. Impoundments have extirpated populations of this species and separated remaining populations (Boschung and Mayden 2004). A viable population remains in the Cahaba River, but elsewhere populations are small and isolated. The remaining population in the Cahaba is thought to be declining to stable (NatureServe 2008). The Alabama Dept. of Conservation and

Natural Resources (2008) reports that this species may require population augmentation and/or reintroduction to suitable habitats to maintain viability.

Status:

NatureServe (2008) ranks the coal darter as imperiled. The coal darter is ranked as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat degradation and narrow range. Williams et al. (1989), Warren et al. (2000), and Boschung and Mayden (2004) also categorize this species as threatened. At a meeting of the Southeastern Fishes Council and the Center for Biological Diversity, there was agreement that the coal darter should be listed as threatened (SFC and CBD 2010). Shepard (2004) concluded: "Has a disjunct distribution in only three river systems. As a main channel species, vulnerable to chronic water quality and habitat degradation as well as acute impacts such as toxic chemical spills. A single major spill could potentially eliminate this species from Cahaba River, Locust Fork, or Hatchet Creek."

Habitat destruction:

The coal darter is threatened by impoundments, urbanization, forestry, and coal mining (Shepard 2004, NatureServe 2008, SFC and CBD 2010). Impoundments have eliminated populations of this species and continue to isolate remaining populations (Suttkus et al. 1994, Boschung and Mayden 2004). Ongoing urbanization and resulting non-point source pollution and demand for freshwater threaten the remaining viable population(s) in the Cahaba (Shepard 2004, NatureServe 2008). FWS (2007) states that physical alteration of the Cahaba River and water quality degradation present significant challenges to the survival of aquatic biota, citing dams, channelization, dredging, and coal mining as specific threats. Physical alterations to the river have degraded substrates and have led to temperature fluctuations, changes in sediment transport, water depth, and variable stream velocity, and variable dissolved oxygen and pH (FWS 2007). The Cahaba River is also threatened by rapid urbanization and commercial development in Jefferson, Shelby and St. Clair Counties (Ibid.). FWS (2007) states that rampant development of Jefferson and Shelby Counties, and decades of coal mining have degraded river water quality and hydrologic flows that continue to place stress on aquatic species. Jelks et al. (2008) list habitat loss as a threat to this species.

Shepard (2004) concluded that:

"Cahaba River system and Locust Fork system are both experiencing increasingly degraded water quality and habitat conditions. Species has only been collected sporadically in Hatchet Creek in recent years and status of population there unclear. In Cahaba, greatest threats from eutrophication and sedimenation related to urban sprawl in watershed. In Locust Fork system, agricultural activities and surface mining for coal impact habitat and water quality."

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect this darter. NatureServe (2008) reports that no occurrences are protected. The darter is a Species of Conservation Need in Alabama, but this designation does not confer regulatory protection.

Other factors:

The major remaining population of this species is threatened by severe pollution (NatureServe 2008). During low water periods especially, the Cahaba River has serious water quality problems. The upper Cahaba River receives approximately half of its flow from wastewater treatment plants, and encompasses approximately two-thirds of the remaining range of this species (NatureServe 2008). Water quality degradation from impoundments, and siltation from urbanization, silviculture, and mining are known threats (NatureServe 2008).

The species also has a narrow range limited to three systems, where as an annual species it is sensitve to any major disturbances (Shepard 2004).

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Scientific Name:
Percina cymatotaenia
Common Name:
Bluestripe Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	EN - Endangered

Range:
The bluestripe darter occurs in the Osage and Gasconade river drainages in the northern Ozarks of south-central Missouri (NatureServe 2008). It was widely distributed in the Gasconade River system and in the Niangua River, but now inhabits only six streams: Big Piney River, Gasconade River, Roubidoux Creek, Osage Fork, Whetstone Creek, and Niangua River (Page and Burr 1991, Burr and Page 1993, Pflieger 1997).

Habitat:
This species occurs in quiet pools and backwaters with sandy substrate and abundant cover in small to medium rivers. It prefers areas of submerged vegetation or organic debris. It also occurs in areas of submerged vegetation over mud substrate, and is occasionally found along sand or gravel bars in areas of emergent vegetation (Page and Burr 1991). It prefers very slight currents and water depths of 25-140 cm. It has been associated with plant species including Justicia, Ranunculus, Myriophyllum, Potamogeton, and Heteranthera (Pflieger 1984). Spawning apparently takes place over gravel riffles (NatureServe 2008). Novinger (2006) describes this species' habitat as clear, moderate to swift flowing streams in rocky habitats that are largely free of silt and with sufficient riffle habitats for spawning, where this fish occurs along the periphery of slow runs and pools in aquatic vegetation over silt-free substrate.

Populations:
There are less than 20 extant populations of this species (NatureServe 2008). For the period 1945-1995, Pflieger (1997) mapped approximately 29 collection sites, and several additional historical locations which probably no longer support populations. This species has been recently detected in several distinct occurrences in six streams. Total population size is estimated at 10,000 to more than 50,000 fish, based on the approximate average number of fish seined per 100 linear feet of stream (4.08 darters) in known occupied habitat, and on total occupied stream miles (240 mi) (Pflieger 1984). It is unclear whether occupied stream miles includes intervening inappropriate habitat, which would put the population estimate at the lower end of the range, probably more than 10,000.

Population Trends:
This species is declining in the short-term (10-30 percent), and has experienced a substantial long-term decline of 50-75 percent (NatureServe 2008). It declined rapidly in the first half of the 20th century, but few data are available on recent decades. Based on sampling in 1969 and 1980, Pflieger (1984) concluded the species was in slow decline.

Status:
This fish has been extirpated from several historical locations (Pflieger 1997). It is ranked as imperiled by NatureServe (2008) and by the state of Missouri. Warren et al. (2000) categorized this species as threatened. It is classified as threatened by the American Fisheries Society (Jelks et al. 2008). It is classified as endangered by the IUCN. It is a Federal Species of Concern.

Habitat destruction:

The bluestripe darter requires high water quality and minimally altered hydrologic regime and is thus highly vulnerable to habitat loss and modification (Novinger 2006). This species has a high degree of impending threats associated with loss of stream habitats due to livestock impacts, erosion, urban development, and hydrologic alteration (Novinger 2006). It is threatened by increasing development and conversion of forest to pasture (Pflieger 1984). There is a general trend in the rural Gasconade River watershed toward increased cattle numbers per pastured acre (Blanc 2001). Sand and gravel mining are also a threat (Blanc 2001). The U.S. Forest Service (2009) reports threats to this fish as channelization, impoundment, and gravel dredging. Jelks et al. (2008) list habitat loss as a threat to this species.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which protect this species, and no occurrences are appropriately protected and managed (NatureServe 2008). It is protected as a nongame species by the state of Missouri, but does not have habitat protection in the state. NatureServe (2008) recommends that the Gasconade River by protected from impoundment, and that state water quality standards be strengthened and enforced.

Other factors:

Non-point source pollution threatens this species, particularly from cattle manure, but also from landfills, farms, mining operations, construction sites, forestry, residential septics, and impervious surface in urbanized areas (Blanc 2001). Water quality in the Lower Gasconade River has been rated as poor due to the lack of forested stream corridor (Blanc 2001). This species is also threatened by accidental toxic spills. In December 1988, an oil spill from a broken pipeline near Vienna released hundreds of thousands of gallons of crude oil into the main stem of the Gasconade River (Blanc 2001). This fish is also potentially threatened by pollution from smokes and obscurants used in military training on Fort Leonard Wood (Cropek et al. 2008).

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Scientific Name:
Percina kusha
Common Name:
Bridled Darter

G Rank:	**AFS Status:**
G2	Endangered

Range:
The bridled darter is endemic to the headwaters of the Coosa River in Georgia and Tennessee, where it is found in the main channel of the Conasauga River in Murray and Whitfield counties, Georgia, and Bradley and Polk counties, Tennessee, three tributaries of the Conasauga River, including Holly Creek, Murray County, Georgia; and Ball Play and Minnewauga creeks, Polk County, Tennessee, in the main channel of the Etowah River in Dawson and Lumpkin counties, Georgia, and in several tributaries of the Etowah, including Amicalola, Little Amicalola, Cochran and Shoal creeks, Dawson County, Georgia (Williams et al. 2007).

Habitat:
Williams et al. (2007) list habitat as small rivers and lower reaches of tributaries with moderate gradient, good water quality, and sand, gravel, cobble and bedrock substrates, adding that the species "is usually found in flowing pools and backwaters adjacent to runs." Within pools, the bridled darter has been observed hovering over underwater objects, such as boulders or woody debris (Etnier and Starnes 1993, Williams et al. 2007). Etnier and Starnes (1993) emphasized that the species is found in small rivers with "exceptional water quality."

Populations:
Williams et al. (2007) show 12 locations for the species and observe that the species "naturally occurs in low abundance."

Population Trends:
Although the historic extent of the species is unknown, Williams et al. (2007) state that "its association with slow-flowing habitats" suggests that the species "could have occurred throughout the Conasauga and Etowah rivers, and possibly in the geographically intermediate Coosawattee River, below the gorge now impounded by Carters Dam and Reservoir." If this is the case, the species has experienced substantial decline.

Status:
Williams et al. (2007) conclude that this species is endangered, stating "considering its very limited distribution in portions of two small rivers and threats to its habitat from municipal and industrial development and forestry and agriculture activities we consider P. kusha to be endangered." Likewise, Jelks et al. (2008) list the bridled darter as endangered because of threats to habitat and a narrow and restricted range. NatureServe (2008) lists the species as critically imperiled in both Tennessee and Georgia. The state of Georgia also lists the species as endangered (Albanese 2008). At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the bridled darter should be listed as endangered (SFC and CBD 2010). Albanese (2008) concluded: "This species has very small populations and very limited range within each of the three areas (Etowah River, Conasauga River, and Talking Rock Creek)."

Habitat destruction:

NatureServe (2008) concludes that the bridled darter's habitat "is threatened by municipal and industrial development and forestry and agriculture activities." AFS (Jelks et al. 2008) conclude that the bridled darter is endangered because of the present or threatened destruction, modification, or reduction of the species range. Some populations of this species may have been extirpated by impoundment (Williams et al. 2007). Threatened by urban sprawl and pollution from Atlanta (SFC and CBD 2010). Albanese (2009) concluded:

"Limited geographic range and the species' restriction to clear flowing pools in medium-sized rivers make the bridled darter vulnerable to habitat degradation. Land disturbance associated with residential and urban development in the north Georgia mountains could threaten populations, especially in the upper reaches of the Etowah River and Long Swamp Creek where development is imminent. Failure to follow agricultural best-management practices is a threat to the Conasauga River population."

Inadequacy of existing regulatory mechanisms:

There are few to no regulatory protections for the bridled darter. It is listed as threatened (as P. macrocephala) in Tennessee and endangered in Georgia, but these designations fail to provide any protection for the species' habitat. Albanese (2008) concluded that "Public lands in the headwaters of the Etowah and Conasauga river systems provide partial but not complete protection for these two populations." A draft HCP was prepared for the Etowah River that includes the bridled darter, but has never been finalized (Available at http://www.etowahhcp.org/documents.htm).

Other factors:

The bridled darter is threatened by pollution from a variety of sources (Williams et al. 2007).

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Scientific Name:
Percina macrocephala
Common Name:
Longhead Darter

G Rank:	AFS Status:	IUCN Status:
G3	Threatened	NT - Near threatened

Range:
The longhead darter is a small freshwater fish species endemic to the central Appalachian region, New York, and Pennsylvania. It is found in substantial numbers in West Virginia's Elk River system (NatureServe 2008) and relatively common in the Allegheny River in Pennsylvania, but less so elsewhere in the state (Felbaum et al. 1995, Page and Near 2007, NatureServe 2008), rare in Kentucky, and rare and extirpated from many locations in Tennessee (Burr and Warren 1986, Etnier and Starnes 1993). Page and Near (2007) observed that the species "has been extirpated from much of its range" and "appears to be common only in the Allegheny River, Pennsylvania."

Habitat:
The longhead darter is found primarily in creeks and medium-sized rivers with moderate flow gradients, often in pool or riffle habitat (NatureServe 2008). This species favors boulder- and cobble-strewn pools above or below deep, fast-flowing riffles (Burr and Warren 1986). It is intolerant of polluted conditions (PA Fish and Boat Commission 1997).

Ecology:
Spawning takes place in spring (March-May) in gravel shoal habitat; eggs are buried in the substrate and adults do not engage in any parental care (NatureServe 2008). Sexual maturity is reached at approximately 2 years of age. Total lifespan is approximately 3-4 years (Page 1978, Etnier and Starnes 1973, Jenkins and Burkhead 1994). Both adults and juveniles consume invertebrates, including crayfish and insect larvae, foraging primarily in benthic habitat beneath rocks and in substrate (Page 1978, 1983). The longhead darter is a non-migratory species (NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are approximately 25 existing occurrences of P. macrocephala across its range. The total adult population size of P. macrocephala is not known. This species is generally described as widespread but rare and highly localized (Page and Burr 1991, Etnier and Starnes 1993). It was recently established that the populations formerly considered to be P. macrocephala included a separate species, P. williamsi, reducing the total population size of the longhead darter (Page and Near 2007). Even before this discovery, Etnier and Starnes (1993) asserted that P. macrocephala warranted "threatened" status across its range. Because of temporally varied observations of population size, it has been suggested that the population dynamics of this species may be somewhat cyclic, which could lead to erroneous estimates of population density or viability (NatureServe 2008).

Population Trends:
The species was extirpated from the Cumberland by impoundment in the 1930s and more recently other locations by habitat degradation (Page and Near 2007, NatureServe 2008).

Status:
NatureServe (2008) lists the longhead darter as critically imperiled in Kentucky, and New York, imperiled in Pennsylvania, Tennessee, and West Virginia, and reports that it is extirpated from Ohio. The longhead darter is state-listed as endangered in KY, threatened in TN, NY, and of special concern in NC. Although the precise degree of decline is unknown, the extent of occurrence, total area of occupancy, number of subpopulations, and population size have all declined over the long term (Page 1978, Trautman 1981, Burr and Warren 1986, NatureServe 2008). This species is likely extirpated from the Cumberland and Kentucky Rivers in Kentucky (Burr and Warren 1986). It has also been extirpated from several rivers and streams in Tennessee, including the Cumberland River (Page 1978, Etnier and Starnes 1993). Jelks et al. (2008) list the species as vulnerable.

Habitat destruction:
Widespread threats to the longhead darter include increased pollution, turbidity, and siltation from agriculture, industry, and residential development, and habitat fragmentation and degradation by the construction of impoundments or channelization of rivers or streams (Page and Near 2007, NatureServe 2008). The clearing of woody debris from riverbanks or channels to facilitate boat passage also degrades this species' habitat (NatureServe 2008).

The degradation of riparian and aquatic habitat by livestock poses a threat in Kentucky, Tennessee, New York, and Pennsylvania (NatureServe 2008). Populations of the longhead darter in New York are most threatened by silt deposition from agricultural runoff that smothers eggs and juvenile life stages (NYSDEC pers. comm. as cited in NatureServe 2009). Acid mine drainage has degraded significant habitat in the Ohio River Basin (PA Fish and Boat Commission 1997). More southerly populations are also affected by agriculturally related pollution, but mining (particularly coal mining) is an unparalleled threat to aquatic species in the areas where it occurs (West Virginia), even more so since the advent of mountaintop removal (MTR) (NatureServe 2008). Numerous populations in the southern portion of this species' range are also isolated by impoundments, dams, and other barriers to dispersal (NatureServe 2008).

This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Jelks et al. (2008) classify the species as vulnerable based on the present or threatened destruction, modificaton, or reduction in habitat or range.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the longhead darter from the variety of threats it currently faces. Though it is listed as endangered, threatened, or as a species of special concern in several states, these designations have little meaning in terms of substantial regulatory protection for the species' habitat. NatureServe (2008) reports that few occurrences are protected or managed adequately.

Other factors:

This species' narrow habitat preference reduces its resilience to habitat loss and degradation, making the restoration and protection of suitable habitat critical to its persistence (NatureServe 2009).

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Scientific Name:
Percina nasuta
Common Name:
Longnose Darter

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	NT - Near threatened

Range:
The longnose darter is sporadically distributed in the St. Francis, White, Arkansas, and Ouachita river drainages in the Ozark and Ouachita uplands of southern Missouri, northern Arkansas, and eastern Oklahoma (Page and Burr 1991). In Arkansas, it occurs in the Ouachita, Arkansas, Little Red, and White river systems, and in Frog Bayou/Clear Creek, Mulberry River, War Eagle Creek, Big Piney Creek, Illinois Bayou Drainage, Caddo River, and South Fourche la Fare River (Robison 1992a and 1992b). It occurs in Lee Creek in Arkansas and Oklahoma. In Missouri, it occurs in the St. Francis River.

Habitat:
This fish occurs in clear, small to medium rivers. During spring it occurs iin gravel and rubble riffles, but during fall moves to slower quieter waters over sand and silt. It has also been reported from an impoundment (NatureServe 2008).

Populations:
Prior to 1980 there were 21 collection sites for this species (Lee et al. 1980). In Arkansas, this species was documented at 39 sites and 21-100 estimated extant occurrences, but many of these records have been re-identified as a new species, decreasing the formerly widespread Arkansas range. In Oklahoma, 30 collection sites were recorded from 1939-1989, with an estimated 0-5 extant occurrences being in good condition (C. Vaughn, pers. comm., 1997 cited in NatureServe 2008), but Lee's Creek may be the only remaining population in Oklahoma (Wagner et al. 1984). In Missouri this species was last collected in 1987 when one individual was detected in the St. Francis River. This fish is extirpated in the White River in Missouri, and may also be extirpated in the St. Francis (J. Sternburg, pers. comm., 1997 cited in NatureServe 2008).

Total population size is unknown and is difficult to determine. This fish is uncommon (Page and Burr 1991), occurs in small localized populations, and is not abundant at any locality (Wagner et al. 1984, Robison 1992a and 1992b).

Population Trends:
The longnose darter has declined by up to 30 percent in the short-term and has experienced a long-term decline of 25-75 percent (NatureServe 2008). Buchanan (1984) noted that numbers have been drastically reduced and a number of populations have been extirpated over the past 22 years. In Oklahoma, this fish is extirpated from the Poteau River System and there is only one remaining population in the state (Robison 1992b). In Missouri, this species may be extirpated in the St. Francis, White, and Poteau river systems (Stewart 1993). It has not been detected in the White River watershed since the mid-1950's and was last seen in the St. Francis in 1987. The Missouri Dept. of Conservation (2010) states that the longnose darter is extremely rare and vulnerable to extirpation from the state. The longnose darter is believed to be stable in Arkansas, but may be extirpated in the Little Missouri River. In surveys in the early 1990's it was detected in all previously occupied river systems except for the Little Missouri; it might still be extant in the

Little Missouri but at reduced numbers (Robison 1992a).

Status:
The longnose darter is critically imperiled in Missouri and Oklahoma and imperiled in Arkansas (NatureServe 2008). This rare fish has been exirpated from entire river systems and is vulnerable to further extirpations. It is ranked as threatened by the American Fisheries Society (Jelks et al. 2008) due to habitat loss and degradation. It is isted as endangered by the state of Missouri.

Habitat destruction:
Impoundment is a primary threat to the longnose darter. The construction of reservoirs has extirpated or reduced populations of this species (Buchanan 1984, Wagner et al. 1984, Robison 1992a and 1992b, Stewart 1993). This species was likely extirpated from the Missouri portion of the White River watershed by Table Rock Dam. The range of the longnose darter has also been negatively impacted by the inundations of Beaver Lake (Missouri Dept. of Conservation 2010). Water quality changes resulting from existing impoundments and a proposed impoundment on Lee Creek are ongoing threats (Stewart 1993). This fish is also threatened by gravel and sand mining, and channel modification for flood control (Stewart 1993). The Arkansas Game and Fish Commission (2005) lists threats to this species as channel alteration, dams, sedimentation, grazing, resource extraction, and road construction. The Missouri Dept. of Conservation (2010) reports that fish in the White River watershed are threatened by urbanization, livestock grazing, gravel mining, and reservoir operations. Jelks et al. (2008) list habitat loss as a threat to this species.

Inadequacy of existing regulatory mechanisms:
The longnose darter is not protected by any existing regulatory mechanisms. It is listed as endangered by the state of Missouri, and as a Species of Special Concern in Arkansas, but these designations do not confer substantial regulatory protection to the species or its habitat. It occurs on Ouachita National Forest which conveys some level of protection, but leaves the species vulnerable to impacts from logging and recreation.

Other factors:
The longnose darter is threatened by pollution including pesticides, agricultural runoff, municipal and industrial discharges, and sedimentation (Buchanan 1984, Wagner et al. 1984, Robison 1992a, 1992b, Stewart 1993). The Missouri Dept. of Conservation (2010) reports that fish in the Whiter River watershed are threatened by point and non-point source pollution, particularly from municipal sewage spills and poultry operations. This fish is threatened by past and ongoing metal contamination from the Big River Mine Tailings Superfund Site (FWS 2009).

This species is vulnerable to extirpation due to low population sizes and low densities, and is susceptible to stochastic events such as drought (Wagner et al. 1984, Robison 1992a, 1992b).

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Scientific Name:
Percina sipsi
Common Name:
Bankhead Darter

G Rank:	**AFS Status:**
G1	Threatened

Range:
The bankhead darter has a highly restricted distribution limited to four streams in the Sipsey Fork of the Black Warrior River, including Borden, Brushy and Caney Creeks, and the Sipsey Fork itself (Mettee et al. 1996, Boschung and Mayden 2004, Kuhajda 2004, Williams et al. 2007, NatureServe et al. 2008).

Habitat:
The bankhead darter occurs in large upland streams with moderate current and rocky substrates and is frequently associated with woody debris (Kuhajda 2004, Boschung and Mayden 2004, Williams et al. 2007).

Populations:
The bankhead darter is limited to four streams, where it is not abundant (Boschung and Mayden 2004, Kuhajda 2004, Williams et al. 2007).

Population Trends:
Jelks et al. (2008) listed the bankhead darter as declining and changed its status from threatened to endangered. Prior to recent declines, the species lost range to the Lewis Smith Reservoir (Kuhajda 2004, Williams et al. 2007).

Status:
NatureServe (2008) lists this fish as critically imperiled, noting that "abundance is low," that its "limited distribution makes it vulnerable to localized habitat alterations," and that "sedimentation from poor forestry management practices is a threat." Jelks et al. (2008) lists it as endangered. Williams et al. (2007) concluded:

"We consider P. sipsi to be highly endangered based on its restricted distribution, rarity within the occupied range, habitat vulnerability, and absence of downstream habitat for future recovery. Percina sipsi is extremely vulnerable and needs continuous monitoring and proactive management actions to prevent extinction."

At a meeting of the Southeastern Fishes Council and Center for Biological Diveristy, there was a strong consensus that the bankhead darter should be listed as endangered.

Habitat destruction:
Jelks et al. (2008) lists the bankhead darter as endangered because of the "present or threatened destruction, modification, or reduction of a taxon’s habitat or range." The species' range was curtailed by construction of the Lewis Smith Dam in 1960, which flooded habitat in the Sipsey Fork (NatureServe 2008). Logging and road construction are both currently threats to the bankhead darter (Kuhajda 2004). Clearcutting and excessive sedimentation are the main threat to this species and warrant its listing as endangered (SFC and CBD 2010).

Inadequacy of existing regulatory mechanisms:

This species is found entirely on the Bankhead National Forest, which provides some level of protection (Williams et al. 2007), but does not necessarily protect this fish from the impacts of logging, roadbuilding, and recreation. Williams et al. (2007) describe this species as "extremely vulnerable" and in need of "continuous monitoring and proactive management actions to prevent extinction."

Other factors:

Jelks et al. (2008) list the bankhead darter as endangered because of "a narrowly restricted range."

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Scientific Name:
Percina sp. cf. palmaris
Common Name:
Halloween Darter

G Rank:	**AFS Status:**
G2	Vulnerable

Range:
The halloween darter is endemic to the Apalachicola River drainage in the Flint River system in Georgia and the Chattahoochee River system in Alabama and Georgia (Freeman et al. 2008). In the Flint, it occurs in the mainstem above and below the Fall Line and in at least four tributaries, including Lazer, Potato, Muckalee, and Ichawaynochaway Creeks (Ibid.) In the Chattahoochee, it occurs in two disjunt areas: one in the upper watershed in the mainstem of the river, as well as the Chestatee River and Sautee Creek, and another in the Uchee Creek system in Alabama (Ibid.)

Based on this disjuct distribution, Freeman et al. (2008) hypothesized that the halloween darter occurred more widely in the Chattahoochee prior to consturction of a number of dams, and expansion of Atlanta with concurrent impacts on water quality. They also believe it may have occurred more widely on the Coastal Plain prior to clearing of the Chattahoochee and Flint Rivers of rock shoals and other obstacles to navigation.

Likewise, Johnston and Kuhadja (2002) concluded:

"Distribution significantly fragmented and restricted to four isolated stream reaches in Apalachicola River drainage. Assuming a continuous presettlement distribution between these four isolated populations, this species has dissapeared from vast majority of former distribution primarily due to construction of impoundments."

Habitat:
The halloween darter is found in swift currents over bedrock or course boulder or gravel substrates, otherwise known as shoal habitats (Marcinek 2003, Freeman et al. 2008)

Populations:
The halloween darter is still abundant in shoals of the upper Flint above the Fall Line, but is less common and occurs in fewer localities in the lower Flint or in the Chattahoochee system (Marcinek 2003, Freeman et al. 2008).

Population Trends:
The halloween darter is believed to have been extirpated from a major portion of its range in the Chattahoochee River because of impoundments and channel modification for navigation (Johnston and Kuhajda 2002).

Status:
Both Warren et al. (2000) and Jelks et al. (2008) classified the halloween darter as vulnerable. Johnston and Kudajda (2002) classified it as a species of highest conservation concern. It is listed as threatened by the state of Georgia. NatureServe (2008) classifies the halloween darter as critically imperiled in Alabama and imperiled in Georgia. Population fragmentation caused by dams is considered a primary threat to the species (Johnston and Kuhajda 2002, Freeman et al.

2008). At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the halloween darter should be listed as threatened because of population fragmentation, range loss and severe threats (SFC and CBD 2010).

Habitat destruction:

The halloween darter faces numerous threats to its habitat, including water withdrawal, pollution and sedimentation related to urbanization and other land use (Johnston and Kuhajda 2002, Freeman et al 2008, SFC and CBD 2010). In particular, the halloween darter is thretened by urban sprawl from metropolitan Atlanta. Freeman et al. (2008), for example, state:

"Present threats to the persistence of P. crypta primarily consist of effects of urban growth on stream hydrology and water quality, particularly in the north Georgia mountains and in the vicinity of the Atlanta Metropolitan area. The Flint River headwaters originate in Atlanta, and population growth in the upper Flint River system is expected to place increasing demands on the river system for water supply and waste assimilation. Similarly, population growth in the Blue Ridge province of North Georgia will affect water availability and quality in the Chattahoochee River headwaters."

In relation to an increased human population and increased demand for water, a series of new impoundments are proposed for the Atlanta area, which further threaten the holiday darter. Johnston and Kuhajda (2002) further identified declining habitat quality in the Uchee Creek system as a serious threat to the species.

Inadequacy of existing regulatory mechanisms:

The halloween darter is considered a threatened by the state of Georgia and a species of highest conservation concern in Alabama (Freeman et al. 2009). Neither of these designations, however provide protection for the halloween darter's habitat. No other protections are in place for this species.

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Scientific Name:
Percina williamsi
Common Name:
Sickle Darter

G Rank:	AFS Status:
G2	Threatened

Range:
The sickle darter historically occurred in the upper Tennessee River of Tennessee, Virginia and North Carolina, including the French Broad, Emory, Holston and Clinch Rivers (Page and Near 2007). The species has been extirpated from streams where it was previously collected and is considered extirpated in North Carolina (Page and Near 2007).

Habitat:
The sickle darter occurs in flowing pools over rocky, sandy, or silty substrates in clear creeks or small rivers most often in association with woody debris, vegetation or boulders (Page 1978, Etnier and Starnes 1993, Jenkins and Burkhead 1994, Page and Near 2007). Page and Near (2007) note that: "as its fusiform shape suggests, it spends most of its time swimming in current in the water column" with the prominent black stripe on its side "characteristic of darters living near vegetation in flowing pools."

Populations:
According to Page and Near (2007), the sickle darter "can be observed with regularity in a few streams, but populations are widely scattered and the species has been extirpated from several streams where it was collected in the late 1800s and early to mid-1900s." In total, Page and Near (2007) identify a mere 15 localities where the species has been collected over the past roughly 30 years.

Population Trends:
The species is known to have dissapeared from several streams and is considered extirpated in North Carolina, indicating species decline (Etnier and Starnes 1993, Page and Near 2007, NatureServe 2008).

Status:
The sickle darter is considered extirpated in North Carolina, critically imperiled in Virginia, and imperiled in Tennessee (Etnier and Starnes 1993, Jenkins and Burkhead 1994, NatureServe 2008). Jelks et al. (2008) list the species as threatened based on the present or threatened destruction, modification or reduction of habitat or range. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the sickle darter should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
Page and Near (2007) identify "increased turbidity and siltation resulting from agricultural, industrial, and municipal development" as likely threats to the sickle darter, noting that these factors are "the ultimate result of population growth in Homo sapiens." Other threats include chemical pollution and impoundment, which has isolated many populations (Burkhead and Jenkins 1991, NatureServe 2008). Jelks et al. (2008) identify the sickle darter as threatened based on the present or threatened destruction, modification or reduction in habitat or range.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) determines that "few occurrences are appropriately protected and managed," identifying a population in the Little River, Tennessee as receiving protection from Great Smoky National Park. This one population, however, is not sufficient to ensure the continued existence of the species. The species is listed as threatened by the state of Tennessee, but this designation does not provide any protection for the species' habitat.

Other factors:

The sickle darter is restricted to a small number of isolated locations in the upper Tennessee River and is thus highly vulnerable to stochastic genetic and environmental events. Water pollution also threatens this species (Page and Near 2007).

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SFC and CBD 2010. Meeting of the Southeastern Fishes Council and Center for Biological Diversity April 5-9, 2010. Auburn, AL, Knoxville, TN and Raleigh, NC.

Scientific Name:
Phaeophyscia leana
Common Name:
Lea's Bog Lichen
G Rank:
G2
Range:
Lea’s bog lichen is a rare lichen found only in floodplains of the Ohio River Valley. It is found in Illinois, Kentucky, Pennsylvania, and Tennessee, and was once also present in Ohio (NatureServe 2008). It is currently known in Gallatin, Massac, Pope, and White Counties in Illinois, Posey County in Indiana, and Ballard and Livingston Counties in Kentucky (NatureServe 2008).

Habitat:
This lichen is epiphytic, growing below the spring high-water mark on the bark of several species of trees, including the eastern cottonwood, Populus deltoides, the bald cypress, Taxodium distichum, and species in the genera Acer, Carya, Liquidambar, and Ulmus in bottomland or floodplain forests, and along rivers or oxbow lakes (NatureServe 2008, Skorepa 1984). It reportedly grows only on the trunks of trees inundated by seasonal flooding (Skorepa 1984).
Ecology:
Reproduction is primarily asexual, and it is therefore unknown how many genetically distinct populations exist.
Populations:
There are eight sizable known populations of this species, each comprised of thousands of thalli, though the number of genetically distinct individuals in these populations is not known (NatureServe 2008).
Population Trends:
Long-term population trends are not known, but short-term fluctuations are reported (NatureServe 2008).
Status:
NatureServe (2008) ranks Lea's bog lichen as critically imperiled in Illinois, Kentucky, Ohio, and Tennessee. Its status is under review in Pennsylvania. This species is state-listed as threatened in Illinois.
Habitat destruction:
Populations of this species are declining because of heavy river traffic, flooding, and bank erosion that kills the trees that provide substrate for the Lea’s bog lichen. The most significant threats include irregular major flooding and wakes left by river traffic, both of which erode riverbank habitat and kill the trees that host P. leana (Wilhelm and Masters 1994). These irregular floods are a result of alterations in hydrologic flow caused by dams, locks, or other impoundments, and are exacerbated by land clearing or wetland drainage that removes natural flood control mechanisms (Gillespie and Methven 2002). Many backwater sloughs and oxbow lakes that provide suitable habitat for P. leana’s host trees have been drained or are plagued by eutrophication or sedimentation; silt and sediment may coat tree surfaces or smother P. leana (Gillespie and Methven 2002). Reduced water flow may also compromise populations of P. leana:

periodic flooding must be adequate to suppress shrubby undergrowth that would otherwise preclude P. leana's growth on the low parts of tree trunks (Wilhelm and Masters 1994). This species has been extirpated from Ohio, where it was historically present in several watersheds, although no sources report the specific cause of extirpation (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Lea's bog lichen; it is listed as threatened only in Illinois, a designation that nonetheless affords it no significant regulatory protection.

Other factors:
This lichen is threatened by sedimentation and eutrophication from flooding, impoundment, and other sources (Gillespie and Methven 2002).

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Scientific Name:
Phoxinus saylori
Common Name:
Laurel Dace

G Rank:	**AFS Status:**
G1	Endangered

Range:
The Laurel dace is only known from six streams on the Walden Ridge portion of the Cumberland Plateau in Tennessee, including Soddy, Horn Branch of Rock, Cupp, Youngs, Moccasin and Bumbee Creeks (Skelton 2001). It is extirpated from the Laurel Branch of Rock Creek with remaining populations extremely localized, occupying reaches of 0.3 to 8 km in length (Skelton 2001, Strange and Skelton 2005).

Habitat:
The Laurel dace occurs on cobble, rubble or boulder substrates in pools or slow runs associated with undercut banks or beneath boulders in small, cool (less than 26 degrees C), headwater streams surrounded by dense riparian vegetation (Skelton 2001).

Populations:
The laurel dace is limited to six discrete stream populations. Recent surveys of streams occupied by the laurel dace suggest serious cause for concern in three of the six creeks occupied by the species. Surveys in 2004 found a single juvenile in the 2.5 km section of Soddy Creek historically occupied by the species, a single juvenile in an unamed tributarty to Horn Branch, where no fish were found in the pool historically occupied by the species, and no individuals in Cupp Creek (Strange and Skelton 2005).

Population Trends:
The laurel dace has apparently experienced dramatic declines in the last 10-30 years in three of the six streams in which it occurs (Strange and Skelton 2005). In 1995-1996, for example, 19 laurel dace were collected in Cupp Creek, but in 2004, no laurel dace could be found. In both Soddy and Horn Branch Creeks, only one juvenile was found in each in 2004. By comparison, Skelton collected 52 laurel dace in 1993-1994 in Soddy Creek, as well as observing a number of the species in 1996 and 1997, and nearly 2,000 of what are now presumed to be laurel dace were collected from Horn Branch in 1976 with surveys by Skelton in the 1990s regularly producing 30 to 50 fish (Strange and Skelton 2005).

Status:
Jelks et al. (2008) list the species as endangered, the U.S. Fish and Wildlife Service lists the species as a candidate for listing, Tennessee lists it as endangered, and NatureServe (2008) lists it as critically imperiled. There can be no doubt that the laurel dace is in immediate danger of extinction. At a meeting of the Southeastern Fishes Council and Center for Biological Diversity, there was agreement that the laurel dace should be listed as theatened (SFC and CBD 2010).

Habitat destruction:
The laurel dace is well known to be threatened by logging, road construction, blockage of habitat by culverts, mining, agriculture, and clearance of riparian vegetation (Skelton 2001, Strange and Skelton 2005, NatureServe 2008). Skelton (2001), for example, states:

"Agriculture, mining, and timbering have been widespread on Walden Ridge, and it is likely that additional populations may have existed before these types of human activities began. Extensive timber harvesting and some agriculture are ongoing in the vicinity of some P saylori populations. A large area surrounding the headwaters of Horn Branch of Rock Creek has recently been clearcut, as has an approximately 200 m stretch adjacent to the type locality. Further cutting is proposed near the type locality in the next four years (W. Boyd, Bowater Newsprint, pers. comm.). Increased siltation from these activities is already evident and has the potential of destroying available spawning areas."

Skelton goes on to note that:

"An encouraging note about P saylori is that the species seems to be fairly tolerant of a wide range of physical conditions. They are apparently tolerant of low pH values (lowest recorded was 5.4 in Horn Branch) and presumably tolerant of some siltation. Most of the areas adjacent to streams where P saylori occurs have been clearcut at one time or another and at least some of the populations have survived. Currently, the individual populations appear to be fairly secure. However, since there are only six known populations, a single catastrophic event could significantly reduce the species range."

Conclusions about the tolerance of the laurel dace, however, may have been premature, as only one juvenile laurel dace was found in Horn Branch.

According to Strange and Skelton (2005) siltation is a threat to all six of the populations of laurel dace. They note, for example, that extensive clear-cutting and road construction adjacent to Bumbee Creek resulted in a heavy sediment load in the stream and that conditions deteriorated between 2002 and 2005.

FWS (2007) further notes that "habitat destruction and modification also stems from existing or proposed infrastructure development," and specifically identifies existing culverts proposed water lines and a proposed impoundment in the Soddy Creek watershed as all threatening the laurel dace.

The Laurel dace is also threatened by mountaintop removal coal mining which can fill in streams entirely and can cause significant downstream pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Elevated selenium concentrations downstream of mountaintop removal operations can cause teratogenic deformities in larval fish (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, eliminating food sources for fish (Wood 2009).

Consistent with these observations, Jelks et al. (2008) list the dace as endangered because of the present or threatened destruction, modification, or reduction of habitat or range.

Disease or predation:
FWS (2007) cited an observation by Skelton that declines of laurel dace in Horn Branch appeared to be correlated with an increase of green sunfish in the creek and that perhaps these predatory fish are a threat to the species in this and other creeks.

Inadequacy of existing regulatory mechanisms:
FWS (2007) concluded that there were no effective regulations for protecting the laurel dace from logging on the private lands covering most to all of its range. Specifically, they noted that landowners are exempt from obtaining permits for forestry activities, which "hinders TDEC-WPC's [Tennessee Department of Environment and Conservation, Division of Water Pollution Control] ability to target

forest operations from random inspections to ensure that BMPs are effective at preventing point source pollution from occurring due to forestry activities" They further note that "adherence to BMPs is strictly voluntary" and that "the only opportunity for enforcement would be after a violation has occurred."

FWS (2007) further notes that the laurel dace's listing as endangered under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112) is "inadequate for the protection of" laurel dace because "it only requires parties to consider alternatives before knowingly destroying the habitat of it or other species listed by the State of Tennessee as threatened or endangered."

Other factors:

Jelks et al. (2008) list the laurel dace as endangered in part because it is limited to a narrow, restricted range. FWS (2007) concludes that "the laurel dace's limited geographic range and apparent small population size in half of the streams it inhabits leaves the species extremely vulnerable to localized extinctions from intentional or accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity," noting that a report of a fish kill in Cupp Creek by a local landowner provides evidence of the possibility for such disturbances. They also note that the restricted range of the species makes it "more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes."

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Scientific Name:
Physostegia correllii
Common Name:
Correll's False Dragon-head

G Rank:
G2

Range:
This plant was formerly widespread throughout the Gulf Coast but is now declining. Correll's false dragon-head is a wetland perennial now known only from southern Louisiana and Texas; populations may still exist in northern Mexico (Coahuila, Nuevo Leon, and Sonora) but have not been recently confirmed (Center for Plant Conservation 2009, Irving 1980). The single remaining occurrence in Texas is found in Travis County (Singhurst 2001 as cited in Center for Plant Conservation 2009), and populations may still be found in Louisiana's Cameron, St. Charles, St. James, and St. Tammany Counties, though most of these occurrences have not been confirmed in the past decade (NatureServe 2008).

Habitat:
The false dragon-head is found in wet, silty clay loams along streamsides, creekbeds, irrigation channels and drainage ditches. This plant may establish in anthropogenic habitats if conditions are suitable (NatureServe 2008). It is often found in association with Johnson grass (Sorghum spp.), spike rush (Eleocharis spp.), alligatorweed (Alternanthera philoxeroides), and cottonwood (Populus spp.) (Irving 1980).

Ecology:
This plant is perennial, self-compatible, and often reproduces via rhizomes; populations may thus exhibit low genetic diversity. It is primarily bee-pollinated,and flowers in June and July (Center for Plant Conservation 2009).

Populations:
Fewer than 5 occurrences of this species have been confirmed in the past decade, and several historical occurrences have not been recently confirmed. Total population size is not known but is likely quite small (NatureServe 2008).

Population Trends:
Trend has not been formally reported for this species, but it appears to be in serious decline (NatureServe 2008, Center for Plant Conservation 2009).

Status:
This plant was formerly widespread, but its range appears to be contracting; most historical occurrences have not been recently confirmed. NatureServe (2008) ranks the Correll's false dragonhead as critically imperiled in Louisiana and imperiled in Texas.

Habitat destruction:
The wetland habitat preferred by P. correllii is threatened mainly by logging and/or conversion to silvicultural plantations; because this species often establishes in human-made habitats (drainage ditches, irrigation channels) it is exposed to frequent disturbance (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect the Correll's false dragon-head or its habitat.

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Scientific Name:
Plagiochila caduciloba
Common Name:
Gorge Leafy Liverwort

G Rank:
G2

Range:
The gorge leafy liverwort is endemic to a narrow range in the southern Appalachians in Tennessee, North Carolina, South Carolina, Georgia, and Kentucky. Natural heritage data show records of this species in Burke, Clay, Graham, Haywood, Jackson, Macon, Transylvania, and Yancey Counties, North Carolina (Boyer 1991), Rabun County, Georgia, and Oconee and Pickens Counties, South Carolina (NatureServe 2008). This species is most common in the core of its range, the Escarpment region of North Carolina (Boyer 1991, as updated 1992 and 1996).

Habitat:
The liverwort is most frequently found on vertical rock walls or on the underside of projecting ledges in damp areas near waterfalls, in sheltered sites within rocky gorges, ravines, or ridges (Schafale and Weakley 1990). It prefers shade and high humidity, and no direct sunlight. It is found near the spray zone, but not within it, and preferred rock substrate is not calcareous (Boyer 1991). Soils are rocky and acidic within this habitat, and forest canopy is dense and often dominated by birch (e.g., Betula lenta, Betula alleghaniensis), tulip (Liriodendron tulipifera), hemlock (Tsuga canadensis), red maple (Acer rubrum), and red oak (Quercus rubra), with a well-developed shrub layer and sparse herb layer. The liverwort occurs at elevations up to 1500 m (Hicks and Amoroso 1996).

Ecology:
The liverwort requires undisturbed, shaded, humid habitat (NatureServe 2008). It is largely maintained and propagated by asexual reproduction.

Populations:
This liverwort is currently known from approximately 21 occurrences-- one in Kentucky, two in Tennessee, four in South Carolina, and 13 in North Carolina (Hicks and Amoroso 1996). Global population size is not known.

Population Trends:
NatureServe (2008) reports that this species is in decline and has been extirpated from some historical sites.

Status:
This liverwort is endemic to a narrow range within which it is known from relatively few occurrences and reportedly in decline. NatureServe (2008) ranks the gorge leafy liverwort as critically imperiled in Georgia and South Carolina and imperiled in North Carolina and Tennessee.

Habitat destruction:
The liverwort's habitat is threatened primarily by silvicultural management: as an ecological specialist, this species is greatly affected by changes to its habitat (Boyer 1991, updated 1992, 1996, NatureServe 2008). Some individuals or populations may be destroyed by recreational trampling (Hicks and Amoroso 1996).

Inadequacy of existing regulatory mechanisms:

Some populations of this species are located in Great Smoky Mountains National Park, where they are protected from timber harvest but vulnerable to recreational impacts (Hicks and Amoroso 1996). Several populations occur on National Forest lands, where they are ostensibly protected but remain vulnerable to timber harvest activities (Boyer 1991). No existing regulatory mechanisms adequately protect this species or its habitat; though it is listed as a species of special concern in Georgia and as a sensitive species on the Nantahala National Forest, these designations offer it no substantial protections.

References:

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Scientific Name:
Plagiochila sharpii ssp. sharpii
Common Name:
Sharp's Leafy Liverwort

G Rank:
T3

Range:
Sharp's leafy liverwort is endemic to the southern Appalachian region in North Carolina, Tennessee, and South Carolina's escarpment region (NatureServe 2008).

Habitat:
This liverwort forms dense mats on boulders and rock outcroppings in the escarpment gorges of the Whitewater and Chattooga Rivers, and may occur at lower abundance at other, less suitable sites (Hicks 1996).

Populations:
This liverwort is known from 42 historical sites, only ten of which are extant. Of the ten extant occurrences, there are two in Tennessee, four in North Carolina, one in Georgia, two in gorges on the state boundary between the Carolinas, and one in a gorge that forms the state boundary between South Carolina and Georgia (Hicks 1996).

Population Trends:
This liverwort is extant at only 10 of 42 historical sites, representing a decline of nearly 75 percent. There are robust occurrences at some undisturbed sites. This liverwort has been reported from the spruce-fir zone of the Appalachians but has not been located there, which could be due to it never having been there or to the dramatic changes in that habitat due to adelgid infestation (Hicks 1996).

Status:
The liverwort is nearly restricted to deep, dense forests of the southern Appalachians. It has not been ranked by NatureServe.

Habitat destruction:
This liverwort has disappeared from three-quarters of its historic locations, though no specific causes are cited. Any changes in the streams in the area of Plagiochila sharpii distribution would threaten this plant's habitat, including logging, clear cutting and roadbuilding. Impoundment is also a potential threat (Hicks 1996). If this species occurs in the spruce-fir zone where it has been reported but not confirmed, that habitat is widely threatened by adelgid infestation (Hicks 1996).

Inadequacy of existing regulatory mechanisms:
The majority of the occurrences of Plagiochila sharpii are in the Great Smoky Mountains National Park, where they are protected from development but vulnerable to recreational impacts. Plagiochila sharpii also occurs in Nantahalla National Forest and in the Ellicott Rock Wilderness which are protected from commercial development, but not protected from clearcutting or road building (Hicks 1996).

References:

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Scientific Name:
Planorbella magnifica
Common Name:
Magnificent Rams-horn

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of the Magnificent Rams-horn consists of less than 100 square km in one to two lakes about 15 miles apart in the Lower Cape Fear River basin in Brunswick and New Hanover counties in North Carolina (Burch 1989, LeGrand et al. 2006).

Habitat:
This species' habitat is in two old human-made lakes where it inhabits sheltered areas with a diverse assemblage of aquatic plants (Scientific Council on Freshwater and Terrestrial Mollusks 1990). This snail has been detected on the stems and undersides of the floating leaves of Spatterdock (Niiphar liiteum) and Fragrant Waterlily (Nymphaea odorata) at a depth of approximately one meter with organic substrate. Both lakes were created early in the last century as a water source for rice agriculture (NatureServe 2008).

Populations:
Historically known from two sites, Ortan Pond and Greenfield Lake, this snail is now extant only in Ortan Pond (Fuller 1977, Adams and Gerberich 1988, Dillon et al. 2006, LeGrand et al. 2006). Total population size is crudely estimated at 50 - 2500 individuals.

Population Trends:
NatureServe (2008) reports that this snail is rapidly declining (decline of 30-50 percent) in the short-term and has experienced a long-term decline of 50 percent. This species has been extirpated at one of two historical locations (Adams and Gerberich 1988). It has not been reported in the wild since several hurricanes hit its remaining habitat in the late 1990s (Dillon et al. 2006).

Status:
This species was considered to be possibly extinct until it was redetected in 1986. It is critically imperiled (G1S1, NatureServe 2008). It is ranked as vulnerable by the IUCN.

Habitat destruction:
The Magnificent Rams-horn was extirpated from Greenfield Lake due to water quality detoriation resulting primarily from development. The watershed is "almost totally developed" and undergoes intensive management to control nuisance algae including algicide applications and drawdown (NatureServe 2008). This species' remaining site is privately owned and also potentially threatened by development from the expanding city of Wilmington. The lands surrounding the pond are currently managed for timber and wildlife, making sedimentation from logging a potential threat. This species is threatened by water quality degradation resulting from off-site impacts within the rapidly developing watershed (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms to protect this species, which now occurs only in a single pond on private land.

Other factors:

The Magnificent Rams-horn is threatened by stochastic weather events, such as hurricanes, which are expected to increase in frequency and intensity as the result of global climate change (Field et al. 2006). This species has not been detected since its habitat was hit by several hurricanes during the late 1990s (Dillon et al. 2006).

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Scientific Name:
Plethobasus cyphyus
Common Name:
Sheepnose

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Threatened	NT - Near threatened

Range:
The sheepnose is a freshwater mussel species endemic to the southeastern and midwestern United States. It is present in Alabama, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. Existing populations are known from 26 streams in the aforementioned states: the Mississippi, Kankakee, Ohio, and Wabash Rivers in Illinois (Sietman et al. 2001), the Ohio, Wabash, Tippecanoe, and Eel Rivers in Indiana, the Mississippi River in Iowa (Fisher 2006), the Ohio, Licking, Kentucky, Green, and Cumberland Rivers in Kentucky, the Mississippi and St. Croix Rivers in Minnesota, the Big Sunflower River in Mississippi (only in the Yazoo drainage, Jones et al. 2005), the Mississippi, Meramec, Bourbeuse, Osage Fork, and Gasconade Rivers in Missouri (commonly found only in the Meramec River, Oesch 1995), the Ohio and Muskingum Rivers in Ohio, the Allegheny River in Pennsylvania, the Tennessee, Holston, Clinch, and Powell Rivers in Tennessee, the Clinch and Powell Rivers in Virginia, the Ohio and Kanawha Rivers in West Virginia, and in the Mississippi, St. Croix, Chippewa, Flambeau, and Wisconsin Rivers in Wisconsin (Zeto et al. 1987, USFWS 2003, Cummings and Berlocher 1990, Butler 2003, Cochran and Layzer 1993). In Alabama, this species remains only in the tailwaters of the Guntersville and Wilson Dams (Williams et al. 2008).

The sheepnose has been extirpated from much of its former range – approximately 2/3 of the streams in which it was once reported no longer host this species. Though it is still widely distributed, remaining populations are small and isolated (Parmalee and Bogan 1998, Neves 1991).

Habitat:
Though it may also inhabit medium-sized rivers, the sheepnose is generally considered a large-river species (NatureServe 2008). It is most often reported from deep waters (greater than 2 m) and seems to be tolerant of a range of currents and substrate types (Gordon and Layzer 1989). It may also be adaptable to reservoir conditions, as it has been found in the upper Chickamauga Reservoir (Ahlstedt 1989).

Ecology:
This species is a short-term brooder, and known glochidial host species include the sauger, Stizostedion canadense and the central stoneroller, Campostoma anomalum (Surber 1913, Wilson 1916, Watters et al. 2005). While juveniles are parasitic, adults are filter-feeders, primarily consuming detritus from the water column.

Populations:
The sheepnose is known to be extant in 26 streams, and total population size is thought to be at least 2500 individuals. This mussel occurs at very low abundance, and very rarely are more than a few individuals found at a particular site (NatureServe 2008).

Population Trends:
The sheepnose has experienced a long-term decline of up to 75 percent, and has also undergone rapid short-term decline of up to 70 percent. NatureServe (2008) states: "The sheepnose has been eliminated from two-thirds of the total number of streams from which it was historically known (26 streams currently compared to 77 streams historically). This species has also been eliminated from long reaches of former habitat in hundreds of miles of rivers such as the Illinois and Cumberland, and from several reaches of the Mississippi and Tennessee Rivers. In addition, the species is no longer known to occur in the State of Arkansas (see USFWS, 2003; Butler, 2003; Cummings and Mayer, 1997; Parmalee and Bogan, 1998). Sietman (2003) reports it extirpated from the lower Minnesota River in Minnesota."

Status:
NatureServe (2008) ranks the sheepnose as critically imperiled in Alabama, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Ohio, Pennsylvania, Virginia, West Virginia, and Wisconsin, and imperiled in Missouri and Tennessee. It is listed as endangered in Missouri, Mississippi, Illinois, Ohio, Indiana, and Virginia, and threatened in Pennsylvania. It is a federal candidate. Its rank is being changed from threatened (Williams et al. 1993) to endangered (2010 draft, in review) by the American Fisheries Society.

Habitat destruction:
Butler (2002), in a status review of this species, discusses primary threats to its survival across its range including impoundment, channelization, coal mining, gravel mining, agriculture, silviculture, and development.

Similarly, the Kentucky Department of Fish and Wildlife Resources (2005) lists threats to this species' habitat as dredging, gravel and sand quarrying, impoundments, channelization, urbanization, and agriculture.

This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Concerning threats to this species' habitat, the Pennsylvania Fish and Boat Commission (2010) states: "[T]he lock and dam system in the Allegheny and Ohio Rivers, combined with maintenance/commercial sand and gravel dredging have destroyed Sheepnose habitat, eliminated habitat continuity and genetically isolated subpopulations occurring in the Allegheny and Monongahela River systems. Sedimentation from oil and gas developments, forestry and agricultural practices could have an adverse effect on mussel/host interactions and reduce Sheepnose recruitment. The Sheepnose produces narrow, red lanceolate packets of glochidia called conglutinates. These conglutinates resemble fish prey items, specifically worms. Excessive turbidity associated with increased sedimentation would likely alter host numbers or behavior (such as, ability of fish to find and consume conglutinates) thereby reducing Sheepnose recruitment."

Overutilization:
The sheepnose has been harvested commercially in the past for buttons and jewelry, and though it

is not currently a commercially valuable species, it may be inadvertently harvested as by catch or by inexperienced musselers. An increasingly rare species like the sheepnose may increasingly be sought by collectors. Although collecting is not thought to represent a significant threat, localized populations could become impacted and possibly extirpated by overcollecting (Butler 2002).

Inadequacy of existing regulatory mechanisms:

Butler (2002) states: "Most states with extant sheepnose populations prohibit the taking of mussels for scientific purposes without a State collecting permit. However, enforcement of this permit requirement is difficult. Furthermore, State regulations do not generally protect mussels from other threats . . . Existing authorities available to protect riverine ecosystems may not have been fully utilized, such as the Clean Water Act (CWA), which is administered by the Environmental Protection Agency and the Corps. This may have contributed to the general habitat degradation apparent in riverine ecosystems and loss of populations of aquatic species in the Southeast and Midwest. Although the sheepnose coexists with other federally listed mussels and fishes throughout a portion of its range, listing under the Endangered Species Act (Act) would provide additional layers of protection. Federal permits would be required to take the species, and Federal agencies would be required to consult with the Service when activities they fund, authorize, or carry out may adversely affect the species."

Other factors:

The sheepnose is threatened by invasive aquatic species, such as the zebra mussel, Dreissena polymorpha, the Asian clam, Corbicula fluminea, and the black carp, Mylopharyngodon piceus, which have caused the local extirpation of many native mussel species in the eastern United States (Butler 2002, NatureServe 2008). For example, zebra mussels have colonized the Allegheny and Ohio Rivers, and sheepnose mortality from zebra mussel infestation is expected (Pennsylvania Fish and Boat Commission 2010).

This mussel is threatened by habitat fragmentation and population isolation. Remaining populations are small, isolated, and thought to be below effective population size, making them more susceptible to extirpation by stochastic events and less capable of repopulation following any loss (Soule 1980, Butler 2002, Kentucky Department of Fish and Wildlife Resources 2005, NatureServe 2008). The Pennsylvania Fish and Boat Commission (2010) states that anthropogenic disturbances such as acute or chronic pollution events could destroy the remaining Allegheny River Sheepnose subpopulation. Small populations are also more vulnerable to inbreeding depressions and other risks conferred by low genetic diversity.

The sheepnose is threatened by any factor which threatens the host fishes on which it is dependent for reproduction.

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Scientific Name:
Pleurobema athearni
Common Name:
Canoe Creek Pigtoe

G Rank:
G1

Range:
The range of the Canoe Creek Pigtoe covers less than 100 square km in northeast Alabama (NatureServe 2008). It is known only from the Big Canoe Creek watershed, a western tributary of the Coosa River (Gangloff et al. 2006).

Habitat:
This mussel uses shoal habitat in a medium to large river tributary, and prefers gravel substrate (Williams et al. 2008).

Ecology:
The detection of a gravid female in May suggests that this species is a short-term brooder (Gangloff et al. 2006).

Populations:
The Canoe Creek Pigtoe is restricted to roughly six sites in a single small (less than 500 square km) watershed in northeast Alabama (NatureServe 2008). Only 19 individuals are known, but only one-third of these are from recent collections. Four live individuals were found from 2000-2004, including a gravid female, which indicates that P. athearni remains reproductively viable (Gangloff et al. 2006).

Population Trends:
The Canoe Creek Pigtoe is declining in the short-term (decline of 10-30 percent), and the long-term trend is unknown as this mussel was first described in 2006 (Gangloff et al.). Of 19 known individuals, approximately 6 are from recent surveys. Williams et al. (2008) describe this mussel as extremely rare in Big Canoe Creek, and report that it appears to be extirpated in the Coosa River proper.

Status:
NatureServe (2008) ranks the Canoe Creek Pigtoe as critically imperiled in Alabama, stating, "This recently described species has an extremely limited distribution and range with few recently collected specimens; and habitat degradation is a continuing threat. Although declining, the extent of the decline is not known because the species is known from fewer than two dozen specimens, only one-third of which are recent." This snail is on the Alabama Natural Heritage Program Tracking List. It is being ranked as endangered by the American Fisheries Society (2010 draft, in review).

Habitat destruction:
Habitat loss and modification is the greatest threat to the Canoe Creek Pigtoe (NatureServe 2008). NatureServe (2008) states that there are substantial, imminent, high-level threats to this species. Mussel habitat in the Coosa River ecosystem is highly reduced and fragmented with only five tributary sub-basins supporting near-historic levels of mollusk species richness (Gangloff et al. 2006). NatureServe (2008) states, "Protection of these few remaining fragments is critical to preserving populations of mussels and other aquatic species in the Mobile Basin." Because this

species only occurs in a single, small watershed, it is particularly vulnerable to habitat degradation.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Canoe Creek Pigtoe, and no occurrences are appropriately protected and managed (NatureServe 2008). It has no state protective status.

Other factors:

The Canoe Creek Pigtoe is threatened by any factor which degrades water quality or threatens host fish populations. It is also inherently vulnerable to extinction because of its small population size and very restricted range.

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Scientific Name:
Pleurobema oviforme
Common Name:
Tennessee Clubshell

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	VU - Vulnerable

Range:
The Tennesee Clubshell once ranged through most of the Cumberlandian region of the Tennessee River drainage, but is considered extirpated in the Tennessee River system in Mississippi, and now only occurs in small, scattered, disjunct populations in the Clinch, Duck, Elk, Holston, Powell, and Paint Rock river systems (Jones et al. 2005, NatureServe 2008). Records for this species in the Cumberland River system are possibly erroneous (NatureServe 2008).

Habitat:
The Tennessee Clubshell occurs near riffles and shoals on mixed sand-gravel substrate, sometimes on mud or between slabs of bedrock. This mussel generally does not occur in deeper water, but was detected in deep water below Watts Bar Dam (Ahlstedt 1989). It occurs directly above riffles or in flats in small rivers and creeks, and generally prefers at least moderate flow (NatureServe 2008). Mirarchi et al. (2004) describe this species' habitat as "creeks and small to large rivers in shoals and riffles with substrata of coarse gravel and sand (Parmalee and Bogan 1998)."

Ecology:
The Tennessee Clubshell is a short-term brooder. Fish hosts include short-tail and common shiners, central stoneroller, and fantail darter, and possibly other related species of stonerollers and shiners (Parmalee and Bogan 1998, Weaver et al. 1991, Mirarchi et al. 2004).

Populations:
There are from 21-80 extant populations of the Tennessee Clubshell. This mussel's current distribution is highly restricted and fragmented in comparison to its historical range. Extant populations are disjunctly scattered in tributaries of the Tennessee River in the Cumberlandian Region and are often limited to short sections of headwater streams. Populations of the large river form of this species which are surviving in low numbers at a few sites below dams likely consist of relict, non-reproducing invividuals (Ahlstedt 1988). In Mississippi this species appears to be extirpated. This mussel was once widespread in the Tennessee River system in Alabama, but is now restricted to the Paint Rock River drainage in Jackson County, and a few tributaries to the Tennessee River in northern Alabama which are likely nonviable (Mirarchi et al. 2004). In Tennessee this mussel occurs in undammed portions of the Clinch, Powell, Hiwassee, Duck, Little Pigeon, Big South Fork Cumberland, Tellico, Elk, and Stone rivers (Parmalee and Bogan 1998). Within and near the Cherokee National Forest in Tennessee, this mussel occurs in Citico Creek in Monroe County and in the Hiwassee River in Polk County (Johnson et al. 2005). In North Carolina this mussel is still extant in Cherokee and Transylvania counties in the French Broad, Hiwassee, and Little Tennessee rivers (Bogan 2002, LeGrand et al. 2006). In Kentucky this mussel sporadically occurs below Cumberland Falls in the lower and upper Cumberland (Cicerello and Schuster 2003). In Virginia, the Tennessee Clubshell occurs in the upper Clinch drainage in Copper Creek (Fraley and Ahlstedt 2000, Jones et al. 2001) and in Smyth and Bland counties in a short section of the upper North Fork Holston River (Jones and Neves 2007). Overall population size of this mussel is crudely estimated at 10,000-100,000 individuals, but

most remaining populations of this species have very low densities. This mussel was "quite common" historically (NatureServe 2008).

Population Trends:

In the short term, the Tennessee Clubshell has declined rapidly, from 10-50 percent, and this mussel has experienced a long-term decline of 25-50 percent (NatureServe 2008). The Tennessee Clubshell has experienced widespread range reduction and extant populations appear to be in decline. Abundance at extant sites is typically low, and many occurrences are likely not viable. NatureServe (2008) states, "All extant occurrences are potentially in jeopardy."

Status:

The Tennessee Clubshell is critically imperiled in Alabama and Kentucky, is possibly extirpated in Mississippi, is imperiled in Tennessee and Virginia, and iis unrankable in North Carolina (NatureServe 2008). It is considered to be endangered by the Kentucky State Nature Preserves Commission. It is a federal species of management concern. This species is classified as Vulnerable by the IUCN. Its rank is being changed from Special Concern (Williams et al. 1993) to Threatened by the American Fisheries Society (2010 draft, in review).

Habitat destruction:

The Tennessee Clubshell is threatened by habitat loss and degradation from factors that reduce water qualilty and alter flow regime. The species is and has been impacted by channel alteration and inundation from reservoirs such as the Columbia Dam on the Duck River and the hydropower dam on the Little Tennessee River. Much of this species former range has been inundated by reservoirs, and there are existing proposals for the construction of additional dams (NatureServe 2008). The species is also threatened by siltation and contamination from logging, coal mining, and agricultural run-off, from chemical and organic pollution, and from urban development (NatureServe 2008). NatureServe (2008) reports that declines continue from pollution, siltation, and poor land use practices. Mussels in the Little South Fork are threatened by strip mining and oil extraction (Warren et al. 2001, Warren and Haag 2005). The Kentucky Dept. of Fish and Wildlife Resources (2005) lists the following conservation issues for this mussel: gravel and sand removal, impoundments, stream channelization, agriculture, development, coal mining, acid mine drainage, sewage discharge, oil and gas drilling, pesticides and runoff, siltation, and silviculture. Mussels in the Clinch and Powell watershed are threatened by coal mining and agricultural practices (U.S. EPA 2002). This species is also threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates (Wood 2009).

Overutilization:

NatureServe (2008) reports that the Tennessee Clubshell may be threatened by commercial clamming in some reservoirs of the Tennessee River.

Disease or predation:

Neves and Odom (1989) cite muskrat predation as a threat to imperiled mussels in the North Fork of the Holston in Virginia.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Tennessee Clubshell. This species is listed as Endangered by the state of North Carolina but this designation does not provide the mussel with any substantial regulatory protection. It is a species of Greatest Conservation Need in Alabama and Kentucky, and a species of Special Concern in Virginia, but these listings do not protect the species. It has no state status in Tennessee or Mississippi.

A few locations of this species are in protected areas, but there are no sites which are adequately protected (NatureServe 2008). This mussel occurs on The Nature Conservancy's Pendleton Island Preserve and in an area administered by the National Park Service in the Little River at Foothills Parkway bridge. This species occurs in the Cherokee National Forest in Tennessee in Citico Creek and in the Hiwassee River. NatureServe (2008) states: "All populations should receive protection through acquisition, easement, registry, and working with local, state, and federal government agencies on issues relating to development, water quality, river designation, etc. Instigation of watershed management plans for soil conservation and maintenance of water quality essential. Excellent chance to protect and promote recovery of a species before it goes beyond the point of saving."

Other factors:

The Tennessee Clubshell is threatened by any factor which alters flow conditions or reduces water quality. The North Fork of the Holston River has been severely impacted by mercury releases (Stansberry and Clench 1975, Neves 1991 in Flebbe et al. 1996).

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Scientific Name:
Pleurobema rubellum
Common Name:
Warrior Pigtoe

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EX - Extinct

Range:
The range of the Warrior Pigtoe covers less than 100 square km in Alabama, Georgia, and historically, in Tennessee. It is endemic to the Black Warrior, Coosa, and Cahaba River systems (Parmalee and Bogan 1998), but has been extirpated from much of its historic range (NatureServe 2008).

Habitat:
This species is known from headwaters and shoals and is thought to use mixed coarse sand, gravel and cobble substrates (Conrad 1834, van der Schalie 1938, 1981).

Populations:
There are less than five extant populations of Warrior Pigtoe, and total population size is unknown, but is very low. This mussel formerly occurred in the Conasauga River in Tennessee, but is now extinct in the state (Parmalee and Bogan 1998, Simpson 1914). In the Coosa River basin in Georgia it occurred historically in the Etowah, Conasauga, and Coosawattee River drainages but has not been recently detected (Williams and Hughes 1998), except for a specimen on the Coosa/Etowah confluence in Georgia (J. Williams, pers. comm., 2007 cited in NatureServe 2008). In Alabama, it was recently detected at Brushy Creek in Winston County (David Campbell, University of Alabama pers. comm., February 2004, J. Cordeiro cited in NatureServe 2008). Williams et al. (2008) report that in Alabama it is only extant in the headwaters of Sipsey Fork in the Bankhead National Forest and in the North River upstream of Lake Tuscaloosa.

Population Trends:
The Warrior Pigtoe is severely declining in the short-term (decline of more than 70 percent) and has experienced a very large long-term decline of more than 90 percent (NatureServe 2008). It was considered to be extinct until two recent detections, one in Alabama and one in Georgia.

Status:
NatureServe (2008) ranks the Warrior Pigtoe as critically imperiled in Alabama, extirpated in Tennessee, and unranked in Georgia. It is classified as Extinct by the IUCN. This species merits immediate protection under the Endangered Species Act. It is ranked as endangered by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Impoundment poses the greatest threat to the Warrior Pigtoe. This species was formerly considered extinct due to damming. Because only two disjunct populations of this species remain, any modification of existing habitat could drive the species to extinction. This species' habitat is threatened by any activity which degrades water quality, increases sedimentation, or threatens host fish populations (Neves et al. 1997). One of the two recent detections of this mussel is at the confluence of the Etowah and Coosa Rivers (J. Williams, pers. comm., 2007 cited in NatureServe 2008). Mussels in the Etowah are threatened by impoundments, sedimentation, harmful

agricultural practices, urbanization, pollution, and large-scale water withdrawal (Burkhead et al. 1997). Threats to mussels in the Coosa are well known and include impoundment, sedimentation, eutrophication, and water quality degradation (Alabama Dept. of Conservation and Natural Resources 2005).

Overutilization:
Because so few individuals of Warrior Pigtoe are still extant, any amount of collection could drive this species to extinction.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechansims that adequately protect the Warrior Pigtoe and no occurrences are appropriately protected and managed (NatureServe 2008). It is a Species of Greatest Conservation Need in Alabama and Tennessee but these designations do not provide this mussel with any substantial regulatory protection.

Other factors:
The Warrior Pigtoe is threatened by any factor which degrades water quality. This species is highly vulnerable to extinction because of drastically reduced range and population size. It is vulnerable to stochastic genetic and environmental events, and existing remnant populations may not be viable.

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Scientific Name:
Pleurobema rubrum
Common Name:
Pyramid Pigtoe

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	NT - Near threatened

Range:
The pyramid pigtoe is a freshwater mussel species native to the southeastern and central United States. It is currently found in Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Nebraska, Ohio, Oklahoma, Tennessee, and Virginia, and though it was historically present in these states, is thought to be extirpated from Iowa, Illinois, Indiana, and Pennsylvania (NatureServe 2008). Williams et al. (2008) state: "P. rubrum is widespread in the Mississippi Basin from southwestern Wisconsin south to Louisiana, and from Ohio River headwaters in western Pennsylvania west to eastern Kansas. It is known from the Cumberland River drainage downstream of Cumberland Falls, Kentucky and Tennessee. In the Tennesee River drainage, P. rubrum occurs from headwaters in southwestern Virginia downstream to the mouth of the Tennessee River, Kentucky" (p. 565).

Habitat:
The pyramid pigtoe is found primarily in medium to large rivers with low to moderate flow gradients, often in riffles or shoals (NatureServe 2008). It has also been identified below some dams or reservoirs in lotic environments.

Ecology:
Adults consume organic matter, mainly filter-feeding detritus from the water column. Very little is known about the reproductive ecology of P. rubrum, but like other freshwater mussel species, juveniles (larvae) are parasitic on various fish species. Identified host species for P. rubrum include the spotfin shiner (Cyprinella spiloptera), the streamline chub (Erimystax dissimilis), the scarlet shiner (Lythrurus fasciolaris), and the silver shiner (Notropis photogenis) (Culp et al. 2006).

Populations:
NatureServe (2008) reports that there 21-80 occurrences of this species, and total population size is at least 2,500 individuals. This mussel has been extirpated from much of its historical range, and occurrences are patchily distributed across its still-extensive range. The largest remaining populations are found in Kentucky's Green River system, and in Arkansas' Little Missouri, Ouachita, White, St. Francis, and Saline Rivers (Harris et al. 1997, Posey 1997, Ahlstedt and Jenkinson 1991, Harris and Gordon 1987, Anderson 2006).

Population Trends:
NatureServe (2008) reports that the pyramid pigtoe has experienced long-term decline of up to 50 percent, and has continued to decline by up to 30 percent in the short-term, stating: "A number of occurrences and abundance has and continues to decline dramatically. It is likely extripated from Illinois where it once occurred in the Little Wabash River, as well as the Illinois River (pre-modern specimens found) (Cummings and Mayer, 1997). Parmalee and Bogan (1998) report it was known to inhabit the French Broad, Holston, and Little Tennessee Rivers prior to 1960 and in the Little Tennessee River prior to the closing of the Tellico Dam gates but no longer occurs there. It is likely extirpated from Indiana (IN NHP, pers. comm., 2009). This species is extirpated

in Pennsylvania (Bogan, 1993) where it formerly occurred in the Upper Ohio and Middle Allegheny-Redbank drainages (Ortmann, 1919). It has likely disappeared from nearly all of the Ohio River (Cicerello and Schuster, 2003; Watters, 1995). In Alabama, it historically occurred in the Tennessee River across northern Alabama and in the Paint Rock River and extreme lower Limestone Creek in Limestone Co. but is extant only in the tailwaters of Guntersville and Wilson Dams (Williams et al., 2008)."

Status:
NatureServe (2008) reports that the pyramid pigtoe is critically imperiled in Alabama, Kentucky, Mississippi, Ohio, and Virginia, and Tennessee, imperiled in Arkansas and Louisiana, and extirpated from Illinois, Indiana, Iowa, and Pennsylvania. It is not ranked or is under review in Nebraska and Oklahoma. Williams et al. (2008) state: "Pleurobema rubrum (as P. pyramidatum) was listed as endangered throughout its range by Stansbery (1970) and threatened throughout its range by Williams et al. (1993). In Alabama it was listed as extirpated by Stansbery (1976) and considered imperiled by Lydeard et al. (1999). Garner et al. (2004) designated P. rubrum a species of highest conservation concern in the state (Alabama)" (p. 566). It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
NatureServe (2008) reports that the pyramid pigtoe is sensitive to habitat perturbation and inundation and is threatened by channel alteration, impoundment, mining, and urban and industrial development. In the Clinch River, this species is extirpated below Norris Reservoir due to impoundment (Ahlstedt 1984), and NatureServe (2008) reports that "plans are underway to impound 54 miles of the Duck River in Tennessee where P. rubrum occurs." The Arkansas Fish and Game Commission (2005) reports that this mussel is threatened by channel alteration and maintenance, impoundments, and cattle grazing. The Kentucky Department of Fish and Wildlife Resources (2005) reports that the pyramid pigtoe is threatened by dredging, gravel and sand quarrying, impoundments, stream channelization, and riparian zone removal for agriculture and development. This mussel is also specifically threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, disrupting food web dynamics (Wood 2009).

Overutilization:
NatureServe (2008) reports that the pyramid pigtoe is a minor commercial species that is sometimes harvested for its pink shells, stating, "its occurrence with and resemblance to some commercial species results in its harvest by clammers." The Kentucky Department of Fish and Wildlife Resources (2005) reports that this mussel is threatened by "incidental mortality due to commercial fishing/musseling (mortality and overharvest)."

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that few occurrences are appropriately protected or managed, though this species does occur in some preserves (the Nature Conservancy's Pendleton Island Preserve and some mussel refuges on the Tennessee and Cumberland Rivers), the protection they afford is not adequate.

This species is state-listed as endangered in Ohio, Mississippi, Kentucky, Indiana, and Virginia, but these designations do not afford it any substantial regulatory protection. No existing regulatory mechanisms offer sufficient protection to the pyramid pigtoe or its habitat.

Other factors:

Water pollution is a primary threat to the survival of the pyramid pigtoe, which is sensitive to declines in water quality. This species is threatened by siltation, mine run-off, fly ash and quarry runoff, sewage effluent, nutrient loading, and herbicides (Arkansas Game and Fish Commission 2005, Kentucky Department of Fish and Wildlife Resources 2005, NatureServe 2008). It is also threatened by any factor which threatens populations of its host fishes (NatureServe 2008).

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Scientific Name:
Pleurobema strodeanum
Common Name:
Fuzzy Pigtoe

G Rank:	AFS Status:	IUCN Status:
G2	Special Concern	VU - Vulnerable

Range:
The Fuzzy Pigtoe occurs in Florida where it is endemic to the Escambia and Choctawhatchee rivers, and Alabama where it occurs in the Yellow River (Mirarchi et al., 2004). The historical range of this species has been recently expanded (Williams et al. 2000, Blalock-Herod et al. 2005). In the Escambia drainage, this mussel occurs in the Escambia River in Escambia and Santa Rosa Counties in Florida, in the Conecuh River in Escambia, Covington, Crenshaw, and Pike Counties in Alabama, and in Murder, Sandy, and Burnt Corn Creeks in Conecuh County, Alabama, in the Sepulga River in Conecuh County, Alabama, in Pigeon Creek in Covington County, Alabama, in Patsaliga and Little Patsaliga Creeks in Crenshaw County, Alabama, and in Mill Creek in Pike County, Alabama. In the Yellow River drainage in Alabama, this mussel occurs in the Yellow River in Covington County. In the Choctawhatchee drainage, this mussel is known from the Choctawhatchee River in Washington, Walton, and Holmes Counties in Florida, from Limestone Creek in Walton County, Florida, from Wrights Creek in Holmes County, Florida, from Holmes Creek in Washington County, Florida, from the Choctawhatchee River in Geneva and Dale Counties in Alabama, from the Little Choctawhatchee River in Dale and Houston Counties, Alabama, from Panther Creek in Houston County, Alabama, from the West Fork Choctawhatchee River in Dale and Barbour Counties, Alabama, from the East Fork Choctawhatchee River in Henry County, Alabama, and the Pea River in Geneva, Dale, and Coffee Counties, Alabama (Williams et al. 2000, Blalock-Herod et al. 2005). Blalock-Herod et al. (2005) listed this species from 21 historical sites in the Choctawhatchee River drainage, detected this species at six historical sites, and detected 34 new scattered sites in the upper and lower portions of the river in Alabama and Florida.

Habitat:
The Fuzzy Pigtoe occurs in medium-sized creeks and rivers with slow to moderate current on sand and silty-sand substrates (Williams and Butler 1994, Williams et al. 2000). Mirarchi et al. (2004) describe this species' habitat as: "predominantly sand substrata in small to large streams with scattered gravel, woody debris, and moderate flow (Clench and Turner 1956)."

Ecology:
Mirarchi et al. (2004) state that nothing is known about the ecology of this species, but that it is presumably a short-term brooder similar to its congeners.

Populations:
NatureServe (2008) estimates that there from 21-80 populations of Fuzzy Pigtoe, providing the following details: "Recent mussel status surveys found that the populations of the fuzzy pigtoe (represented by live animals and shell material) have declined from: 31 historic sites to 18 currently active sites, 8 inactive, and 5 undetermined population status within the Escambia River drainage; 4 historic sites to 0 currently active sites within the Yellow River drainage; and 51 historic sites to 40 currently active sites, 7 inactive sites. In totality, the fuzzy pigtoe has declined from a total of 86 historic sites to its remaining distribution of 58 sites. It has been extirpated

from approximately 22% of its historic range. Only 4 populations were represented by 10 - 20 individuals, but most supported only 1 or 2 individuals (Williams et al., 2000; Blalock-Herod et al., 2005). At least some of the extant populations may be capable of reproducing, as one specimen was found with eggs partially in swollen marsupia during July (Williams et al. in review). Low-level recruitment may be occurring; however, long-term viability of the fuzzy pigtoe is questionable (see USFWS, 2003). Blalock-Herod et al. (2005) listed this species from 21 historical sites in the Choctawhatchee River drainage, relocated it at 6 and found it at 34 new sites scattered in the upper and lower portions of the river in Alabama and Florida. Pilarczyk et al. (2006) recorded recent collections (in 2004) of this species following surveys of 24 sites at 11 sites including West Fork Choctawhatchee River, Eightmile Creek (just over the border in Florida), Patsaliga Creek, Pea River, Pea Creek, East Fork Choctawhatchee River, and Murder Creek compared to Murder Creek, Bottle Creek, West Fork Choctawhatchee River, Patsaliga Creek, Pigeon Creek, Jordan Creek, Little Patsaliga Creek, Flat River, Eightmile Creek (Florida), Pea River, Pea Creek, Judy Creek, and Hurricane Creek in surveys of the same sites in the 1990s. White et al. (2008) utilized specimens from Eightmile Creek in Walton Co., Florida for host suitability studies." Total population size is unknown for this species. Extant populations in Alabama appear to be small (NatureServe 2008).

Population Trends:
The Fuzzy Pigtoe is declining (decline of 10-30 percent) in the short-term and moderately declining (25-50 percent) in the long-term. This mussel has experienced at least a 22 percent range reduction and now occurs at only 58 sites, many of which have very low abundance (FWS 2003, NatureServe 2008).

Status:
NatureServe (2008) ranks the Fuzzy Pigtoe as imperiled in Alabama and Florida. Recently discovered populations slightly expanded the overall range of this species, but abundance is low, populations appear to be declining, and there is general deterioration of habitat and water quality in some portion of its range (NatureServe 2008). This species is a federal Candidate and merits full ESA protection before long-term population viability is compromised. Its rank is being changed from special concern (Williams et al. 1993) to threatened by the American Fisheries Society (draft 2010, in review).

Habitat destruction:
Habitat loss and degradation pose the greatest threat to the survival of mussels in the southeastern United States including the Fuzzy Pigtoe (Neves et al. 1997). The Fuzzy Pigtoe is threatened by stream channelization and alteration, siltation and runoff from agriculture and silviculture, eutrophication from chicken farms, gravel and sand mining, oil and gas exploration, localized industrial pollution from pulp mills on the Escambia, municipal pollution, watershed development, and impoundment (NatureServe 2008). NatureServe (2008) states: “Silvicultural activities and chicken farms are expanding in southern Alabama. Twenty-five different impoundments have been proposed for the Choctawhatchee River system alone (Blalock et al., 1998). Bank sloughing has impacted habitat in the Escambia mainstem in Florida. The stream and river habitats are vulnerable to habitat modification, sedimentation, and water quality degradation from a number of activities. Highway and reservoir construction, improper logging practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing often result in physical disturbance of stream substrates or the riparian zone, and/or changes in water quality, temperature, or flow. Sedimentation can cause direct mortality of mussels by deposition and suffocation (Ellis, 1936; Brim Box and Mossa, 1999) and can eliminate or reduce the recruitment of juvenile mussels (Negus, 1966; Brim Box and Mossa, 1999). Suspended sediment can also

interfere with feeding activity of mussels (Dennis, 1984). Many of the confirmed extant populations of this species are in the vicinity of highway and unpaved road crossings due to ease of access for surveyors. Highway and bridge construction and widening could affect populations of these species unless appropriate precautions are implemented during construction to reduce erosion and sedimentation, and maintain water quality standards. The construction of reservoirs and the associated habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can directly impact mussel populations (Neves et al., 1997). Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams."

Disease or predation:

NatureServe (2008) states that disease or predation are poorly known for this species, but could contribute to further decline due to its restricted distribution and low numbers associated with extant populations.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Fuzzy Pigtoe, and no occurrences are appropriately protected and managed (NatureServe 2008). This species is a federal candidate and merits immediate ESA protection. It is a Species of Greatest Conservation Need in Alabama but this designation does not confer regulatory protection. It has no state status in Florida. It is possible that at least one occurrence of this species may border the Conecuh National Forest in Alabama, but this does not provide habitat protection. NatureServe (2008) provides the following management recommendations for this species: "protect populations through acquisitions and easements by working with government agencies and conservation organizations; establish buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; maintain high water and benthic habitat quality; consider propagation and reintroduction of cultured stock, and consider federal listing if populations decline further. Conservation activities have been limited to working with private landowners in south Alabama and west Florida to encourage the use of Best Management Practices to reduce the effects of agriculture and silviculture (see USFWS, 2003)."

Other factors:

Several other factors threaten the Fuzzy Pigtoe. This mussel is threatened by impacts from non-point source pollution and sedimentation (NatureServe 2008). It is particularly susceptible to catastrophic events because populations are generally small and geographically isolated. The Fuzzy Pigtoe is threatened by any factor which threatens its host fishes. Genetic inviability is a potential threat to this species as populations may be below effective population size to maintain long term viability. This mussels is also potentially threatened by invasive species such as Asiatic clam, zebra mussel, and black carp (USFWS 2003, NatureServe 2008).

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Scientific Name:
Pleurocera corpulenta
Common Name:
Corpulent Hornsnail

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
This snail is endemic to the Tennessee River in Tennessee and Alabama. This snail occurred in Bridgeport, TN and in Battle Creek in Marion County, TN, and also at Muscle Shoals and Florence, Alabama (Goodrich 1928, Burch and Tottnham 1980). It is only known to be extant in the tailwaters of Nickajack Dam in the vicinity of Bridgeport with a total range of less than 4 square km (Mirarchi et al. 2004).

Habitat:
This snail was associated with large river, high gradient riffles with gravel and cobble substrate in moderate to swift current. The only extant population is in the tailwaters of a dam at depths of two to four meters (Mirarchi et al. 2004).

Populations:
There is only one known extant population of this species, and population size is unknown but likely low.

Population Trends:
This snail has experienced a large long-term decline of 75 to 90 percent (NatureServe 2008).

Status:
The Corpulent Hornsnail is critically imperiled (NatureServe 2008). It is classified as vulnerable by the IUCN.

Habitat destruction:
Impoundment has reduced the range of this species to a single occurrence in the tailwaters of a dam. Because there is only one surviving population, it is very vulnerable to further habitat loss and degradation. The survival of this species is contingent upon high water quality and sound water release practices at the dam (NatureServe 2008). Several factors threaten to degrade water quality for this species. It is potentially threatened by the development of a commercial marina on the bank of the Tennessee River in Marion County (U.S. ACOE 2009). It also potentially occurs within the project area of a proposed industrial development by the Chicago Bridge and Iron Company on the bank of the Tennessee River and Guntersville Reservoir in Marion County (TVA 2009). The Alabama Dept. of Environmental Management (2003) reports that the Tennessee River basin has been widely degraded by nonpoint source pollution from many sources, particularly agriculture, urban development, logging, and surface coal mining (ADEM 2003). Agricultural runoff increases sedimentation and nutrient loading and degrades habitat quality for aquatic species such as the Corpulent Hornsnail. In addition, there are more than 130 confined animal feeding operations in the Tennessee River basin (ADEM 2003). Aquatic habitats in the basin are also degraded by water-related recreational activities and nonpoint source pollution from onsite residential sewage systems (ADEM 2003).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect this species.

Other factors:

Due to this snail's extremely limited distribution, specialized habitat requirements, and limited dispersal capability, it is vulnerable to random catastrophic events (NatureServe 2008).

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Scientific Name:
Pleurocera curta
Common Name:
Shortspire Hornsnail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
This snail is endemic to the Tennessee River system in Kentucky, Tennessee, and Alabama (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are from 6-20 populations of this species, and that total population size is unknown. Mirarchi (2004) reports that no extant populations of this species have been detected recently. Historically this snail occurred in the Duck River in Humphreys County, Tennessee (van der Schalie 1973) and in the Tennessee River and Shoal Creek in Florence, Alabama (Hinkley 1906). Goodrich (1928) cites the nominal subspecies as occurring from the Holston-Tennessee River from McMillan, Knox County, Tennessee, to the Muscle Shoals area in Alabama, and potentially below it. Goodrich also cites the Cumberland River in the vicinity of Nashville, Tennessee, and Caney Fork near Carthage, Tennessee, including sub-fossil specimens in Wayne County, Kentucky, and also just above the mouths of the Clinch, Little, and Little Tennessee Rivers, and Paint Rock and Flint Rivers in Alabama. Goodrich (1928) cites the subspecies roanense from the Emory River in Emory and Roane counties and from the Little River in Blount County, Tennessee. Branson and Batch (1987) report this species in Kentucky from the Red River in Logan and Todd counties and in the Rockcastle River in Laurel Co. and the Cumberland River in McCreary County (NatureServe 2008). Burch and Tottenham (1980) report that the range of this species is contracting.

Population Trends:
This snail has experienced a substantial long-term decline of 50 to more than 90 percent, and has declined in the short-term by 30 to over 70 percent (NatureServe 2008).

Status:
The Shortspire Hornsnail is critically imperiled (S1S2) in Alabama, and imperiled (S2) in Kentucky and Tennessee (NatureServe 2008). It is state listed as threatened by the state of Tennessee. It is categorized as vulnerable by the IUCN.

Habitat destruction:
This snail is threatened by habitat loss and degradation from a variety of sources. The Alabama Dept. of Environmental Management (2003) reports that the Tennessee River basin has been widely degraded by nonpoint source pollution from many sources, particularly agriculture, urban development, logging, and surface coal mining (ADEM 2003). Agricultural runoff increases sedimentation and nutrient loading and degrades habitat quality for aquatic species such as the Shortspire Hornsnail. In addition, there are more than 130 confined animal feeding operations in the Tennessee River basin (ADEM 2003). Aquatic habitats in the basin are also degraded by water-related recreational activities and nonpoint source pollution from onsite residential sewage systems (ADEM 2003).

Inadequacy of existing regulatory mechanisms:

This snail is listed as threatened by the state of Tennessee, but this designation does not confer regulatory protection. There are no regulatory mechanisms in place to protect this declining species.

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Scientific Name:
Pleurocera pyrenella
Common Name:
Skirted Hornsnail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The range of the Skirted Hornsnail is 100-250 square km in tributaries of the Tennessee River in Alabama and Georgia. This species is endemic to north-central Alabama and parts of Walker County, Georgia. There are historical reports from tributaries in portions of Limestone, Madison, and Morgan counties (Burch 1989). This species was not detected south of the Tennessee River in Morgan County in a mid-1990s surveys (Mirarchi et al. 2004).

Habitat:
This snail utilizes a variety of habitats, generally in areas that lack swift current. It occurs in pools, runs, and occasionally riffles, as well as in swampy streams and impounded springs, and appears to be tolerant to silty conditions (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 6 - 20 populations of this snail, but many of these are no longer extant. In Georgia, it was known from Crawford Creek in Walker County and from Peavine Creek and Little and West Chickamauga creeks in Catoosa County. Only the Chickamauga and West Chickamauga Creek populations have recently been documented as extant. In Alabama this species is known from a few sites in Limestone, Madison, and Morgan counties, but may no longer be extant in Morgan County.

Population Trends:
The Skirted Hornsnail is rapidly declining (decline of 30-50 percent) in the short-term, and has experienced a substantial long-term decline of 50-75 percent (NatureServe 2008). It is extirpated from several areas where it formerly occurred.

Status:
NatureServe (2008) categorizes the Skirted Hornsnail as imperiled (S2) in Alabama and historical in Georgia. It is ranked as vulnerable by the IUCN.

Habitat destruction:
Limited distribution and vulnerability to habitat degradation make this snail vulnerable to extinction (Mirarchi et al. 2004). It occurs in an area which is used almost exclusively for intensive agriculture and is thus threatened by water quality degradation from input of sediment, pesticides, and fertilizers (Mirarchi et al. 2004). Extensive irrigation is also a threat. This snail is further threatened by urban sprawl from Huntsville, which could result in direct habitat loss and nonpoint source pollution (Mirarchi et al. 2004). One example of the threat from development is Billy Christopher River Front Development on the bank of the Elk River and Wheeler Reservoir in Limestone County. This community water use facility includes dredging, construction of a boat dock, and a back-lying development, including boat storage, an inland lake, parking area, roads, culverts, and associated residential development (U.S. ACOE 2009). Runoff from this development is one example of the increasing threats in the area that are cumulatively degrading aquatic habitats for species such as the Skirted Hornsnail.

This snail occurs in waters in or adjacent to Wheeler National Wildlife Refuge Complex. The Comprehensive Conservation Plan and Environmental Assessment for Wheeler (FWS 2007) states that habitat loss and fragmentation and the degradation of aquatic ecosystems are two of the most important ecological threats facing the complex. Habitat has been lost and degraded for development to support burgeoning human population. The region surrounding the refuge is one of the fastest growing areas in Alabama. Habitat has been lost and degraded for agriculture, flood-control projects, transportation corridors, and residential development (FWS 2007). The Conservation Plan states that aquatic ecosystems have been greatly deteriorated by human activities including impoundment and other activities that cause erosion and sedimentation.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this snail.

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Scientific Name:
Polycentropus floridensis
Common Name:
Florida Brown Checkered Summer Sedge

G Rank:
G2

Range:
NatureServe (2008) estimates the range of Polycentropus floridensis as 100-250 square km (about 40-100 square miles). It is known only from Florida and southernmost Alabama. Distribution in each state is limited to a few ocurrences (Lago and Harris 1983, Rasmussen, 2004- 4 sites).

Habitat:
This caddisfly is found in small, clear streams with moderate flow in sandhills with a fairly heavy pine-oak canopy (NatureServe 2008).

Populations:
This caddisfly is known only from three occurrences: one in Alabama (Baldwin County) and two in Florida (Walton and Hamilton Counties-the latter being disputed). Rasmussen (2004) also found this species to be widespread, though not common, in Eglin Air Force Base in Florida.

Population Trends:
This species is believed to be relatively stable "as long as stream habitats supporting populations on Eglin AFB are protected" (Rasmussen et al. 2008).

Status:
NatureServe (2008) ranks this species as critically imperiled in Florida and not rated in Alabama. In Florida it is a Species of Greatest Conservation Need. According to Morse, in Deyrup (1994), this species is Threatened.

Habitat destruction:
According to NatureServe (2008), the habitat for this species is subject to pollution, siltation, and other forms of environmental degradation. The wellbeing of this species is largely dependent on the quality of its stream habitat at Eglin Air Force Base (Rasmussen et al. 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this caddisfly. It is thought to be stable, largely based on the current condition of its stream habitat at Eglin Air Force Base. Given, however, that issues of national security are prioritized over species protection, its occurrence on the Base does not ensure its continued survival.

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Scientific Name:
Potamogeton floridanus
Common Name:
Florida Pondweed

G Rank:
G1

Range:
This plant is known from a single drainage, the Blackwater River, in Santa Rosa County, Florida (NatureServe 2008).

Habitat:
This plant is found in ponds and along river margins (NatureServe 2008).

Ecology:
The pondweed is sometimes water-pollinated, with dispersal occurring passively by downstream flow.

Populations:
As of 1997, four occurrences were reported in the Blackwater River (NatureServe 2008). Global population size is not known.

Population Trends:
Trend information is not available for this species.

Status:
The pondweed is known from an extremely small range. NatureServe (2008) ranks the Florida pondweed as critically imperiled in Florida, where it is also listed as endangered.

Habitat destruction:
Within its extremely limited range, this plant is threatened by recreation (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in Florida, this designation affords the Florida pondweed no significant regulatory protections; no existing regulatory mechanisms adequately protect the Florida pondweed.

References:

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Scientific Name:
Potamogeton tennesseensis
Common Name:
Tennessee Pondweed

G Rank:
G2

Range:
Tennessee pondweed is an aquatic herb endemic to a small area within the Appalachian region of the southeastern United States. According to natural heritage records, it is currently known in the following counties: Jackson, Pike, and Vinton Counties in Ohio, Fayette and Fulton Counties in Pennsylvania, Blount, Cumberland, Monroe, Morgan, Polk, and Scott Counties in Tennessee, Bath County in Alabama, and Harrison and Tucker Counties in West Virginia (NatureServe 2008).

Habitat:
This plant occurs in ponds and slow-moving, acidic rivers or streams, generally in shallow waters (TN NHP 2008).

Ecology:
Pondweed is aquatic, perennial, and produces both submerged and floating leaves. It flowers May-September, and fruits mature August-September (NatureServe 2008).

Populations:
Total population size is unknown, but there are reportedly 5 occurrences in Tennessee, 1 in Pennsylvania, 2 in Virginia, and 7 in West Virginia, though more were known historically (NatureServe 2008). Population size is unknown.

Population Trends:
Tennnessee pondweed appears to be in decline.

Status:
NatureServe (2008) ranks the Tennessee pondweed as critically imperiled in North Carolina, Pennsylvania, and Virginia, and imperiled in Tennessee and West Virginia.

Habitat destruction:
Because this species is sensitive to changes in water level, it is threatened by impoundments and diversions. Individual populations may also be threatened by the commercial development of habitat, land-use conversion, agriculture, and habitat fragmentation (Southern Appalachian Species Viability Project 2002).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Tennessee pondweed; though it is listed as threatened in Tennesse and widely recognized as rare or in need of conservation, these designations offer it no substantial regulatory protections.

Other factors:
Tennessee pondweed is sensitive to water quality and is highly threatened by agricultural run-off and other pollutants (Southern Appalachian Species Viability Project 2002).

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Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Scientific Name:
Problema bulenta
Common Name:
Rare Skipper

G Rank:
G2

IUCN Status:
NE - Not evaluated

Range:
This butterfly is present in Delaware, Georgia, Maryland, North Carolina, New Jersey, South Carolina, and Virginia, and ranges from Delaware Bay and the Mullica estuary in New Jersey to the Savannah River in Georgia. Natural heritage records indicate that the species is present in Delaware's Kent County, Maryland's Dorchester County, North Carolina's Brunswick and New Hanover Counties, New Jersey's Atlantic, Burlington, Cape May, Cumberland, and Salem Counties, and in Virginia's James City, King William, New Kent, and Surry Counties (NatureServe 2008). Distribution across its range is patchy and inconsistent.

Habitat:
This species is typically found in brackish wetlands along tidal rivers, though individuals may also occupy salt or freshwater marshes. Populations are present along the coastline and up to three miles upriver. Adults leave marshes to feed, traveling up to half a kilometer or more, and are most often observed foraging along roadsides. It is associated with Zizaneopsis in the southerly portion of its range, and with Spartina cynosuroides in New Jersey and Maryland. Suitable habitat must include nectar-bearing plants or nearby access to nectar foraging grounds. Preferred breeding habitat is unknown. Though the species is non-migratory, adults are powerful fliers and disperse relatively long distances to feed.

Ecology:
Adults are diurnal and feed exclusively on nectar: preferred nectar plants are swamp milkweed (Asclepias incarnata), common milkweed (Asclepias syriaca), dogbane (Apocynum androsaemifolium), and buttonbush (Cephalanthus occidentalis). The juvenile form (larvae) is herbivorous, and is often found on Spartina cynosuroides (Cromartie and Schweitzer 1993). Larvae overwinter in one of the mid instars: larval period with diapause is approximately August to June in the northern portion of this species' range (NatureServe 2008).

Populations:
Total adult population size is unknown for this species: adults may be sparsely distributed over large areas of habitat, which makes censusing difficult. There are roughly 20 known occurrences, 9 of which are in New Jersey (NatureServe 2008). This species is rare throughout its range.

Population Trends:
Population trends are unknown.

Status:
NatureServe (2008) reports that P. bulenta is critically endangered in Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and imperiled in New Jersey.

Habitat destruction:
This species is threatened by river impoundments and diversions which threaten riparian habitat (Shepherd 2005). Management activities can also threaten this species' habitat. Prescribed

burning can destroy breeding habitat and kill larvae, and mowing of roadsides and fields destroys foraging habitat (Shepherd 2005, NatureServe 2008). Shepherd (2005) reports that it is probable that this species is threatened by development and by recreational activities. LeGrand (2006) reports that in North Carolina, construction work on the dikes at Eagle Island has removed most of the verbena used as a nectar source by this species.

Overutilization:
This species may be threatened by overcollection in some parts of its range, most particularly Maryland and New Jersey (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listed as endangered in Delaware and threatened in Maryland, these designations afford the rare skipper no significant regulatory protections. No existing regulatory mechanisms adequately protect the rare skipper from the threats it faces.

Other factors:
Shepherd (2005) reports that spraying for mosquito control is a significant threat to this species, especially in Delaware. NatureServe (2008) reports that insecticide applications may exclude this species from some habitat, and that the use of Dibrome and other highly toxic biocidal chemicals are known threats at several occurrences (NatureServe 2008). This butterfly is also threatened by invasive species. Invasion by Phragmites spp. (common reed) may exclude native foodplants at some sites, and require significant management action (NatureServe 2008). Walton (2000) cites invasive Phragmites australis as a threat to the rare skipper in Virginia. LeGrand (2006) also reports that in North Carolina this species is threatened by the spread of common reed, which may displace preferred plants. This species is also threatened by stochastic weather events, as extreme storms likely eliminate small populations of this butterfly (Shepherd 2005).

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Scientific Name:
Procambarus acherontis
Common Name:
Orlando Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
NatureServe (2008) estimates that the total range of P. acherontis is less than 100-250 square km (less than about 40 to 100 square miles). It is endemic to central peninsular Florida. All element ocurrances lie within a small limestone region on the south side of the Wekiva River, in the vicinity of metropolitan Orlando in Seminole and Orange counties.

Habitat:
The Orlando Cave crayfish occupies karst aquifers (NatureServe 2008). It has been collected from mouths of springs, sinkholes, underground streams, wells, and caves. It frequents both the lighted and deeper, dark portions of such systems. Deyrup and Franz (1994) state that "[t]his crayfish is restricted to groundwater sites associated with spring caves and wells. It has been reported from the lighted portions of sinkholes and from the vicinity of spring openings at several sites. At the Apopka site, divers reported finding specimens throughout the cave system, as well as in the lighted 'blue hole' portion of the sinkhole entrance. Presumably these white crustaceans are vulnerable to fish predation in the lighted vents of spring caves, such as those at Wekiva and Palm springs."

Ecology:
According to Deyrup and Franz (1994), "This cavernicolous crayfish is of particular interest because it represents an aberrant, probably relictual, species with no surviving surface relatives... Hobbs (1942) suggests that this group of crayfishes was derived from the earliest crayfish stocks that invaded the Florida peninsula."

Populations:
NatureServe (2008) reports that there are approximately four ocurrences, all near Orlando, Florida. The type locality, a well, has collapsed. There are estimated to be fewer than 5 populations with less than 1000 total individuals. The largest known population contains less than 50 adults.

Population Trends:
Trend information is not available for this rare species. The type locality was lost when a well collapsed.

Status:
Procambarus acherontis is endemic to a very narrow region of Florida with a rapidly expanding human population. There are very few ocurrences, and the species is critically imperiled (NatureServe 2008). Florida lists it as a Species of Greatest Conservation Need. The Florida Committee on Rare and Endangered Plants and Animals designates P. acherontis as Rare. In 1985 the U.S. Fish and Wildlife Service found that listing Procambarus acherontis as Endangered was warranted by the available scientific information (50 FR 19761). The listing was precluded by other FWS actions, and the species languished on the C-2 Candidate List until that list was abolished. It is ranked as endangered by both the IUCN and the American Fisheries Society. NatureServe (2010) recommends state and federal listing.

Habitat destruction:

NatureServe (2010) states that this species is likely susceptible to many forms of disturbance and is threatened by human population growth in the rapidly expanding city of Orlando, and that increasing development may negatively affect hydrological conditions and threaten aquatic cave environments.

Deyrup and Franz (1994) report that "the extensive urbanization in this area is affecting both water quality and quantity of local groundwater reserves."

In 1985 the Orlando Sentinel reported that "[Procambarus acherontis) is one variety that has found itself in the worst position -- living in wells and underwater caves that straddle the Orange-Seminole county line, where growth is erupting in once-rural areas." Furthermore, the Sentinel quotes Richard Franz, "[b]esides the direct effect of development replacing crayfish territory, the creature may be threatened by water quality deterioration caused by storm water runoff and groundwater pollution… It is in a very tenuous situation."

According to the Florida Springs Task Force (2000), the entire range of the Orlando Cave Crayfish (P. acherontis) lies within heavily urbanized areas that are at risk for groundwater pollution.

Inadequacy of existing regulatory mechanisms:

NatureServe (2010) reports that none to few (0-3) occurrences of this species are appropriately protected and managed. There might be an occurrence at Wekiva Springs State Park, but it was not detected by Franz during 2002 surveys. NatureServe recommends preservation of existing occurrences, state/federal listing, and the acquisition of Apopka Blue Sink and buffer.

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Scientific Name:
Procambarus apalachicolae
Common Name:
Coastal Flatwoods Crayfish

G Rank:	AFS Status:	IUCN Status:
G2	Threatened	VU - Vulnerable

Range:
Procambarus apalachiacolae is known from the coastal flatwoods of Bay and Gulf counties, Florida (NatureServe 2008).

Habitat:
Procambarus apalachicolae is found in Florida's coastal flatwoods in lentic situations and burrows (Crandall and Fetzer 2003).

Populations:
This species is known from two counties, and information is not available on population size or trend.

Status:
Procambarus apalachicolae has a restricted range, and is threatened by commercial and residential development (NatureServe 2008). Its status in Florida is imperiled (NatureServe 2008). AFS lists this species as Threatened due to habitat loss and limited range.

Habitat destruction:
Procambarus apalachicolae is facing habitat loss threats from continued development of coastal property in and around Panama City, Florida (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

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Scientific Name:
Procambarus attiguus
Common Name:
Silver Glen Springs Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	CR - Critically endangered

Range:
The Silver Glen Springs Crayfish is known only from the type locality, which is Silver Glen Springs, in Marion County, Florida (Hobbs and Franz 1992). This species has an Area of Occupancy of less than 10 sq. km (NatureServe 2008).

Habitat:
P. attiguus inhabits a subterranean karst stream with a moderately strong discharge through springs and sand boils (NatureServe 2008). The spring is currently used for recreation (swimming). According to NatureServe (2008), most specimens were observed "sequestered in small cervices in the walls [of the cave]".

Deyrup and Franz (1994) state that "this crayfish was collected in a large cavern, about 213 m (700 ft) inside the main spring entrance. Specimens have been found in flocculence of reddish organic material, possibly bacterial growth, on a breakdown slope near the floor of the cavern, and floating about 30 m (100 ft) above the floor in the water column, presumably displaced from the ceiling by bubbles of air escaping from the diver's regulator (Hobbs and Franz 1992)."

Populations:
This species is known from a single site. Although only three animals have been collected, Hobbs and Franz (1992) report that the collectors observed several more sequestered in small crevices in the walls of the cave.

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of Florida lists it as a Species of Greatest Conservation Need. It is ranked by AFS as endangered and by the IUCN as critically endangered.

Habitat destruction:
The survival of this crayfish is threatened by recreation. It occurs in a single cave in the Ocala National Forest which is owned by the St. Johns River Water Management District and is managed as a public recreation area. This species is threatened by water pollution or disturbance from tourists. One solution tube has been roped off to protect wildlife, but this ultimately does not stop tourists from entering the cave. Snorkelers and scuba divers are able to access many of the cave solution tubes which lead to the chamber where P. attiguus is present.

Inadequacy of existing regulatory mechanisms:
According to the USFS (2005), P. attiguus is found in the Ocala National Forest, where it is a USFS Sensitive Species, but this designation offers the species no regulatory protection.

Other factors:
Due to the low levels of nutrients reaching the cave chamber due to the strong outflow current, it can be assumed that this species has a late reproductive maturity and a long life history making it susceptible to any loss of individuals (NatureServe 2008).

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Scientific Name:
Procambarus barbiger
Common Name:
Jackson Prairie Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
The Jackson Prairie crayfish is confined to the Jackson Prairie area in Mississippi.

Habitat:
P. barbiger has been found in deep, simple burrows in well-drained prairie soils that are rich in organic material; it burrows generally to bedrock and is intolerant of cultivation (NatureServe 2008). The Mississppi Department of Wildlife, Fisheries and Parks (2005) notes that the species occupies Jackson Prairie and associated pine seeps.

Populations:
NatureServe (2008) reports about 6-20 populations of P. barbiger with a total of 1000-2500 individuals. A recent study by MS NHP has greatly increased the number of known populations of this species.

Population Trends:
According to NatureServe (2008) this species is presently secure, but fragile.

Status:
Procambarus barbiger is ranked as imperiled (NatureServe 2008). The State of Mississippi has designated it as a Tier 1 Species of Greatest Conservation Need. It was also a Federal C-2 Candidate Species before that list was abolished. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
The Jackson Prairie crayfish is threatened by development. NatureServe (2008) states: "The TVA is upgrading a section of transmission line in Scott county, which will see heavy equipment moving through the Jackson Prairie area. The presence of heavy vehicles will cause the soils to compact, crushing the burrows of this species. Additionally, the construction work that will take place, will cause increased run-off making the water turbid and increasing sedimentation. Conversion of prairie to agricultural land leads to extirpation of this species. Re-estalishment of prairie does not see the return of this species (Fitzpatrick 1996). Land use may pose a significant threat to this species. . . . Data suggest that when prairie is disturbed (e.g., by farming) the species disappears and is replaced by other species when disturbance ceases."

Inadequacy of existing regulatory mechanisms:
Procambarus barbiger occurs on the Bienville National Forest, where it is considered a Forest Service Sensitive Species (USFS 2008), but the protection offered under this designation is discretionary. No existing regulatory mechanisms protect this species.

Other factors:
This crayfish is threatened by pollution from agriculture and development, particularly sedimentation (NatureServe 2008).

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Scientific Name:
Procambarus cometes
Common Name:
Mississippi Flatwoods Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
All known sites for this species are within ten miles of Starkville in Lowndes and Oktibbeha counties, Mississippi (NatureServe 2008).

Habitat:
The Mississippi Flatwoods crayfish is found in relatively simple burrows in flatwood and meadows; it occupies rich, well-drained soils with bedrock approximately seven meters maximum below the surface (NatureServe 2008).

Populations:
Less than ten occurrences of this species are known. NatureServe (2010) estimates global abundance at 250-2500 individuals.

Population Trends:
NatureServe (2010) reports a short-term decline of 10-30 percent for this species, stating: "The complex of species within "hagenianus" (of which cometes is one), was historically abundant in Mississippi, and in some cases even an agricultural pest. The decline appears to be associated with increased chemical use in agricultural activities. Urbanization and construction would also have local impacts on species, however the species within this complex are poorly known (Hartfield pers. comm. 1995). The species no longer occurs at the type locality (B. Jones, pers. comm., 2009)."

Status:
NatureServe (2010) ranks this species as critically imperiled. It was a Federal C-2 Candidate species before that list was abolished. The State of Mississippi classifies it as a Tier 1 Species of Greatest Conservation Need. This means that it is in need of immediate conservation action and/or research because of extreme rarity, restricted distribution, unknown or decreasing population trends, specialized habitat needs and/or habitat vulnerability. It is ranked as vulnerable by the IUCN and as endangered by the American Fisheries Society.

Habitat destruction:
NatureServe (2010) reports that this species is susceptible to habitat modification, and that it was extirpated from its type locality due to habitat modification. It is threatened by increased chemical use in agricultural activities, urbanization, and construction (NatureServe 2010).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

Other factors:
NatureServe (2010) states that this species "has been poisoned owing to the problems they caused to crops."

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Scientific Name:
Procambarus delicatus
Common Name:
Bigcheek Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	CR - Critically endangered

Range:
Procambarus delicatus is restricted to one site (Alexander Springs Cave) in Lake County, Florida, USA (NatureServe 2008).

Habitat:
This species lives in subterranean pools in aquatic caves characterized by low energy input, according to NatureServe (2008). The springs are "surrounded by cypress, cabbage palmettoes, and a number of hardwood trees and shrubs" (Hobbs and Franz 1986). According to Deyrup and Franz (1994), "the first two specimens reportedly were collected at the mouth of a small vent and in the main spring boil at Alexander Springs … while the third specimen was taken in an algal covered area at a depthof a little less than two meters and about 15 meters from the nearest vent" (Internal citations omitted).

Populations:
The Bigcheek Cave Crayfish is only known from the type locality, Alexander Springs, as reported by NatureServe (2008). Fewer than 10 specimens have been taken in the 15 plus years its existence has been known. This may be related to the fact that its cave habitat at Alexander Springs is inaccessible to humans. Hobbs and Franz (1986) postulate that the low population of P. delicatus (and P. horsti from Big Blue Springs) is linked to the low energy input into springs, as compared to the larger amount of energy available in sinks via organic inputs.

Population Trends:
Trend information is not available for this rare species.

Status:
Only one occurrence of this species is known (NatureServe 2008), giving it a Florida state status of critically imperiled. AFS lists this species as Endangered due to its extremely limited range. Florida lists it as a Species of Greatest Conservation Need. It is ranked as critically endangered by the IUCN.

Habitat destruction:
There is an extensive recreation area at Alexander Springs, including camping, boating, swimming, and other activities (Waymarking.com 2007). This has the potential to reduce the water quality of the Springs.

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

According to Walsh (2001):

"Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

Inadequacy of existing regulatory mechanisms:
According to NatureServe(2008), the only occurrence at Alexander Springs is on land belonging to the U.S. Forest Service (Ocala National Forest). The Ocala National Forest Land and Resource Management Plan does not mention Procambarus delicatus. It is a Forest Service Sensitive Species, but this designation provides no regulatory protection and this crayfish is threatened by recreation.

Alexander Springs is designated as a Wild River for 3 miles and a Scenic River for 7 miles under the U.S. Wild and Scenic Rivers Act (USFS 1999 at p. 4-10). The goal of the Forest Service is to "provide an essentially unmodified natural environment along wild segments of wild and scenic rivers and a predominantly natural environment along scenic segments." Id. at p. 4-11.

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Scientific Name:
Procambarus econfinae
Common Name:
Panama City Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
Procambarus econfinae has a range less than 100 square km (less than about 40 square miles). It is known only from a small area on the peninsula that now supports Panama City, Bay County, Florida. Within this area, the species' distribution is patchy. Range is bounded on three sides by St. Andrews Bay system, and on the fourth (east) by Callaway Creek and Bayou.

Habitat:
NatureServe (2008) reports that the Panama City crayfish lives in ditches and temporary ponds in pine flatwoods in which the water table is near the surface. The species is a secondary burrower. It appears that the species has been driven from its natural habitat (depressions in pine flatwoods) by habitat alteration and now survives largely or almost entirely in disturbed habitats. Power line rights-of-way now support the largest populations. Importantly, the species is restricted to certain soil types and habitats within its range.

In dry periods, the species inhabits simple burrows that it constructs in wet pine flatwoods soils; burrows are marked by short chimneys of stacked mud balls. During times of higher water, [Panama City] crayfish leave the burrows and inhabit the flooded flatwoods as well as adjacent drainage ditches (Florida FWC 2001). According to Florida FWC (2001), P. econfinae occupies sites year-round, but its seasonal presence above ground is tied to periods of high water.

Ecology:
Females are known to reproduce in late spring and early summer.

Populations:
According to NatureServe (2008), there are less than five populations of P. econfinae. While slightly more than two dozen sites are known, all are from the same local area and essentially represent parts or fragments of a larger metapopulation. Each local population occupies less than 1.5 acres in a small area of Bay County, Florida. Florida FWC (2001) reports that this species is known only from two localities on the small peninsula on which Panama City, Bay County, is located.

Population Trends:
NatureServe (2008) warns that this species is being extirpated rapidly. It is facing a very rapidly decline (decline of 50-70 percent) in the short term. The loss of populations and decline in area of occupancy between 2000 and 2010 is projected to exceed 50 percent. Most known sites are threatened by road widening, pollution, pipeline installation, drainage, and other forms of disturbance.

Status:
This species is classified as critically imperiled. According to NatureServe (2008) it has a very limited range and high threats to nearly all remaining occupied habitat. Despite one petition to change its Florida State status to Threatened due to a tiny range and ongoing significant habitat

loss (Keppner 2001b), and another to declassify it entirely because its natural habitat is completely eliminated (Bingham 2003), P. econfinae remains a Florida Species of Special Concern, as it has been since 1987. It is ranked as endangered by both the IUCN and the American Fisheries Society.

Habitat destruction:
Land development is the primary cause of the decline of this species (Anonymous 2006). Restriction to a rapidly growing urbanized area severely endangers this species with habitat loss, drainage, and pollution. Most of the known occurrences are imminently threatened by highway expansion and infrastructural and other forms of development. Silvicultural activities have also heavily impacted the species (NatureServe 2008).

Deyrup and Franz (1994) state that "[u]ntil recently, it was feared that this species had become extinct as a result of wetland drainage and the impacts of increased urbanization. However, recent collections in the vicinity of the type locality (near junction of County Roads 389 and 390) indicate that the species is still extant, but due to its small range it should be considered extremely vulnerable to extinction because of continued drainage projects and development in the Panama City area."

Florida FWC (2001) warns that wetland drainage and urban and residential development have greatly reduced and continue to threaten the remaining habitat of this species, stating: "[t]here is a dire need to protect from development and drainage any wet flatwoods habitat that is known to or which may harbor this species."

Inadequacy of existing regulatory mechanisms:
NatureServe (2009) reports that there is no known protection for this species, and strongly recommends the following: "Maintain natural hydrologic regimes of all pine flatwoods and included ephemeral wetlands in area; this entails absolutely no drainage, ditching, and filling. Protect sites from pollutants, including runoff from roads and leakage from septic tanks. Avoid dredging and installation of box culverts at locations of roadside populations."

NatureServe (2009) reports that a CCAA may be in development for this species.

Other factors:
This crayfish is threatened by pollution from development and silviculture (Anonymous 2006).

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Scientific Name:
Procambarus erythrops
Common Name:
Santa Fe Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
NatureServe (2008) reports that the Santa Fe Cave crayfish has a range less than 100-250 square km (less than about 40 to 100 square miles), being known only from southern Suwannee County, Florida.

Habitat:
Procambarus erythrops inhabits subterranean pools. It occurs near entrances of flooded sinkholes and caves on accumulations of detritus. Deyrup and Franz (1994) state: "Procambarus erythrops occupies debris cones under large flooded sinkholes. As yet, no colonies have been found in association with bat colonies. Little or no water flow, other than vertical movements associated with local changes in the water table, has been noted in cave sites where this speciesoccurs. This suggests that this species, like others in lucifugus complex, prefers the more stagnant portions of cave systems where detrital material can accumulate without being washed away."

Ecology:
The species is long-lived for a crayfish with animals marked before August 1978 collected during 1994 in a cave in Suwannee Co., Florida (Streever 1996).

Populations:
NatureServe (2008) estimates 1 - 5 populations with less than 2500 individuals of P. erythrops. It is known from several caves and sinks, probably interconnected, in Suwannee County, Florida. All occurrences may be interconnected and function as one. Only two of the known sites (Sims and Azure Blue sinks) contain substantial populations. There are an estimated 500 individuals at Sims Sink, with other populations believed to be much smaller.

Status:
Florida lists this crayfish as a Species of Special Concern. NatureServe (2008) ranks it as critically imperiled. It is ranked as endangered by both the IUCN and the AFS.

Habitat destruction:
NatureServe (2008) warns that this species is potentially threatened by changes in hydrology and detrital flow. All known occurrences possibly may function as one through interconnection of the local aquifer. Contamination from runoff and alteration of the local water table may pose potential problems. One site where this species occurred, Hildreth Cave, became a garbage dump in the early 1970s (NatureServe 2008).

According to Walsh (2001): "Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation. These threats could be avoided by state acquisition of the springs, or through comprehensive land use planning.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) recommends instigating measures to protect the local aquifer throughout the entire area encompassing known occurrences. According to Deyrup and Franz (1994) "Sims Sink recently was secured by The Nature Conservancy and will be managed to protect this species. The conservation status at most other sites is undocumented, although no crayfishes have been seen at Hildreth Cave after it became a garbage dump in the early 1970s." No existing regulatory mechanisms adequately protect this species.

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Scientific Name:
Procambarus fitzpatricki
Common Name:
Spinytail Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
P. fitzpatricki is restricted to extreme southern Mississippi between the Wolf and Pascagoula rivers. It occurs in George, Harrison, Jackson, and Stone Cos., Mississippi (S. Adams, pers. comm., 2009 cited in NatureServe 2010).

Habitat:
The Spinytail crayfish has been found in moderately complex burrows in sandy soil, usually with a high water table (NatureServe 2008).

Populations:
There are fewer than 20 known occurrences of this species. Recent interest in this crayfish by the Mississippi Natural Heritage Program has greatly increased the number of known populations of this species. Most colonies are of moderate size for burrowers.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as imperiled. It was a Federal C2 Candidate Species until that list was abolished. The State of Mississippi classifies it as a Tier 1 Species of Greatest Conservation Need. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
According to NatureServe (2008) this species has been historically threatened by lowering of the water table and to a lesser extent overall toxic accumulation from industry. Currently it is threatened by development and by food processing industries and chemical industries (Fitzpatrick pers. comm. 1995 cited in NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
This species occurs on the DeSoto National Forest in Mississippi, where it is considered a Forest Service Sensitive Species (USFS 2008) but this provides only discretionary levels of protection.

NatureServe (2010 reports that no occurrences of this species are appropriately protected and managed.

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Scientific Name:
Procambarus franzi
Common Name:
Orange Lake Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
This species is known only from three caves in the vicinity of Orange Lake, north-central Marion County, Florida, USA.

Habitat:
This speicies is found in pools under bat roosts in the dark zones of caves (NatureServe 2008). According to Deyrup and Franz (1994), "two of the three sites are caves that house nursery colonies of the southeastern bat (Myotis austroriparous). The third is a flooded cave system that is entered through a big sink that accumulates a large quantity of detritus." Deyrup and Franz (1994) report that "this cavernicolous crayfish focuses its activities at major sources of detrital input."

Populations:
According to NatureServe (2008) there are less than five populations with fewer than 1000 total individuals of Procambarus franzi. There are only three known sites, all in the vicinity of Orange Lake, Marion County, Florida; these may be interconnected and act as one occurrence. All known populations are small.

Status:
NatureServe (2008) ranks this species as critically imperiled, stating: "The limited populations sizes, limited distribution, and fluctuation in water levels are all threats to this species." Florida lists it as a Species of Greatest Conservation Need. It is ranked as endangered by both the IUCN and the American Fisheries Society.

Habitat destruction:
NatureServe (2010) reports that potential threats include pollution and changes in hydrology, stating: "The type locality is impacted by quarrying activies, and it is unknown what impacts this will be having on the groundwater quality and general disturbance. The species is known to occupy only one chamber in its type locality, making it sensitive to any threat which disturbs this chamber."

Deyrup and Franz (1994) state that "Since the species has a very restricted distribution and is dependent on accumulations of detritus, it is vulnerable to habitat changes from both within caves and around their entrances. Presumably, changes in groundwater quality and quantity, as well as disruption of associated bat colonies, could lead to the extirpation of important crayfish colonies."

According to Walsh (2001): “Perhaps the most serious potential threat to Florida’s hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

According to Dickson and Franz (1980): "Because troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations, troglobitic species may be susceptible to subtle changes in water quality."

Inadequacy of existing regulatory mechanisms:

According to Deyrup and Franz (1994) "all known localities are in private ownership." NatureServe (2010) reports that no occurrences are appropriately protected.

Other factors:

Because this species is closely associated with bat guano, it is threatened by any factor which threatens bat populations (NatureServe 2008).

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Scientific Name:
Procambarus horsti
Common Name:
Big Blue Springs Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
This species is endemic to northern Florida (NatureServe 2008). It has been found at less than five sites in Jefferson, Leon and Wakulla counties. The entire area is less than 100 square km (less than about 40 square miles).

Habitat:
This troglobitic species occurs in aquatic caves at the bottom of limestone springs, and has been seen in the twilight zone between light and dark, according to NatureServe (2008). Deyrup and Franz (1994) state that P. horsti was "seen in the boil area of springs as well as in caves at water depths of 21-26 m (70-80 ft)."

Ecology:
Caine (1978) believes the specialized habitat of P. horsti, a fast-flowing freshwater spring, has caused it to adapt its behaviour to attacks. Display differences and the lack of a swimming response are adaptations to the fast flow, contrasting with the behaviour of surface species.

Hobbs and Means (1972) report that when they observed P. horsti, gastropods were the only obvious form of food. The species was inactive during daytime and very active at night.

Populations:
NatureServe (2008) states that this species is known from three sites in 3 adjoining counties, but all occurrences are within a 12 mile radius. Reports of a fourth occurrence in Wakulla County (Sally Ward Springs) requires verification.

NatureServe (2008) estimates less than 1000 total members of this species. Hobbs and Means indicated in 1972 that the Big Blue Spring population may have been very large at that time.

Hobbs and Franz (1986) postulate that the low population P. horsti (and P. delicatus from Alexander Springs) is linked to the low energy input into springs, as compared to the larger amount of energy available via organic inputs into sinks.

Population Trends:
Trend is unknown.

Status:
Endemic to a very localized region in northern Florida, with no more than five known occurrences, according to NatureServe (2008). This species may be sensitive to changes in water levels and quality. Florida lists it as a Species of Greatest Conservation Need.

IUCN lists this species as endangered, as does the American Fisheries Society. The Florida State Rank is critically imperiled, while the Florida Committee on Rare and Endangered Plants and Animals lists Procambarus horsti as Rare.

Deyrup and Franz (1994) state that "[t]his crayfish, like other cave species, is dependent on organic detritus from the surface for food. Changes in land use on the surface and presumably groundwater contamination could impact these subterranean crustaceans."

Habitat destruction:

NatureServe (2008) states that Procambarus horsti is very likely susceptible to habitat damage or destruction from pollution of groundwater or aquifer.

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

According to Walsh (2001):

"Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

Overutilization:

According to the Florida DEP (2007), in the Wakulla Springs State Park, "blind crayfish [such as P. orcinus and P. horsti] are vulnerable to over collecting. Since the 1987 dive project, no specimen collections of any troglodytic fauna have been authorized."

Inadequacy of existing regulatory mechanisms:

This species enjoys some protection in the following sites in Florida: Shepherd Spring in the St. Marks National Wildlife Refuge, Wakulla County; Big Blue Spring, Wacissa River, Jefferson County; and, if species' presence is confirmed, Wakulla/Sally Ward Springs, Wakulla County (NatureServe 2008). However, site protection alone does not assure protection of species, as the water quality in the aquifer is subject to external influences.

The upper Wacissa River and an upland buffer is protected by the State of Florida, following purchase by the Nature Conservancy (Business Wire 2000).

Deyrup and Franz (1994) suggest that "upstream drainage basins of the Wacissa River in Jefferson County and Spring Creek in the St. Marks area should be protected.
Reports of P. horsti from Wakulla and Sally Ward springs should be investigated, and voucher specimens from these sites should be deposited at the Smithsonian Institution, where there is comparative material available for study. There should be an intensive survey of springs and caves in the Tallahassee limestone area to find additional localities where this species exists."

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Scientific Name:
Procambarus lagniappe
Common Name:
Lagniappe Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008), Procambarus lagniappe is known from seven localities in Kemper County and one location in Lauderdale County, Mississippi, and one location in Sumter County, Alabama.

Habitat:
The Lagniappe crayfish occupies clear, swift, cool streams with firm sandy bottoms and emergent vegetation (NatureServe 2008).

Populations:
This species is estimated to have less than 5 total populations with less than 1000 individuals (NatureServe 2008). It is known from nine localities. There are fewer than 50 specimens known.

Status:
The limited range and small population of this species gives it a status of critically imperiled in Alabama and Mississippi (NatureServe 2008). In Alabama it is categorized as a Priority 2 - High Conservation Need Species, while in Mississippi it is Tier 1 - "in need of immediate conservation action and/or research because of extreme rarity, restricted distribution, unknown or decreasing population trends, specialized habitat needs and/or habitat vulnerability." It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
The main threat to this species is water quality degradation through urbanization, deforestation, and agriculture (McGregor et al. 1999). NatureServe (2008) states, "Lots of deforestation and agriculture occur in this species range in Mississippi."

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) notes that P. lagniappe is recognized by MS NHP, but there are no known no specific sites which are protected.

Other factors:
This species is threatened by water pollution. In the area where P. lagniappe occurs, infertile eggs of a related species, P. jonesi, have been detected, and the empty eggs are possibly attributed to water quality problems (NatureServe 2008).

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Scientific Name:
Procambarus leitheuseri
Common Name:
Coastal Lowland Cave Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	VU - Vulnerable

Range:
NatureServe (2008) reports that the total range of the Coastal Lowland Cave crayfish is less than 100-250 square km (less than about 40 to 100 square miles). It is known only from Pasco and Hernando counties, Florida, USA. This is the southwestern limit of troglobitic members of this subgenus in peninsular Florida.

Habitat:
Procambarus leitheuseri is found in flooded limestone cave systems (karst), at least some of which open to the surface via sinkhole ponds (NatureServe 2008). It has been found at depths of 16.7 to 69.9 m. It is usually associated with silt on cave floors. One site is a freshwater lens within a salt marsh. Most of the known sites show some tidal influence. Franz and Hobbs (1983) report that this species was discovered in flooded cave system in Hernando County, Florida, with floors made up of coarse sand and large blocks of breakdown in rooms and tunnels, thick layers of organic silt in entrance shafts and deeper sections of the caves. It was only observed in the freshwater zone above the halocline. The silt in its habitat is deposited on the cave floors in thick layers, accumulating under vertical shafts or dispersing into the caves, depending on water movement. The organic fraction of the silt is generated from biotic production in surface ponds. The crayfish are associated with the silt, but are not found in shafts or surface ponds. According to Deyrup and Franz (1994), "[T]his crustacean has been recovered from vertical sinkholes at waterdepths in excess of 60 m (200 ft). It has been observed in these caves only in the freshwater layer that lies above salt water zone. Most of the sinks in which this crayfish has been collected show some tidal influences."

Populations:
The Coastal Lowland Cave crayfish is known from eight sites, five of which are within a 3-mile radius and may constitute one occurrence (i.e., common aquifer).

Status:
The American Fisheries Society lists this species as Endangered due to limited range and habitat loss. It as also been classified as Rare by the Florida Committee on Rare and Endangered Plants and Animals. Florida lists it as a Species of Greatest Conservation Need. It is ranked as vulnerable by the IUCN and as critically imperiled by NatureServe (2008).

Habitat destruction:
Procambarus leitheuseri is potentially threatened by changes in hydrology, with possible saltwater intrusion into aquifer at some sites as a consequence of withdrawal of fresh water by humans in this rapidly developing area (NatureServe 2008). Deyrup and Franz (1994) state that "[t]he species is vulnerable to salt water rintrusion and other changes in water quality. As a result of rapid urbanization in Hernando and Pasco counties, the surface area above these deep caves could be affected by changes in land use practices. Alteration of sinkhole ponds that connect with these vertical tubes could change the type, quality, and quantity of detrital matter that enters these caves, thus impacting the crayfish's food supply."

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

According to Walsh (2001): "Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) states that there are probably no protected occurrences. One occurrence is just south of Chassahowitzka Swamp CARL project within the Southwest Florida Water Management District's Weekiwachee Riverine System project. NatureServe suggests that it is essential to protect or acquire at least some occurrences (e.g., Eagles Nest and Die Polder) with adequate buffers and consider state listing. This includes protect the local aquifer from pollution and over-consumption. According to Hicks (1993), "None of the [eight] caves [inhabited by P. leitheuseri] is protected, but one is within the Save Our Rivers' Weeki Wachee study area for possible purchase."

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Scientific Name:
Procambarus lucifugus
Common Name:
Florida Cave Crayfish
G Rank:
G2
Range:
The total range of Procambarus lucifugus is less than 100-250 square km (less than about 40 to 100 square miles) as determined by NatureServe (2008). The Florida Cave crayfish is restricted to Florida in an arc about 80 miles long. P. lucifugus lucifugus (type locality: Sweet Gum Cave, Citrus County) has been recorded from Citrus and Hernando Counties, northward to Marion County, where it intergrades with P. lucifugus alachua (type locality: Hog Sink, Alachua County); the latter continues into Alachua, Gilchrist, and Levy counties.

Habitat:
This species occupies subterranean/karstic fresh waters near surface openings of sinks, solution chimneys, and caves, according to NatureServe (2008).

Ecology:
It is usually associated with bat roosts and roost-related debris. If the local bat fauna is depleted this species could face population declines.

Populations:
NatureServe (2008) reports that there are 20-25 known elemental occurrences of this species. Population size and trend information is unavailable.

Status:
According to NatureServe (2008), this species is endemic to small region of Florida, with no known protected occurrences, and many populations are easily accessible to humans. Its status within Florida is imperiled. Florida lists it as a Species of Greatest Conservation Need.

Habitat destruction:
NatureServe (2008) states that alteration in hydrology or flow of detritus could destroy populations of this species, and that it is likely that it is being impacted by urbanization, alterations to the hydrological regime and water pollution.

The Dudley Farm Historic State Park has several caves that contain Procambarus lucifugus, and the caves have been impacted by heavy visitation including “modern garbage.”

According to Dickson and Franz (1980) “[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality.”

According to Walsh (2001): “Perhaps the most serious potential threat to Florida’s hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation. These threats could be avoided by state acquisition of the springs, or through comprehensive land use planning.

Inadequacy of existing regulatory mechanisms:

NatureServe (2008) recommends protection and/or aquisition of populations of both subspecies and that appropriate authorities should consider state and federal listing because no populations of this species are currently protected.

Other factors:

Because this crayfish is usually associated with bat roosts and roost-related debris, it is threatened by declines in bat populations.

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Scientific Name:
Procambarus lucifugus alachua
Common Name:
Alachua Light Fleeing Cave Crayfish

G Rank:	AFS Status:	IUCN Status:
T2	Threatened	VU - Vulnerable

Range:
This species is found exclusively in Florida where it is known from 11 or more caves in Southwestern Alachua, western Gilchrist, and northern and eastern Levy counties, intergrading with P. (O.) lucifugus lucifugus in Marion County.

Habitat:
The Alachua Light Fleeing Cave Crayfish lives in limestone sinks common to Florida. Some can live in direct light, some require total darkness (NatureServe 2008). According to Deyrup and Franz (1994), "these crayfishes apparently require unlighted groundwater habitats associated with caves and sinks that attract large quantities of organic detritus, particularly bat guano, which they use as food."

Populations:
There are less than 30 known populations of this species, and the total count of individuals is unknown. It is known from 13 caves, while intergrade forms of this species are known from 14 additional caves (Walsh, 2001). Hobbs et al. (1977) found 11 localities in Alachua and Gilchrist Cos., Florida.

Population Trends:
Trend is unknown.

Status:
This species has a restricted range and restricted habitat according to NatureServe (2008). It is imperiled in Florida (NatureServe 2008) where it is also a Species of Greatest Conservation Need. It is classified as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
According to NatureServe (2008), groundwater contamination negatively affects habitat quality and food sources for this crayfish.

Deyrup and Franz (1994) report that P. l. alachua's "dependence on supplies of concentrated detrital material from the surface and on guano from bats makes these crayfishes vulnerable to changes in above ground land use. They also are vulnerable to groundwater pollution and other changes in water quality and quantity."

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of $O2$ consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

According to Walsh (2001):

"Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this species. It occurs in the same location as the Squirrel Chimney cave shrimp (Palaemonetes cummingi), which is listed under the Federal ESA as Threatened (55 Fed. Reg. 25588, June 21, 1990). Therefore P. l. alachua in Squirrel Chimney Cave benefits from the ESA habitat protections afforded to the cave shrimp.

The Dudley Farm Historic State Park has several caves that contain Procambarus lucifugus, but rather than being protective these caves are threatened by recreational impacts.

Deyrup and Franz (1994) recommend that "[c]ertain sites, particularly those at Sunday Sink in Marion County and Hog and Goat sinks in Alachua County, are in need of protection."

Other factors:
Because this species is dependent on guano as a food source, it is threatened by declines in bat populations. Extirpation of bats by urban development impacts the species in the Gainesville metropolitan area.

The Dudley Farm Historic State Park has several caves that contain Procambarus lucifugus. The caves have been impacted by heavy visitation including "modern garbage." Fencing some caves is recommended. Pollution from large community septic systems could also harm the aquatic cave species.

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Scientific Name:
Procambarus lucifugus lucifugus
Common Name:
Florida Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
T2	Endangered	EN - Endangered

Range:
NatureServe (2008) reports that the total range of this species is about 100-250 square km (about 40-100 square miles). P. (O.) l. lucifugus is found in Citrus and Hernando counties northward to Marion County, Florida, where it intergrades with P. (O.) l. alachua.

Habitat:
P. l. lucifugus occupies subterranean/karstic waters near sites of detrital input, particularly large sinkholes and areas under bat roosts in caves (NatureServe 2008). Deyrup and Franz (1994) report that "Procambarus l. lucifugus is associated with a large nursery colony of southeastern bats (Myotis austroriparous) at Sweet Gum Cave. This cave is subject to extreme fluctuations in the local water table. During periods of low water, incredible numbers of this crayfish occur under the traditional bat roost in the rear of the cave. During periods of flooding, crayfishes rarely are seen in the accessible areas near the entrance, even when baited traps are used. This suggests that the residual population remains in deeper portions of the cave where food supplies can be limited during periods when this area is not accessible to bats."

Ecology:
This cave crayfish lilves on the floor of pools thick with organic sediments. It is also dependent on the presence of bats for resources (NatureServe 2008).

Populations:
Hobbs et al. (1977) includes 8 localities of this species in Citrus, Hernando, Lake, and Marion Cos., Florida. Walsh (2001) lists only two but includes 16 additional localities of intergrades between subspecies. NatureServe (2008) estimates 6-20 populations with an unknown number of individuals.

Status:
Procambarus lucigufus lucifugus is critically imperiled in Florida, based on restricted range and restricted habitat (NatureServe 2008). The State of Florida classifies it as Rare, and lists it as a Species of Greatest Conservation Need. It is listed as endangered by the American Fisheries Society and by the IUCN.

Habitat destruction:
NatureServe (2008) states that this species is threatened by groundwater contamination, and is most likely intolerant of disturbances.

According to Deyrup and Franz (1994) "Its presence at Sweet Gum has been documented with collections that span nearly 100 years. The cave is in private ownership, and the current owner is trying to protect the cave. However, since the crayfish is known only from this site, it remains vulnerable to changes in local land use and encroaching urbanization, and with its dependence on bat guano for food, it could be seriously impacted with changes in the bat population."

According to Dickson and Franz (1980) "[b]ecause troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations troglobitic species may be susceptible to subtle changes in water quality."

According to Walsh (2001): "Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill Florida recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms adequately protect this species.

Other factors:

The Florida cave crayfish is closely associated with bat populations and is thus threatened by any factor which threatens bat populations.

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Scientific Name:
Procambarus lylei
Common Name:
Shutispear Crayfish

G Rank:	**AFS Status:**
G2	Special Concern

Range:
Procambarus lylei is restricted to small headwaters streams of the Yalobusha River in Calhoun, Grenada, Montgomery, Yalobusha and Webster counties, Mississippi.

Habitat:
The Shutispear crayfish is found in headwaters of streams with cool, firm sand bottoms, moderate to swift flow, and with trapped leaf litter (NatureServe 2008).

Populations:
This species is known from 17 localities across a five-county area and is never plentiful. A recent study by the MS NHP did not significantly increase its range, number of known populations, or population size elements.

Population Trends:
This species is still present at historical sites that have been revisited and is not considered to be declining in range. Busack (1988) suggested that the species' range was contracting due to habitat degradation, including hydrologic and stream channel alterations and loss of cover, resulting primarily from stream channelization and agriculture, but Fitzpatrick and Suttkus (1992) report that the species is still present at re-visited sites, but may be reduced in abundance. At the most agriculturally impacted site, P. lylei density was extremely low, and only juveniles were captured so identification was not definitive (USFS 2009). NatureServe (2010) reports that recent "improvement" of at least one site seems to have extirpated the species there.

Status:
NatureServe (2008) ranks P. lylei as critically imperiled. The State of Mississippi classifies it as a Tier 1 Species of Special Concern. AFS lists P. lylei as Vulnerable (Taylor et al 2007). It was a Federal C2 Candidate Species before that list was abolished.

Habitat destruction:
The shutispear crayfish is vulnerable to habitat loss and degradation because of its limited range, and because it seems intolerant of channelizing or deepening of its habitat (NatureServe 2008). Fitzpatrick and Suttkus (1992) speculate that the species does not tolerate low oxygen levels or eutrophication. Busack (1988) reports that this species is threatened by hydrologic and stream channel alterations and loss of cover, resulting primarily from stream channelization and agriculture. P. lylei density was found to be extremely low at sites heavily impacted by agriculture (Fitzpatrick and Suttkus 1992, USFS 2009). NatureServe (2008) reports than an additional conservation concern is that the already limited range is fragmented by Grenada reservoir and probably by channelized portions of the Yalobusha River and its major tributaries, presumably isolating populations in the tributary systems from one another. Recent "improvement" of at least one site seems to have extirpated the species there.

Inadequacy of existing regulatory mechanisms:

No existing regulatory mechanisms protect this species, and NatureServe (2008) reports that no occurrences are appropriately protected and managed.

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Scientific Name:
Procambarus milleri
Common Name:
Miami Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	EN - Endangered

Range:
This species is known from only one locality in Miami, Dade County, Florida.

Habitat:
NatureServe (2008) indicates that there is little known about the habiitat requirements of P. milleri. Specimens collected came from a well drilled into oolitic limestone to a depth of 22 feet. Deyrup (1994) reports that individuals were pumped from solution channels in the Biscayne aquifer.

Ecology:
According to Loftus and Bruno (2006), "[t]he origin of P. milleri as a subterranean organism is recent. In fact, it has not yet acquired all the morphological traits, such as blindness and lack of pigmentation, of truly subterranean organisms. Our data indicate that this rare crayfish is endemic to southern and central Miami-Dade County."

Populations:
With only one population known from 18 specimens, found in a well at Little Bird Nursery and Garden Store, Miami, Dade County, Florida, NatureServe (2008) estimates less than 1000 total individuals for the Miami cave crayfish. Loftus and Bruno (2006) found P. milleri in "13 new locations on the Atlantic Coastal Ridge. Most collections were from wells in the Fort Thompson limestone formation between seven to eleven-meters deep, although one collection was made at three meters."

Status:
This species is ranked as critically imperiled by NatureServe (2008), as a Species of Greatest Conservation Need by the state of Florida, and as endangered by the IUCN and the American Fisheries Society. Its occurence only in Miami endangers it because of the multiplicity of threats to the local aquifer from the burgeoning human population and resulting water demands. Protection will be especially difficult because it occurs in a heavily utilized aquifer.

Habitat destruction:
Deyrup (1994) states that P. milleri "is probably extremely vulnerable to groundwater contamination. Since it is restricted to one of the fastest growing urban areas in the United States, the Miami cave crayfish probably has little chance of survival, particularly in light of the impacts of groundwater pumping, salt water intrusion, and the introduction of other toxins."

Loftus and Bruno (2006) report that "its small population and limited range make it vulnerable to human activities that affect groundwater, including pumping of water from the aquifer, degradation of water quality, and limestone removal."

The Florida Springs Task Force (2000) reports that the entire range of the Miami Cave Crayfish (P. milleri) lies within heavily urbanized areas that are at risk for groundwater pollution and salt water intrusion.

Loftus et al (2001) report that: "The Atlantic Coastal Ridge is another area affected by urbanization and changing hydrologic management. Aquatic habitats, such as the transverse glades that cut through the Ridge, have been replaced by canals and will not be restored. Ground-water habitats and animal communities may have been less affected. As in karst areas elsewhere, deeper geological formations (>5 m) beneath the Rocky Glades and the Atlantic Coastal Ridge have voids of various dimensions known to house truly subterranean aquatic species. These include the Miami Cave Crayfish (Procambarus milleri), known only from a few wells in southern Florida."

Inadequacy of existing regulatory mechanisms:

There are no protected populations of this species, as reported by NatureServe (2008). Protection/aquisition of the only EO and as much buffer as possible is recommened. Authorities should consider state/federal listing.

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Scientific Name:
Procambarus morrisi
Common Name:
Putnum County Cave Crayfish

G Rank:	AFS Status:	IUCN Status:
G1	Endangered	CR - Critically endangered

Range:
Procambarus morrisi is known only from a single sinkhole aquatic cave (Devil's Sink) near Interlachen, in Putnam County, Florida.

Habitat:
The Putnam County cave crayfish occupies karst aquatic caves associated with sinkholes in sandy ridges of the Southern Trail Ridge.
According to Deyrup and Franz (1994), "[l]arge numbers of crayfishes were found in a small cave at the bottom of a deep water-filled sinkhole at a water depth in excess of 100 ft."

Populations:
There is only one known occurrence of this species. No estimate of population size is available, but known habitat is very limited in size. The species is known only from 15 specimens, from one collection of seven, and a second collection of eight individuals.

Status:
Florida lists this crayfish as a Species of Greatest Conservation Need. It is ranked as critically imperiled by NatureServe (2008), as critically endangered by the IUCN, and as endangered by the American Fisheries Society. This species is direly threatened. According to the Florida Springs Task Force (2000), "human-caused erosion will soon seal the entrance to the cave where the only known population of the Putnam County Cave Crayfish (Procambarus morrisi) is found, and may extinguish the species. "

Habitat destruction:
NatureServe (2008) warns that the only known population is disturbed by recreational use and dumping. The local ground water is subject to pollution and withdrawal for human consumption.

According to the Florida Springs Task Force (2000), "human-caused erosion will soon seal the entrance to the cave where the only known population of the Putnam County Cave Crayfish (Procambarus morrisi) is found, and may extinguish the species. "

Deyrup and Franz (1994) report that "[t]he only known site for this species is located on private land in the lake district near the town of Interlachen. This area currently is subject to land speculation and development, particularly around the lakes. The sink is used by locals as a swimming hole and by SCUBA divers. Divers probably do not pose any threat to these crustaceans, although none of these crayfishes should be collected except in connection with scientific studies. Divers report junk cars and other trash in the bottom of the sink. There is a real possibility that toxic chemicals could be dumped into the sink, killing the crayfishes in the cave."

Inadequacy of existing regulatory mechanisms:
The only known population is not protected, according to NatureServe (2008).

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Scientific Name:
Procambarus orcinus
Common Name:
Woodville Karst Cave Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Threatened	VU - Vulnerable

Range:
According to NatureServe (2008), the Woodville Karst Cave crayfish has a range less than 100-250 square km (less than about 40 to 100 square miles). It occurs only in the aquifer and sinkholes of a very small area of the Woodville Karst Plain, on the border of Leon and Wakulla counties, Florida.

Habitat:
Procambarus orcinus occupies flooded caves, twilight zones, especially the deep parts of caves (Natureserve 2008). It is often found clinging upside-down on ceilings or head-down on vertical walls. According to Deyrup and Franz (1994) "[t]he Woodville cave crayfish is reported to cling upside down to the ceiling and head down on the vertical walls of flooded caves. Individuals are most numerous along the walls, especially where there are cracks and fissures near the floor. They are seen commonly in both the twilight areas and the dark portions of flooded caves."

Populations:
There are approximately 12-15 known occurrences, many of which may be interconnected, all in Leon and Wakulla counties, Florida. All occurrences lie within a single, relatively small aquifer.

Population Trends:
Trend is unknown.

Status:
NatureServe (2008) ranks this species as critically imperiled. The State of Florida lists it as a Species of Greatest Conservation Need. It is ranked as vulnerable by the IUCN and as threatened by the American Fisheries Society.

Habitat destruction:
Foot and vehiclar traffic have caused erosion around at least one ocurrence at Gopher Sink (NatureServe 2008). All populations are prone to potential pollution and detrital change. There is concern that this aquifer may be receiving pollutants from the Tallahassee area.

Inadequacy of existing regulatory mechanisms:
NatureServe (2010) reports that none to few (0-3) occurrences are appropriately protected and managed, stating, "Wakulla Springs is a state park, but even it is unable to provide adequate protection to the aquifer in which this crayfish lives." This species is also known from Emerald Sink, Apalachicola National Forest, where it is a Sensitive Species, but this provides only discretionary protection.

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Scientific Name:
Procambarus pallidus
Common Name:
Pallid Cave Crayfish

G Rank:	**AFS Status:**
G2	Special Concern

Range:
According to NatureServe (2008), Procambarus pallidus has an estimated range of 250-1000 square km (about 100-400 square miles). It is restricted to Florida,occurring along the upper Suwannee River and some tributaries (lower Withlacoochee and lower Santa Fe rivers), as well as in some sinkholes that probably connect to them. It can be found in Alachua, Columbia, Gilchrist, Hamilton, Lafayette, Levy, Madison, and Suwannee counties.

Habitat:
Deyrup and Franz (1994) report that this cavernicolous species is associated with groundwater habitats in caves that are not as heavily enriched with organic debris as those that attract members of the cavernicolous lucifugus complex. Divers have reported that this species is most strongly associated with caves that have high flow in newly emerging karst areas, particularly along the upper Suwannee River area. The crayfish commonly ventures out into the lighted portions of 'bluehole' sinks. NatureServe (2008) reports that for P. pallidus, the occupied water is usually clear, but in one instance it was "coffee colored."

Populations:
NatureServe (2008) estimates 6 - 80 populations of the Pallid Cave crayfish. There are at least 82 known caves, but many of these may be interconnected.

Status:
NatureServe (2008) ranks this species as imperiled. Florida lists it as a Species of Greatest Conservation Need. It is ranked as vulnerable by the American Fisheries Society (Taylor et al. 2007). P. pallidus was a Federal C-2 Candidate Species until that list was abolished.

Habitat destruction:
Concerning threats to this species, NatureServe (2008) states: "This species is potentially threatened by pollution of the aquifer. Reported major crayfish kills in spring caves along the upper Suwannee River may reflect pollution events. The species is impacted by urban development, groundwater pollution and human disturbance. A large number were killed by a flood from an unconfined aquifer (Abell et al., 2007). Another site is threatened by the construction of a proposed industrial park (Abell et al., 2007). Some of the caves are listed as being good caves for diving and this will cause disturbance to the species. "

According to Deyrup and Franz (1994) "P. pallidus may be sensitive to toxic chemicals, which may have been responsible for major crayfish kills reported by divers in spring caves in the upper Suwannee River basin."

Streever (1995) found that following the 1991 P. pallidus decimation at Peacock Springs, Suwannee County, “recently collected census data are not significantly different from data collected before the 1991 kill (Paired t-test, P gt 0.1). However, crayfish numbers have not returned to their pre-1991 levels in the cave passage where the highest crayfish density occurred before the kill. Also, the scarcity of small (lt 1.5 cm total length) crayfish suggests that the return to pre-1991 levels may reflect dispersal of animals from inaccessible portions of the cave and not replacement of crayfish through reproduction."

According to Walsh (2001): "Perhaps the most serious potential threat to Florida's hypogean and spring faunas is ground-water pollution and/or saltwater intrusion as land surface is developed and aquifer resources are increasingly tapped. Streever (1992, 1995) reported on a kill and post-kill recovery of the troglobitic Santa Fe Cave Crayfish (Procambarus erythrops) and three troglophiles that may have been due to physicochemical changes associated with flushing of contaminants and/or Suwannee River water during a flood event. In recent years, there have been notable increases in contaminants and nutrients within some Florida ground-water sources (e.g., Katz and others, 1999). Eutrophication in spring habitats may result in greater algal growth, increased turbidity, and physicochemical and biological changes that can be detrimental to native species."

The Florida Department of Community Affairs (2008) states that Florida's freshwater springs system is threatened. Major causes of problems in springs include landscaping, development and urban sprawl, water consumption, dumping in sinkholes, agriculture and livestock, golf courses and other recreation.

Dickson and Franz (1980) state that: "Because troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations, troglobitic species may be susceptible to subtle changes in water quality."

Inadequacy of existing regulatory mechanisms:

Deyrup and Franz (1994) state that "[m]any cave sites where this species has been collected are currently protected within county and state parks along the Suwannee and Santa Fe rivers." These sites remain vulnerable to recreational impacts and groundwater pollution. No existing mechanisms adequately protect this species.

Other factors:

This species is threatened by groundwater pollution (NatureServe 2008).

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Scientific Name:
Procambarus pictus
Common Name:
Black Creek Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	VU - Vulnerable

Range:
Tthis species is found in northeastern Florida, principally in the Black Creek (including North and South forks) and Etoniah Creek drainages in Clay, Duval, and Putnum counties. It is also found in one additional small stream in Duval County (NatureServe 2008).

Habitat:
NatureServe (2008) reports this species is found in cool, flowing, tannin-stained headwater streams and larger tributaries. According to Deyrup and Franz (1994) "this colorful crayfish inhabits cool, flowing, tannic-stained streams where it hides by day in submerged detritus, tree roots, and vegetation. At night, it is found crawling on the sandy bottoms of streams. Its coloration fits the background colors of the sand and detritus."

Populations:
The Black Creek crayfish has been found in three stream systems: Black and Etoniah creeks, and a small stream near Ft. Caroline (NatureServe 2008). There have been more than 30 occurrences, mostly in Black Creek. Burgess and Franz (1978) include headwaters and tributaries of Black Creek in Florida. Potential gene flow probably occurs among most or all sites within each system.

Status:
Procambarus pictus is endemic to small region of northeastern Florida, with all occurences are restricted to two or possibly three drainages. Current populations are viable, but all are threatened by heavy development pressure in this region. The NatureServe (2008) state status of this species is imperiled. It was a Candidate 2 species under the Federal ESA when that list was maintained. It is listed as threatened by the American Fisheries Society and as vulnerable by the IUCN.

Florida lists the Black Creek crayfish as a Species of Special Concern due to "significant vulnerability to habitat modification, environmental alteration, human disturbance, or human exploitation which, in the foreseeable future, may result in its becoming a threatened species unless appropriate protective or management techniques are initiated or maintained."

Habitat destruction:
The Black Creek crayfish is threatened by habitat destruction caused by development, alteration of drainage patterns, pollution, and runoff including siltation (NatureServe 2008). All of these activities pose potential, and in some cases, real threats. Studies by Franz and Franz (1979) and Brody (1990) report apparent extirpation of species at some disturbed sites.

Camp Blanding habitat is threatened by timber harvest, while habitat within Jennings State Forest is at risk from offsite development, feral hogs, and human disturbance (Pranty 2002).

Franz and Franz (1979) reported that this species is of special concern due to its absence from most of Black Creek where development increased siltation, nutrients, and channelization while reducing stream flow.

Brody (1990) failed to observe the species at several of the Franz and Franz (1979) collection sites. At these sites, development has been intensive.

Deyrup and Franz (1994) warn that "the species is susceptible to siltation, pollution, and other changes in water quality. With the expansion of Orange Park and Middleburg, urbanization is reaching southward along State Route 21. A toll road and an associated highspeed rail system have been proposed to come through the heart of the Black Creek country, which could potentially impact water quality and the long-term rural aspect of this area." Deyrup and Franz (1994) state that the species is threatened by expanding urbanization and by chemical spills associated with mining activities.

According to Dickson and Franz (1980): "Because troglobitic organisms have evolved in relatively constant environments, many of their adaptations may be highly specialized allowing existence only under prevailing ambient conditions. The reduction of O2 consumption and energy turnover of gill tissues reported in this study gives evidence of the highly specialized nature of physiological and biochemical adaptations in troglobitic organisms. Because of these adaptations, troglobitic species may be susceptible to subtle changes in water quality."

Inadequacy of existing regulatory mechanisms:

There are a few (1-3) occurrences protected by state or federal ownership (NatureServe 2008). The species is widespread in parts of the Black Creek drainage that lie within the Camp Blanding Training Site and presumably Jennings State Forest as well. Camp Blanding is a military base, and most of its streams are relatively pristine.

Etoniah Creek runs through Etoniah Creek State Forest (8769 acres), which was acquired by the state in 1996 as part of the Cross Florida Greenway Conservation and Recreation Lands (CARL) project (Florida Dept. Ag. 2009). The quality of habitat on Etoniah Creek is superb, as seen from the list of endangered species found there. "Species found on the (Etoniah Creek State) forest that are listed as endangered, threatened or species of special concern include eastern indigo snake, gopher tortoise, Florida scrub jay and red-cockaded woodpecker. Etonia rosemary (Conradina etonia) is an endangered plant that was first described in 1991 and is found mostly in scrub habitat. Etoniah Creek State Forest contains the only known population of Etonia rosemary found on public land." Id.

This species is protected from collection in Florida, but no mechanisms adequately protect its habitat.

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Scientific Name:
Procambarus pogum
Common Name:
Bearded Red Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
Procambarus pogum is endemic to Mississippi (NatureServe 2008). The range of this species is very limited, with only two locations identified within 10 miles of each other.

Habitat:
NatureServe (2008) states that this species is found in relatively simple burrows in flatwoods, near margins; sometimes found in riparian areas that are near small streams.

Populations:
NatureServe (2008) reports that this species has an extremely limited population, with less than 15 indviduals identifiied in only two locations. One of these locations is not specific enough to identify again.

Population Trends:
Trend information is not available for this very rare species.

Status:
This critically imperiled (S1) species has very restricted habitat and an extremely small total population. It is listed as endangered by the American Fisheries Society and as vulnerable by the IUCN. In the state of Mississippi, it is listed as a Tier 1 Species of Greatest Conservation Need, meaning it is "in need of immediate conservation action and/or research because of extreme rarity, restricted distribution, unknown or decreasing population trends, specialized habitat needs and/or habitat vulnerability. Some species may be considered critically imperiled and at risk of extinction/extirpation." The Bearded Red crayfish was formerly considered a Candidate 2 species by USFWS until that list was abolished. Fitzpatrick (2000) identified Procambarus pogum as endangered.

Habitat destruction:
NatureServe (2008) states that this species faced minor impacts from cotton farming until the 1950's. This land is now mostly pasture, making the crayfish vulnerable to impacts from runoff and potentially trampling of habitat and/or organisms (Fitzpatrick pers. comm. 1995 cited in NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No populations of this very rare species are appropriately protected (NatureServe 2008).

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Scientific Name:
Procambarus regalis
Common Name:
Regal Burrowing Crayfish

G Rank:	**AFS Status:**
G2	Special Concern

Range:
The Regal Burrowing crayfish is known only from the Ouachita and Red River drainages in Nevada, Howard, and Sevier counties, Arkansas (NatureServe 2008).

Habitat:
P. regalis inhabits simple burrows in colonies that may be extremely large, in southwestern Arkansas (Hobbs and Robison 1988).

Populations:
It is known from eight sites, and future work will most likely reveal additional localities. It can occur in 'extremely large' colonies (Robison and Allen 1995).

Status:
This species is ranked by NatureServe (2008) as imperiled in Arkansas (G1S2S3) and under review (SNR) in Texas. AFS lists this species as Vulnerable (Taylor et al 2007).

Habitat destruction:
According to the Arkansas Wildlife Action Plan (2008), P. regalis is threatened by chemical alteration and habitat destruction due to road construction, and recommends protecting this species from construction activities and herbicide applications.

NatureServe (2010) states that it is likely to be undergoing localized declines due to urbanization, alterations to the hydrological regimes and water pollution.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

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Scientific Name:
Procambarus reimeri
Common Name:
Irons Fork Burrowing Crayfish

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Endangered	VU - Vulnerable

Range:
The Irons Fork Burrowing crayfish has a range less than 100-250 square km (less than about 40 to 100 square miles). According to NatureServe (2008), all localities are in the Ouachita River basin in Polk Co, AR.

Habitat:
P. reimeri digs relatively simple burrows in sandy clay soil in roadside ditches, low wet seepage areas, and riparian areas.

Populations:
According to NatureServe (2008), Procambarus reimeri is known from only six localities, where only 20 adults and 99 juveniles were identified. Thus, there are estimated to be less than 5 populations and less than 1000 total individuals extant.

Status:
NatureServe (2008) ranks this species as critically imperiled. It is rated as vulnerable by the IUCN and as endangered by the American Fisheries Society.

Habitat destruction:
This crayfish is vulnerable to habitat degradation and occurs in a limited area (Crandall et al. 2009). According to the Arkansas Wildlife Action Plan (2008), P. reimeri faces threats from habitat destruction or conversion caused by forestry activities and road construction, and could be harmed by toxins/contaminants used in forestry activities.

Procambarus reimeri occurs on the Mena and Oden Ranger Districts of the Ouachita National Forest (U.S. Forest Service 2008). The Forest Service is planning to cut over 2000 acres of this forest including 300 acres of clearcuts, and construct or reconstruct 11.8 miles of roads in the range of this species.

Inadequacy of existing regulatory mechanisms:
Procambarus reimeri is found on the Menae Ranger District, where it is a USFS Sensitive Species (USFS 2008), but this designation provides only discretionary protection, and the FS is planning a large timbercut including a clearcut and roadbuilding in this species' habitat.

Other factors:
This crayfish is threatened by pollution from logging and forestry activities.

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Scientific Name:
Pseudanophthalmus avernus
Common Name:
Avernus Cave Beetle

G Rank:
G1

Range:
This beetle is found only in the Avernus Cave, Rockingham County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting low level of available food.

Populations:
There is only one population of this species, in a single cave (Holsinger and Culver 1988). Only one individual plus the type series have been collected and identified, and it is uncommon.

Population Trends:
Population size is very low, and trend is unknown.

Status:
This beetle is critically imperiled (NatureServe 2008) and is a Virginia Species of Concern.

Habitat destruction:
The primary threat to this beetle is commercial recreation in the lone cave where it occurs, but the only known locality of the beetle within the cave is not part of the commercial tour route (NatureServe 2008).

In general, cave beetles are threatened by toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
Avernus Cave is privately owned, current owners are conservation minded, according to NatureServe (2008). The cave is gated and protected.

Other factors:
This species is potentially threatned by Diflubenzuron or other biocides applied against gypsy moths (NatureServe 2008).

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Scientific Name:
Pseudanophthalmus colemanensis
Common Name:
Coleman Cave Beetle

G Rank:
G1

Range:
This beetle occurs in a single cave in Montgomery County, Tennessee (NatureServe 2008).

Ecology:
This beetle may be dependent on nutrient input from gray bat guano.

Populations:
One occurrence was extant in 1999 (NatureServe 2008). Population size is unknown and is likely low.

Population Trends:
NatureServe (2008) reports that this species is stable in the short term. Given loss of the gray bat colony and other changes, this population has probably declined over the last century.

Status:
USFWS considers this species extant based on a 1999 observation (NatureServe 2008). It is probably limited to a single cave. It has some protection especially from direct disturbances, but threats may exist and there has been past habitat alteration and loss of former nutrient input from bat guano. It is a Tennessee Species of Greatest Conservation Need, is ranked as critically imperiled by NatureServe (2008), and is a Candidate with Listing Priority of 11 under the Federal ESA.

Habitat destruction:
This beetle is somewhat protected from habitat degradation because it occurs in a cave owned by The Nature Conservancy, but its habitat remains vulnerable to pollution (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), this species has some protection under a Cooperative Management Agreement with The Nature Conservancy at its only known occurrence (USFWS, 2004).

Other factors:
One of the primary threats to this beetle is loss of nutrient input from gay bat guano. It is threatened by any factor which threatens gray bats.

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Scientific Name:
Pseudanophthalmus cordicollis
Common Name:
Little Kennedy Cave Beetle

G Rank:
G1

Range:
P. cordicollis is endemic to Wise County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food (NatureServe 2008).

Populations:
The Little Kennedy Cave beetle has been found in only one cave to date (Holsinger and Culver, 1988). NatureServe (2008) estimates fewer than 1000 individuals exist. It was collected and/or observed in low numbers.

Population Trends:
According to NatureServe (2008), there does appear to be a stable, or at least extant population based on a recent (1995) observation.

Status:
Psuedanophthtalmus cordicollis is endemic to one cave in Wise County, Virginia (NatureServe 2008). Given the fragility of cave habitats and the known utilization of this cave, it is ranked as critically imperiled. It is a Virginia Species of Greatest Conservation Need.

Habitat destruction:
The cave inhabited by P. cordicollis may be used for recreational spelunking (NatureServe 2008). According to the U.S. Forest Service (2004), P. cordicollis is found within the 5th Level HUC Watersheds where Federal Oil and Gas development may occur. This species is also threatened by mountaintop removal coal mining (EPA 2005).

Inadequacy of existing regulatory mechanisms:
The Little Kennedy Cave is privately owned (NatureServe 2008). No existing regulatory mechanisms protect this species.

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Scientific Name:
Pseudanophthalmus egberti
Common Name:
New River Valley Cave Beetle

G Rank:
G1

Range:
This beetle is found in only two caves in Giles County, VA, approximately five kilometers apart (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
This beetle is known from two caves and eight individuals (Holsinger and Culver, 1988).

Status:
Pseudanophthalmus egberti is known from only two caves and has not been seen since 1958. However, surveys have been limited so if the habitat is intact the population may persist. (NatureServe 2008). It is a Virginia Species of Concern, and is critically imperiled (NatureServe 2008).

Habitat destruction:
Caves inhabited by P. egberti may be used for recreational spelunking (NatureServe 2008). This species may also be threatened by general threats to cave beetles including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

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Scientific Name:
Pseudanophthalmus hirsutus
Common Name:
Cumberland Gap Cave Beetle

G Rank:
G1

Range:
This beetle is also known as the Lee County cave beetle. According to NatureServe (2008), the range of this species is less than 100-250 square km (less than about 40 to 100 square miles). It is found in only four caves (two of which are connected and are considered one occurrence) in two adjacent counties of Virginia and Tennessee. Less than 20 kilometers separates the most distant sites.

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting low level of available food.

Populations:
As reported in NatureServe (2008) there are fewer than 5 populations with likely far less than 1000 individuals of P. hirsutus, as only a few individuals are known. It is found in four caves to date (Holsinger and Culver 1988) (two of these are connected and are considered one occurrence). All occurrences are in the Cumberland Plateau physiographic province of Virginia and Tennessee. Only seven individuals plus the type series have ever been collected.

Population Trends:
While NatureServe (2008) reports a short term trend of severely to rapidly declining (decline of 30 to greater than 70 percent), stating that trend cannot be determined from available data.

Status:
Pseudanophthalmus hirsutus has been found in only a few localities and only a few individuals have ever been identified (NatureServe 2008). Given the fact that some threats exist and the known sites are in relatively close proximity to one another, this species is ranked as critically imperiled in both Tennessee and Virginia. It is a Tennessee Species of Greatest Conservation Need, and a Virginia Species of Concern.

Habitat destruction:
The caves where this species occurs may be used for recreational spelunking. One entrance of the connected caves (Cudjos Cavern) was used as a commercial cave in the past, but is now managed by Cumberland Gap National Historic Park. The other entrance (Cumberland Gap Saltpetre Cave) is vertical (ca. 75 foot drop) and receives little caving traffic. Indian Cave receives the most traffic currently of the three Virginia sites (NatureServe 2008).

This beetle may be threatened by pollution from mountaintop removal coal mining (EPA 2005). This species is also threatened by general threats to cave beetles including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
The two connected caves where this species occurs and a third collection site are within one mile of each other and all are within Cumberland Gap National Historical Park boundary (NatureServe 2008). Ownership of the Tennessee site is unknown.

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Scientific Name:
Pseudanophthalmus hubbardi
Common Name:
Hubbard's Cave Beetle

G Rank:
G1

Range:
Pseudanophthalmus hubbardi is endemic to a single cave in Page County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
Hubbard's Cave beetle is found in only one cave to date (Holsinger and Culver, 1988). Likely very few exist.

Status:
P. hubbardi is known from only one cave with known potentially destructive activities (tours) according to NatureServe (2008). It is a Virginia Species of Concern, and is classified as critically imperiled.

Habitat destruction:
This beetle's habitat is threatened by recreation. Hubbard's Cave is a major commercial tour cave (NatureServe 2008). Most of the passage in the cave is part of the commercial tour route. This species may also threatened by general threats to cave beetles including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms which protect this species. Cave access is restricted to guided tourists, and Hubbard's Cave is designated as a national natural landmark (NatureServe 2008).

References:

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Scientific Name:
Pseudanophthalmus hubrichti
Common Name:
Hubricht's Cave Beetle

G Rank:
G1

Range:
P. hubrichti is endemic to Russel County, Virginia (Holsinger and Culver, 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
This species has been found in only one cave to date (Holsinger and Culver, 1988). NatureServe (2008) estimates fewer than 1000 individuals.

Population Trends:
A 1991 observation may indicate some stability in the population (NatureServe 2008).

Status:
Very few specimens have ever been seen, according to NatureServe (2008). It is a Virginia Species of Concern, classified as critically imperiled by NatureServe (2008). It was a Federal C2 Candidate species until that list was abolished.

Habitat destruction:
This beetle may be threatened by recreation, as Hubricht's Cave may be used for recreational spelunking (NatureServe 2008).
This beetle may be threatened by pollution from mountaintop removal coal mining (EPA 2005).
This species is also threatened by general threats to cave beetles including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species. Hubricht's Cave is privately owned (NatureServe 2008).

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Scientific Name:
Pseudanophthalmus intersectus
Common Name:
Crossroads Cave Beetle

G Rank:
G1

Range:
The Crossroads Cave beetle is known from only two caves in Bath County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting low level of available food.

Populations:
This beetle is known from only two caves and is extremely rare where it occurs, with only seven individuals collected and identified to date.

Population Trends:
Trend is unknown due to extremely low population size.

Status:
This beetle is critically imperiled and is known from few individuals at only two caves which lack protection and are extremely fragile (NatureServe 2008). It is a Virginia Species of Concern, and it was a Federal C-2 Candidate species until that list was abolished.

Habitat destruction:
This beetle's habitat is threatened by recreational spelunking (NatureServe 2008). In general, cave beetles are threatened by toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
The caves inhabited by P. intersectus are privately owned (NatureServe 2008). No regulatory mechanisms protect this species.

References:

Arnett, Jr., Ross H., ed. 1983. Checklist of the Beetles of North and Central America and the West Indies. Flora and Fauna Publications, Gainesville, Florida. 24 P. (Pertains to all subsequent fasicle updates as well).

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Scientific Name:
Pseudanophthalmus limicola
Common Name:
Maddens Cave Beetle

G Rank:
G1

Range:
This beetle is known from only three caves in Shenandoah county, Virginia (Holsinger and Culver 1988), within approximately eight kilometers of each other.

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
According to NatureServe (2008), this species has fewer than 5 populations with less than 1000 total individuals. It is known from only three caves (Holsinger and Culver 1988).

Status:
P. limicola is known from only three locations and hasn't been seen since 1962 (NatureServe 2008). despite a lack of recent surveys however, if the habitat quality persists, the populations may also persist. It is a Virginia Species of Concern and is ranked as critically imperiled by NatureServe (2008).

Habitat destruction:
Caves inhabited by P. limicola may be used for recreational/commercial spelunking (NatureServe 2008). This species may also be threatened by general threats to cave beetles including toxic chemical spills, pollution, trash dumping, vandalism, disruption of nutrient input, alteration of entrances, or the creation of new entrances (FWS 2009).

Inadequacy of existing regulatory mechanisms:
The cave inhabited by Maddens Cave beetle is privately owned (NatureServe 2008). No existing regulatory mechanisms protect this species.

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Scientific Name:
Pseudanophthalmus montanus
Common Name:
Dry Fork Valley Cave Beetle
G Rank:
G1
Range:
Pseudanopthalmus montanus is known only from the following four West Virginia caves: Bennett Cave; Cave Hollow-Arbogast System; Lambert Cave, Tucker County; and Rich Mountain Cave, Randolph County.This range may expand as additional caves are surveyed.
Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).
Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting low level of available food.
Populations:
This beetle is known from only four caves in two counties in West Virginia. Population was estimated at less than 1,000 individuals by the West Virginia Natural Heritage Program in January 1991.
Population Trends:
This species is assumed stable as long as there are no major changes in cave habitats.
Status:
P. montanus is located in only four caves in West Virginia (NatureServe 2008). Three of the caves are located in close proximity and are therefore vulnerable to localized destructive events. Its status in West Virginia is critically imperiled.
Habitat destruction:
The three cave systems in Tucker County are concentrated in a small area, and would be highly vulnerable to a localized destructive event, according to NatureServe (2008). Rich mountain Cave in Randolph County is located near a quarry. This species, or its prey may be vulnerable to changes in water quality and/or quantity. Any land use practices that negatively impact groundwater quality or hydrology may be a threat to populations (Culver, pers. comm. cited in NatureServe 2008). Gating may be a threat since this beetle preys on species that rely on transitory organic matter from sporadic cave visitors (Culver, pers. comm. cited in NatureServe 2008).

According to Lewis (2001), P. montanus (and other Pseudanophthalmus cave beetles) face many threats. Specifically:
"Unfortunately, contaminants may be introduced with equal ease, with devastating effects on cave animals. Potential contaminants include (1) sewage or fecal contamination, including sewage plant effluent, septic field waste, campground outhouses, feedlots, grazing pastures or any other source of human or animal waste; (2) pesticides or herbicides used for crops, livestock, trails,

roads or other applications; fertilizers used for crops or lawns ; (3) hazardous material introductions via accidental spills or deliberate dumping, including road salting. Habitat alteration due to sedimentation is a pervasive threat potentially caused by logging, road or other construction, trail building, farming, or any other kind of development that disturbs groundcover. Sedimentation potentially changes cave habitat, blocks recharge sites, or alters flow volume and velocity. Pesticides and other harmful compounds like PCB's can adhere to clay and silt particles and be transported via sedimentation. Impoundments may detrimentally affect cave species. Flooding makes terrestrial habitats unusable and creates changes in stream flow that in turn causes siltation and drastic modification of gravel riffle and pool habitats. Stream back-flooding is also another potential source of introduction of contaminants to cave ecosystems."

"Smoke is another potential source of airborne particulate contamination and hazardous material introduction to the cave environment. Many caves have active air currents that serve to inhale surface air from one entrance and exhale it from another. Potential smoke sources include campfires built in cave entrances, prescribed burns or trash disposal. Concerning the latter, not only may hazardous chemicals be carried into the cave environment, but the residue serves as another source of groundwater contamination. Numerous caves have been affected by quarry activities prior to acquisition. Roadcut construction for highways passing through national forest land is a similar blasting activity and has the potential to destroy or seriously modify cave ecosystems. Indirect effects of blasting include potential destabilization of passages, collapse and destruction of stream passages, changes in water table levels and sediment transport . Oil, gas or water exploration and development may encounter cave passages and introduce drilling mud and fluids into cave passages and streams. Brine produced by wells is extremely toxic, containing high concentrations of dissolved heavy metals, halides or hydrogen sulfide. These substances can enter cave ecosystems through breach of drilling pits, corrosion of inactive well casings, or during injection to increase production of adjacent wells. Cave ecosystems are unfortunately not immune to the introduction of exotic species. Out-competition of native cavernicoles by exotic facultative cavernicoles is becoming more common, with species such as the exotic millipede Oxidus gracilis affecting both terrestrial and aquatic habitats. With the presence of humans in caves comes an increased risk of vandalism or littering of the habitat, disruption of habitat and trampling of fauna, introduction of microbial flora non-native to the cave or introduction of hazardous materials (e.g., spent carbide, batteries). The construction of roads or trails near cave entrances encourages entry." (Internal citations omitted).

Inadequacy of existing regulatory mechanisms:

The entrances to the Cave Hollow-Arbogast System are in the Monongahela National Forest and protected by eight-foot, chain-link fences (NatureServe 2008). The primary concern of the management program is to control access. Casual visitors are discouraged, and most visits are limited to ones with a scientific or conservation purpose. It is a U.S. Forest Service Regional Forester Sensitive Species, but this protection is discretionary and may not protect water quality in the cave from activities permitted on the forest such as logging and oil and gas drilling.

Lewis (2001) reports that "[t]he existing (1985) Monongahela Land and Resource Management Plan does not provide management direction for caves although they are being considered in the Forest Plan revision currently underway. A Forest Plan Amendment in progress for Threatened and Endangered Species will include management for the caves on the forest."

The Revised Monongahela National Forest Plan (USFS 2006) requires the following management for caves:

"Cave entry during closed periods for scientific study and observation may be permitted by Forest Supervisor's written approval and permit from USFWS or delegated authority. Gates or fences installed at cave entrances shall allow free entry and exit by TEP species and shall not restrict normal airflows. Gate installation that disturbs a cave feature or floor must have an archaeological survey prior to disturbance. Gates and fences shall be monitored and maintained. Base monitoring frequency on past cave visits, access, and potential for disturbance. Maintenance and repair of gates shall be undertaken within a reasonable time frame from vandalism discovery."

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Culver, Dr. David C., Department of Biology, American University, 4400 Mass. Ave. NW, Washington DC, 20016 202-885-2180

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Scientific Name:
Pseudanophthalmus pontis
Common Name:
Natural Bridge Cave Beetle

G Rank:
G1

Range:
This beetle occurs in a single cave in Rockbridge County, Virginia (Holsinger and Culver 1988), it was not found in nearby caves that have been surveyed.

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
Found in only one cave to date (Holsinger and Culver 1988), this species is known from only five individuals (Barr 1965).

Population Trends:
Alterations to the cave have likely been detrimental to the population, but trend is not quantified because this species is known from few individuals (NatureServe 2008).

Status:
P. pontis is critically imperiled (NatureServe 2008) and is a Virginia Species of Concern. It is endemic to one cave which is known to have been altered and has not been reported since 1965 (NatureServe 2008).

Habitat destruction:
The Natural Bridge Cave has been drastically altered in the past by a private owner (NatureServe 2008). This cave may be used for recreational spelunking in addition to commercial operations.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species which occurs in a single privately owned cave.

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Scientific Name:
Pseudanophthalmus potomaca
Common Name:
South Branch Valley Cave Beetle

G Rank:
G3

Range:
P. potomaca is known from five to six caves in three adjoining counties of West Virginia and Virginia. The caves (Holsinger and Culver, 1988) span approximately 50 kilometers (NatureServe 2008).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food (NatureServe 2008).

Populations:
NatureServe (2008) estimates that less than 5 populations with fewer than 1000 individuals of this species exist. P. potomaca is known from five to six caves in three adjoining counties of West Virginia and Virginia. Nominate subspecies are known from three to four caves (one in West Virginia and two to three in Virginia).

Status:
NatureServe (2008) ranks this species as critically imperiled in West Virginia and imperiled in Virginia. It is a Virginia Species of Concern,and a West Virginia Species of Greatest Conservation Need.

Habitat destruction:
Although one site occupied by P. potomaca is closed due to visitation pressures, there remain threats to water quality via pollution of ground water sources (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
The entrance to one Virginia cave occupied by this species is closed (NatureServe 2008). No regulatory mechanisms currently protect this species.

References:

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Scientific Name:
Pseudanophthalmus praetermissus
Common Name:
Overlooked Cave Beetle

G Rank:
G1

Range:
The Overlooked Cave Beetle is endemic to Scott County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food (NatureServe 2008).

Populations:
This species is known from four individuals that were collected from one cave (Holsinger and Culver 1988).

Status:
P. praetermissis is endemic to one cave and hasn't been seen in 20 years, but no recent surveys are known (NatureServe 2008). It is ranked as critically imperiled (NatureServe 2008), and is a Virginia Species of Concern.

Habitat destruction:
The cave inhabited by the Overlooked cave beetle may be used for recreational spelunking (NatureServe 2008). This species is also threatened by pollution from mountaintop removal coal mining (EPA 2005).

Inadequacy of existing regulatory mechanisms:
The cave occupied by this species is privately owned (NatureServe 2008). No existing regulatory mechanisms protect this species.

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Scientific Name:
Pseudanophthalmus sanctipauli
Common Name:
Saint Paul Cave Beetle

G Rank:
G1

Range:
The St. Paul Cave beetle is endemic to Russell and Scott Counties, Virginia. Known localities are separated by about 13 kilometers (NatureServe 2008).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
NatureServe (2008) reports that P. sanctipauli has been found in only two locations to date, with only five individuals ever collected and identified.

Status:
This species is limited to two localities in fragile cave habitat (NatureServe 2008). It is a Virginia Species of Concern classified as critically imperiled by NatureServe (2008).

Habitat destruction:
Caves inhabited by Saint Paul Cave beetles may be used for recreational spelunking (NatureServe 2008). This species is also threatened by mountaintop removal coal mining (EPA 2005).

Inadequacy of existing regulatory mechanisms:
St. Paul Cave is privately owned, and no regulatory mechanisms currently protect this species.

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Wood, D. 2009. Memorandum to J. Bailey, J. Wirts, and P. Campbell. Evidence for Secretary Randy Huffman. June 30, 2009. West Virginia Department of Environmental Protection, Charleston, WV.

Scientific Name:
Pseudanophthalmus sericus
Common Name:
Silken Cave Beetle

G Rank:
G1

Range:
Pseudanophthalmus sericus is endemic to Scott County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
This beetle occurs in a single cave (Holsinger and Culver, 1988). Nearby caves are inhabited by P. thomasi. Only ten individuals have ever been collected and identified.

Population Trends:
This beetle was not found during three surveys in the 1990's.

Status:
P. sericus is endemic to one cave and hasn't been seen in 30 years, according to NatureServe (2008). Given the fragility of cave habitat, it is ranked as critically imperiled (NatureServe 2008). It is a Virginia Species of Concern.

Habitat destruction:
Caves inhabited by the Silken Cave beetle may be used for recreational spelunking (NatureServe 2008). This species is also threatened by mountaintop removal coal mining (EPA 2005).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), the cave occupied by P. sericus is privately owned. The landowner expressed some desire to protect this cave in the past. The primary threat to this species may be pollution from outside the cave, particularly from surface coal mining. No existing regulatory mechanisms protect this species.

References:

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Scientific Name:
Pseudanophthalmus thomasi
Common Name:
Thomas' Cave Beetle

G Rank:
G1

Range:
All known localities of Psuedanophthalmus thomasi are within about 10 kilometers of each other in Scott County, Virginia (Holsinger and Culver 1988).

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food (NatureServe 2008).

Populations:
Thomas' Cave beetle is only known from two localities (Holsinger and Culver 1988). Only eight individuals have ever been collected and identified.

Status:
NatureServe (2008) ranks this species as critically imperiled, and it is a Virginia Species of Concern.

Habitat destruction:
This species is threatened by mountaintop removal coal mining (EPA 2005). It is possibly threatened by occasional spelunking at one site, but the owner restricts access making outside pollution the greatest threat to this species.

Inadequacy of existing regulatory mechanisms:
Both caves occupied by this species are privately owned. The owner restricts access to Blair-Collins Cave to speleological studies only. No regulatory mechanisms protect this species.

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Scientific Name:
Pseudanophthalmus virginicus
Common Name:
Maiden Spring Cave Beetle

G Rank:
G1

Range:
This beetle is endemic to one cave in Tazewell County, VA (Holsinger and Culver 1988). Nearby caves are inhabited by different species of cave beetles.

Habitat:
Beetles of this genus typically occur in the twilight zone or deeper in or on moist soil, often near streams or drip areas. They probably burrow some, especially larvae. They are often found under rocks or debris (NatureServe 2008).

Ecology:
Species of this genus seem to occur as sparse populations, probably reflecting a low level of available food.

Populations:
This species occurs in very low abundance in a single cave (Holsinger and Culver 1988). Ten surveys of Hugh-Young Cave have been conducted by J. R. Holsinger and his cave biology classes between 1976 and 1998 with no additional observations or collections. Other surveys by J. R. Holsinger have not been successful in locating this species. Only two specimens have ever been collected (Barr 1960, 1981) and identified despite multiple surveys.

Status:
Pseudanopthalmus virginicus is apparently endemic to one cave and is very rare in that cave (NatureServe 2008). It hasn't been seen since 1966 despite frequent survey efforts and may be extinct. However, the condition of the cave is good, so there is good potential for eventual rediscovery, particularly through the use of baiting techniques. It is a Virginia Species of Concern and is ranked as critically imperiled by NatureServe (2008).

Habitat destruction:
There is a stream in the Maiden Spring Cave that may be susceptible to pollution from ground water sources (NatureServe 2008).
This species is also threatened by mountaintop removal coal mining (EPA 2005).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), Maiden Spring Cave is privately owned. The owner is extremely restrictive on access, and permits entry by a few individuals only for speleological studies. No regulatory mechanisms protect this species, which is primarily threatened by pollution from sources outside the cave including coal mining.

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Scientific Name:
Pseudemys nelsoni pop. 1
Common Name:
Florida Red-bellied Turtle - Florida Panhandle

G Rank:
T2

Range:
The range of this turtle encompasses less than 100-250 square km (about 40-100 square miles) in the Florida Panhandle. It is found in the lower Apalachicola/Chipola River drainage and associated delta and offshore islands, disjunct from the main population in peninsular Florida (NatureServe 2008).

Habitat:
This turtle occurs in ponds, lakes, and sluggish portions of rivers. It uses adjacent upland habitat for nesting, typically in sunny locations. It potentially uses alligator nests for nesting (NatureServe 2008).

Populations:
There are only six known occurrences of this turtle, and local populations are thought to be small. Total population size is estimated at 250-2500 individuals. It occurs in a relatively small area that is disjunct from the main population of the species (NatureServe 2008).

Population Trends:
No data on population trend are available.

Status:
Pseudemys nelsoni pop. 1 is imperiled in Florida (T2S2) (NatureServe 2008).

Habitat destruction:
Because there are only six known localities of this turtle, it is especially vulnerable to habitat loss. The Florida Natural Areas Inventory (2001) reports that the Chipola River is threatened by habitat degradation from pollution, siltation, impoundment, water withdrawal, drought, and other disturbances, including logging, livestock grazing, and development (http://www.myfwc.com/docs/FWCG/chipola_slabshell.pdf).

Overutilization:
This turtle may be harvested for use as food by turtle trappers (NatureServe 2008). Given its small overall population size, limited distribution, and life-history strategy which depends on adult survivorship, any level of collection makes populations vulnerable to extirpation. Studies have shown that the removal of long-lived, slow-growing animals with life history traits designed for replacement reproduction spread out over the course of a lifetime results in population decline (Congdon et al. 1993, 1994). The elimination of individuals from populations that are already threatened because of habitat degradation is an additive impact on already stressed populations. Buhlmann and Gibbons (1997) state that even presently abundant species are of concern because of the vast numbers of freshwater turtles being removed from the wild and shipped to other countries. The Florida Fish and Wildlife Conservation Commission reports that demand for freshwater turtles is increasing. In recent decades heavy commercial harvest of southeastern freshwater turtles has occurred to meet foreign demand for turtles for use as meat, pets, and in traditional medicine. Over 13 million adult turtles were being sold annually in Asian countries by

the late 1990s. Even limited take of turtles is unsustainable because of the key role of large adult female turtles in sustaining populations (http://myfwc.com/docs/CommissionMeetings/2009/2009_Apr_FreshwaterTurtle.pdf).

Disease or predation:

Predation, especially in conjunction with drought, poses a serious threat for this turtle. Nonriverine populations may be extirpated by predation during drought (NatureServe 2008). At the local level, the effects of predation can be severe, especially on small populations or populations that are stressed by other factors. Raccoons are known to prey heavily on both eggs and young turtles, and fish crows depredate nests (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect this turtle. It lacks state status. It occurs on St. Vincent National Wildlife Refuge in Franklin County.

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Jackson, D. R. (Dr.). Senior Research Zoologist, Florida Natural Areas Inventory, 1018 Thomasville Road, Suite 200-C, Tallahassee, FL 32309. Tel: (850) 224-8207 x 212. E-mail: <djackson@fnai.org>

Scientific Name:
Pseudemys rubriventris
Common Name:
Northern Red-bellied Cooter

G Rank:
G5

IUCN Status:
NT - Near threatened

Range:
The northern red-bellied cooter, Pseudemys rubriventris, is a species of freshwater turtle endemic to the eastern United States. It is found in Delaware, Washington, D.C., Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Virginia, and West Virginia (NatureServe 2008).

Habitat:
This turtle primarily inhabits herbaceous wetlands or riparian areas, and large, deep bodies of water: medium-sized to large rivers with low to moderate flow gradients, marshes, and ponds or lakes (NatureServe 2008). Though it is a freshwater species, it may also be found in brackish waters. P. rubriventris prefers habitat with soft benthic substrate and plentiful aquatic vegetation (NatureServe 2008). The northern red-bellied cooter is terrestrially active in spring and fall, and may utilize sand dune habitat adjacent to its preferred aquatic habitat for burrowing as it aestivates in extremely hot conditions (NatureServe 2008). Both in terms of terrestrial and aquatic habitat, this species relies on fallen logs, large rocks, or other debris for diurnal basking (NatureServe 2008). This species hibernates at the bottom of ponds or other bodies of water during the winter months; in Massachusetts, it is reportedly active between March and October (USFWS 1981).

Ecology:
P. rubriventris reaches sexual maturity between the ages of 5-9 years (USFWS 1981, DeGraaf and Rudis 1983). Females lay clutches of 8-20 eggs in June or July, nesting in soft soil or sandy habitat, generally within 100 m of water; incubation time is between 10 and 15 weeks (US FWS 1981). After hatching, hatchlings often overwinter in the nest and emerge in spring. Juveniles are essentially omnivorous in most locations, consuming invertebrates, plant material, and fish, while adults are almost exclusively herbivorous (Ernst and Barbour 1972, Mitchell 1994).

Populations:
NatureServe (2008) reports that there are many occurrences of P. rubriventris in the core of its range (Maryland, Virginia, Delaware, New Jersey), but that populations are small elsewhere.

Population Trends:
NatureServe (2008) reports that this species is experiencing significant decline.

Status:
NatureServe (2008) lists the Northern Red-bellied Cooter as imperiled in Pennsylvania and West Virginia, vulnerable in North Carolina, apparently secure in Washington, D.C., New Jersey, and Virginia, and secure in Delaware and Maryland. Its status is under review in New York.

It is state- listed as threatened in West Virginia.

Habitat destruction:
Populations along the Delaware River in Pennsylvania have declined because of various effects of industrial expansion, wetland drainage, water pollution, and mosquito control efforts (pesticide contamination, Ernst et al. 1994).

Residential development threatens this species in parts of its range; road construction is particularly devastating to slow-moving species that range across the landscape as P. rubriventris does because of their vulnerability to road mortality. The loss of mature individuals is devastating to turtle populations because of their slow maturation, and on-road mortality has been linked to significant changes in population structure in some turtle species (Steen and Gibbs 2004, Gibbs and Shriver 2002).

Overutilization:
This species was widely collected and marketed as food in the late 19th century, causing the decline of several populations in the East (PA NHP 2009).

Disease or predation:
The northern red-bellied cooter has several natural predators, which, under normal circumstances, do not exert significant pressure on turtle populations. However, residential and agricultural development fragment natural habitat, exposing populations of P. rubriventris to increased nest predation by raccoons, foxes, and other egg predators (PA NHP 2009).

Inadequacy of existing regulatory mechanisms:
Though this species is listed as threatened or endangered in a few states, these designations do not afford the northern red-bellied cooter any substantial regulatory protection. The Massachusetts population (subspecies P. r. bangsi) is federally endangered, but this does not in any way protect the remainder of the population.

Other factors:
Mercury contamination may threaten this species in some locations, though its dietary habits make it less likely to bioaccumulate high levels of mercury than other more carnivorous turtle species (Bergeron et al. 2007).

This species' life history, as characterized by slow maturation and low recruitment of juveniles, makes it especially vulnerable to steep population declines; populations grow slowly, and do not rebound easily from the loss of mature individuals (Nelson et al. 2009, Gibbs and Shriver 2002).

Isolated incidents like the one reported by Saba and Spotila (2003), in which an oil spill affected several freshwater turtle species in a wildlife refuge in southeastern Pennsylvania, may have lasting consequences for reproduction and recruitment that were not explored by this study.

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Scientific Name:
Pseudobranchus striatus lustricolus
Common Name:
Gulf Hammock Dwarf Siren

G Rank:
T1

Range:
The Gulf Hammock Dwarf Siren is known only from the coastal area of Levy and Citrus counties in Florida. The reported range is very small and is impinged upon by other Pseudobranchus taxa (NatureServe 2008).

Habitat:
This salamander's habitat consists of wetlands within hydric hardwood hammock (Gulf Hammock) areas, including stagnant bogs and decaying organic mucks associated with weedy cypress and flatwoods ponds, ditches, and small floodplain lakes (NatureServe 2008). This species is associated with cypress (Taxodium sp.) or gum (Nyssa sp.) ponds and other shallow, acidic, flatwood wetlands, floating mats of frog's-bit (Limnobium spongium), decaying bottom vegetation, and the soft, mucky soils of pond margins (Le Conte 1824, Goin and Crenshaw 1949, Moler and Kezer 1993, in AmphibiaWeb 2009).

Ecology:
Conant and Collins (1991) describe dwarf sirens as small, aquatic eel-like salamanders with tiny forelegs and external gills the size of which depends upon water temperature and other conditions. Dwarf Sirens prey upon aquatic invertabrates and insects (Conant and Collins 1991). Eggs are deposited singly or in small bunches among aquatic vegetation (Noble 1930), and clutch size is unknown (AmphibiaWeb 2009). Ashton and Ashton (1988) indicate Pseudobranchus larvae make take 2 yr to reach sexual maturity (AmphibiaWeb 2009). Potential predators of this species include Southern banded water snakes (Nerodia fasciata), black swamp snakes (Seminatrix pygaea), mud snakes (Farancia abacura), and crayfish snakes (Regina sp.), various species of wading birds, and predaceous fishes. Predation levels are likely intensified when dwarf sirens are concentrated by falling water levels (AmphibiaWeb 2009).

Populations:
Number of extant populations and population size are unknown for this species, which has not been detected in more than 40 years (NatureServe 2008).

Population Trends:
This salamander has declined to rarity or is possibly extirpated (NatureServe 2008).

Status:
The Gulf Hammock Dwarf Siren is critically imperiled in Florida (S1) (NatureServe 2008). It lacks legal protective status.

Habitat destruction:
The Gulf Hammock region has been severely degraded by commercial forestry (NatureServe 2008). Populations of Gulf Hammock Dwarf Siren have been lost as wetland habitats have been reduced through drainage of surface waters associated with residential, agricultural, and silvicultural development (AmphibiaWeb 2009). The Florida Wildlife Conservation Commission reports that the Gulf Hammock Dwarf Siren's lake habitat in Florida is highly threatened by altered hydrologic regime, altered landscape mosaic, altered species composition, and deterioration of water quality

(http://myfwc.com/docs/WildlifeHabitats/Legacy_Natural_Lake.pdf). The salamander's swamp habitat is threatened by conversion to agriculture, conversion to housing and urban development, groundwater withdrawal, insufficient fire regime, roads, water withdrawal and diversion, and eutrophication (http://myfwc.com/docs/WildlifeHabitats/Legacy_Bay_Swamp.pdf). The Service has reported that this salamander's habitat faces multiple threats including land conversion, logging, grazing, water diversion, pollution, and rising sea levels (Simons et al. 1989).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: "The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: "Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)" (p. 327).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from coal mining activities in Alabama, Georgia, Kentucky, Tennessee, Virginia, and West Virginia, and by phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007).
Dodd (1997) states: "In many instances, mining occurs directly through small streams or ponds, and mine tailings are pushed into the larger rivers. . . Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers" (p. 180). Gore (1983) showed that low pH and high conductivity due to mining negatively affect the distribution of larval Desmognathus salamanders in streams on the Cumberland Plateau (in Dodd 1997).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: “Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park” (p. 180).

Overutilization:

Because the Gulf Hammock Dwarf Siren is extremely rare, it is very vulnerable to collection. Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: “Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available” (p. 183).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect this species, and no occurrences are appropriately protected (NatureServe 2008). Much of this species' range is in the Gulf Hammock Wildlife Management Area. NatureServe (2008) recommends protecting any habitat whiich is found to harbor this species, and considering state and federal listing.

Other factors:

Dodd (1997) lists rarity as a potential threat to the Gulf Hammock Dwarf Siren.

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats. The salamander’s swamp habitat is threatened by conversion to agriculture, conversion to housing and urban development, groundwater withdrawal, insufficient fire regime, roads, water withdrawal and diversion, and eutrophication (http://myfwc.com/docs/WildlifeHabitats/Legacy_Bay_Swamp.pdf).

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations” (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

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Scientific Name:
Pteronotropis euryzonus
Common Name:
Broadstripe Shiner

G Rank:	**AFS Status:**
G3	Vulnerable

Range:
The broadstripe shiner has a restricted range in tributaries of the middle Chattahoochee River system of Georgia and Alabama near and below the Fall Line (Lee et al. 1980, Page and Burr 1991, Freeman and Albanese 2009, Boschung and Mayden 2004).

Habitat:
The broadstripe shiner occurs in small, clear or tannin-stained streams with moderate current, in association with vegetation or logs (Lee et al. 1980, Page and Burr 1991, Boschung and Mayden 2004). It is generally found in headwaters (SFC and CBD 2010).

Populations:
Johnston (2004) notes that the broadstripe shiner has suffered a 70 percent reduction in its distribution in Alabama because of habitat degradation in Uchee Creek, and that only eight localities are known in Georgia. Boschung and Mayden (2004) show 23 localities in Alabama.

Population Trends:
The species has experienced a roughly 70 percent reduction in range in Alabama (Johnston 2004). More specifically, in Uchee Creek between Auburn and Phoenix City broadstripe shiner have experienced declines during the last 30 years, and may be further stressed as the region develops in association with an influx of more personel at Fort Benning (SFC and CBD 2010). Populations appear more stable in Georgia (SFC and CBD 2010).

Status:
NatureServe (2008) lists the broadstripe shiner as imperiled in both Georgia and Alabama and vulnerable over all. Johnston (2004) list the species as of high conservation concern, Freeman and Albanese (2009) list it as rare, and Jelks et al. (2008) list it as vulnerable based on the present or threatened destruction, modification or reduction of habitat or range. Although it apparently can be common in the small isolated reaches where it occurs (NatureServe 2008), the broadstripe shiner remains at risk because of its limited distribution and sensitivity to habitat alteration. Johnston (2004) observed that: "As a headwater stream specialist, populations in Alabama are almost certainly isolated from Georgia populations, and recolonization opportunities may not exist," adding that it is therfore "critical to protect species throughout its distribution." The broadstripe shiner was formerly considered a C2 candidate for listing by the U.S. Fish and Wildlife Service before this category was abolished. At a meeting of the Southeastern Fishes Council and CBD, there was tenative support for listing the broadstripe shiner as threatened based on its status in Alabama (SFC and CBD 2010).

Habitat destruction:
Jelks et al. (2008) identify the present or threatened destruction, modification or reduction of range as a factor in the broadstripe shiner being vulnerable. NatureServe (2008) cite information that the shiner is "moderately threatened, mainly due to siltation that affects aquatic vegetation." Johnston (2004) notes that the species has suffered a 70 percent distribution decline because of

habitat degradation in Uchee Creek. Freeman and Albanese (2009) observe that "The major threat to the survival of broadstripe shiners is water quality and habitat degradation in tributary streams to the Chattahoochee River." Taken together, this information demonstrates the broadstripe shiner is threatened by habitat degradation in a significant portion of range.

Water withdrawal, poor land management from agriculture, sod farms and pine conversion and development encroachment are the major sources of habitat degradation on the Uchee (SFC and CBD 2010). Expansion of Fort Benning poses an additional threat to the broadstripe shiner (Ibid.)

Inadequacy of existing regulatory mechanisms:
There are currently no efforts to protect or recover the broadstripe shiner and no populations are known to be protected (NatureServe 2008).

Other factors:
Freeman and Albanese (2009) note that "restricted range and localized distributions further contribute to the vulnerability of this species." This fish is threatened by water pollution, primarily from siltation (NatureServe 2008).

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Scientific Name:
Pteronotropis hubbsi
Common Name:
Bluehead Shiner

G Rank:
G3

IUCN Status:
DD - Data deficient

Range:
The bluehead shiner occurs west of the Mississippi River in Arkansas, Louisiana, Oklahoma, and Texas, and occurred historically in Illinois. This fish is sporadically distributed in the lowlands of the Red, Atchafalaya and Ouachita river systems in southern Arkansas and extreme southeastern Oklahoma (Taylor and Norris 1992), extreme northeastern Texas, and Louisiana. Most occurrences are in southern Arkansas and northern Louisiana. The apparent disjunction in the range between Illinois and the nearest Arkansas population is likely due to the destruction of much of the species' habitat before it was described in 1954 (NatureServe 2008).

Habitat:
This fish occurs in quiet backwater areas and pools with mud or mud-sand substrates in small to medium-sized, sluggish streams and oxbow lakes. It is associated with tannin-stained water and dense vegetation (Bailey and Robison 1978). In Illinois, it occurred in tannin-colored water along the lake margins of a single lake, over mud, decaying plants and submerged logs, and also in a few springs with dense submerged aquatic plants (Burr and Warren 1986). When disturbed, schools of this fish seek cover in vegetation (Bailey and Robison 1978). In Louisiana, this fish has been reported spawning in nests apparently built by warmouth sunfish among bald cypress roots in a side bay off a bayou. This fish also may spawn among other woody plant roots, and may not always use warmouth nests (NatureServe 2008).

Ecology:
This species has numerous fish associates (Bailey and Robison 1978). Predators include two pike (Esox spp.) and largemouth bass (Micropterus salmoides). Adults have been detected only rarely outside the breeding season (April-July) (NatureServe 2008).

Populations:
There are 32 known sites for this species, but the number of distinct occurrences has not been determined (NatureServe 2008). This fish is currently extant in only three river drainages. It is likely under-sampled as no systematic range-wide search has been conducted due to the difficulty of accessing its habitat. It is extirpated in Illinois, but a reintroduction attempt was made at Wolf Lake in 1992, but apparently failed (Ranvestel and Burr 2002). Only one population is known from Texas, at Caddo Lake. There are ten known locations in Louisiana but these may not all represent distinct populations. In Oklahoma, there are two known locations. In Arkansas, it is known from 18 collection stations in nine counties (NatureServe 2008).

The population at Caddo Lake in Texas is estimated to number in the thousands (Price 1992). Populations of this species show high levels of geographic and temporal variability, and conventional sampling methods can be ineffective in its densely vegetated habitat. Abundance from collections in the Ouachita River and nearby backwaters has fluctuated drastically. Collections from these sites from 1967-83 produced only 3 specimens, but 938 individuals were collected from 1984-91, but then from 1992-1995, no individuals were detected (Ranvestel and Burr 2002).

Population Trends:

Short-term trend information is unavailable for this species, but over the long-term it has experienced a decline of 25-75 percent (NatureServe 2008). It is likely extirpated in Illinois where it occurred historically at three locations but has not been detected since the mid-1970's, despite intensive sampling efforts (Ranvestel and Burr 2002). The Arkansas Game and Fish Commission (2005) report that it is declining in Arkansas. The population in the Ouachita River drainage in northeastern Louisiana expanded dramatically between 1983 and 1991, but wasn't detected at all from 1992-1995.

Status:

NatureServe (2008) ranks the bluehead shiner as extirpated in Illinois, critically imperiled in Oklahoma and Texas, imperiled in Louisiana, and vulnerable in Arkansas. It is classified as vulnerable by the American Fisheries Society (Jelks et al. 2008) due to habitat loss. It is listed by the state of Texas as threatened, and by the state of Illinois as endangered, but it is likely extirpated in Illinois. It is a Species of Special Concern in Arkansas and Oklahoma (Scharpf 2005).

Habitat destruction:

The Arkansas Game and Fish Commission (2005) reports that the bluehead shiner is threatened by sedimentation and habitat destruction caused by resource extraction, channel alteration, and forestry. This fish is threatened by the draining, filling, farming, and/or flooding of backwater swamp habitat, by gravel removal, stream-channel alteration, and by construction of small impoundments which block dispersal and migration (NatureServe 2008). Ranvestel and Burr (2002) provide the following description of threats to this species' habitat: "Habitat degradation caused by anthropogenic disturbance is probably the greatest threat to the persistence of healthy populations of P. hubbsi in the wild. In fact, Fletcher and Burr (1992) suggest that the large gap between the P. hubbsi population in southern Illinois and the next closest population in Arkansas is not due to lack of collecting in suitable habitat, as suggested by Bailey and Robison (1978), but rather due to relatively recent habitat alteration. Swamp habitat is disappearing quickly in southern Illinois (Phillippi et al. 1986), southeastern Missouri (Pfleiger 1997), western Kentucky (Burr and Warren 1986), western Tennessee, and northeastern Arkansas (Robison and Buchanan 1988) where P. hubbsi may have historically occurred. Many swamps have been channelized, dredged, cleared, drained, and converted to agricultural crops (Fletcher and Burr 1992). Lowland streams of the Ouachita River sytem, including the type locality of P. hubbsi in Arkansas, are threatened by gravel removal operations (Robison and Buchanan 1988)." Jelks et al. (2008) list habitat loss as a threat to this species.

Overutilization:

The Arkansas Game and Fish Commission (2005) reports that the bluehead shiner is threatened by commercial harvest. Because of their striking breeding colors and rarity in the wild, P. hubbsi are highly coveted in the aquarium trade. Overcollection of P. hubbsi from the wild, in conjunction with their short lifespan, disjunct distribution, and already frail status, leave populations highly vulnerable to decline (Scharpf 2002, Ravenstel and Burr 2002).

Disease or predation:

Bluehead shiners are heavily preyed upon in the wild, but the population effects of predation are not known. Predatory fishes commonly co-occur with P. hubbsi, and may or may not have noticeable negative effects on P. hubbsi populations. Fletcher and Burr (1992) documented P.

hubbsi larvae and adults inside the stomachs of pickerels (Esox americanus) and largemouth bass (Micropterus salmoides). Lemmons et al. (1997) suggest that predatory bowfin may exclude bluehead shiners from certain habitats. Warren et al. (1991) suggest that predation possibly contributed to the extirpation of this species in Illinois.

Populations of P. hubbsi can be heavily infested with parasites and disease. Necropsies of dead or dying individuals from a wild population of P. hubbsi revealed that gills, fins, and body surfaces were heavily infested with Lernaea cyprinacea, a copepod parasite. The gills of individuals were also infected with a Trichodina- like ciliate. Some individuals had columnaris disease caused by the bacterium Flexibacter columnaris. Within about two weeks, nine of 11 individuals placed in an aquarium died from these afflictions (Burr and Heidinger 1987).

In conjunction with other threats, disease and predation could increasingly threaten wild populations of this species.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which adequately protect this species. It is listed as endangered by Illinois, but is likely extirpated in the state. It is listed as threatened by the state of Texas, but this designation does not confer substantial protection to the species or its habitat. Ranvestel and Burr (2002) state that they do not know of any aquatic preserves within the range of P. hubbsi that are designed especially to protect fish communities in swamp- like habitats. In Oklahoma, there is an occurrence in the Little River National Wildlife Refuge.

Other factors:

The bluehead shiner is particularly vulnerable to catastrophic events due to its short life span, limited distribution, and low genetic diversity (Warren et al. 1991). Populations of this fish fluctuate widely, apparently in response to altered hydrologic conditions, making it vulnerable to drought, flooding, and global climate change (Douglas 1992). Chronic and acute pollution events also threaten this fish, and likely contributed to its apparent extirpation in Illinois (Ranvestel and Burr 2002). In the 1970's, train derailments spilled hundreds of pounds of acids and toxic chemicals into the lake in Illinois where this fish formerly occurred (Smith 1979, Burr and Warren 1986). In 1975, an accidental spill reduced the lake pH to 3.1, further threatening aquatic life (Ranvestel and Burr 2002).

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Scientific Name:
Ptilimnium ahlesii
Common Name:
Carolina Bishopweed
G Rank:
G1
Range:
This species occurs very sporadically in freshwater tidal marshes from the outer coastal plain of southeastern North Carolina through South Carolina and into eastern Georgia (NatureServe 2008).
Habitat:
This plant is found in freshwater tidal marshes.
Ecology:
The Carolina bishopweed flowers from June-August.
Populations:
Only three occurrences of this plant are currently known, one in North Carolina's Cape Fear River marshes, one in Georgia's Savanna River, and one at the mouth of the Ashley-Cooper River near Charleston, South Carolina (NatureServe 2008). It seems likely that at least a few other occurrences may be present in nearby habitat. Population sizes are unknown.
Population Trends:
Trend information is not available for this species.
Status:
Only three disjunct occurrences of this species are known, and they are threatened by various factors, particularly non-native species and water pollution. NatureServe (2008) ranks the Carolina bishopweed as critically imperiled in North Carolina and possibly extirpated in Georgia (occurrences not recently confirmed). It is not ranked in South Carolina.
Habitat destruction:
The Carolina bishopweed is threatened by habitat loss and degradation caused by the deposition of dredge spoils and the intrusion of saltwater into freshwater tidal marshes caused by dredging, channelization, or other anthropogenic alteration of local hydrology (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though one occurrence is found within the Savanna River National Wildlife Refuge, no regulatory mechanisms adequately protect this species from the variety of threats it faces.
Other factors:
Invasion by Phragmites spp. has been reported in several parts of this species' range, including the Cape Fear River marshes (NatureServe 2008). This species is also threatened by water pollution from industry (NatureServe 2008).

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Scientific Name:
Ptychobranchus jonesi
Common Name:
Southern Kidneyshell

G Rank:	**AFS Status:**	**IUCN Status:**
G1	Threatened	CR - Critically endangered

Range:
The range of the Southern Kidneyshell encompasses less than 100 square km in the Escambia and Yellow river drainages in Alabama, and the Choctawhatchee river drainage in Alabama and Florida (Williams and Butler 1994, Butler 1989). There are 23 known historical locations for this species-- seven in the Escambia River drainage, two in the Yellow River drainage, and 14 in the Choctawhatchee River drainage. The only recent detection in Alabama is from the west fork of the Choctawhatchee River (Mirarchi et al. 2004). Blalock-Herod et al. (2005) noted very severe decline and found live individuals at only one historical site within the Choctawhatchee River drainage.

Habitat:
The southern kidneyshell is known from medium-sized creeks to rivers in silty sand substrates with slow current and woody debris (Williams and Butler 1994). It has also been located in claystone depressions (Blalock-Herod et al. 2005).

Ecology:
Little is known about the ecology of this species; it is presumed to be a long-term brooder (Mirarchi et al. 2004).

Populations:
There are only from 1-5 extant populations of Southern Kidneyshell. Of 23 historical locations, three have unknown population status, 18 -19 are inactive, and only one to two are active, representing a 78 - 83 percent decline in the number of sites supporting this mussel. It is unknown if these remaining populations are capable of reproduction and recruitment (USFWS 2003). This mussel has been located at only 2 of 14 historical sites in the Choctawhatchee River drainage, one on the Pea River in Coffee County, Alabama, and one on the West Fork Choctawhatchee River in Barbour County, Alabama (Williams et al. 2000; Blalock-Herod et al. 2005). Johnson (1967) lists historical sites in the Pea River drainage in Alabama and the Choctawhatchee River drainage in Alabama (both Choctawhatchee River system). Population abundance is low with an average of 6 individuals detected per site (Blalock-Herod et al., 2005). Population status is undetermined at one site in the Escambia and one site in the Yellow River basins. The remaining sites in these two drainages are inactive and the southern kidneyshell may be extirpated from these basins. The Pea River population may have recently become extirpated. This population was assessed in the early 1990s, but when the locality was revisited in 1998, southern kidneyshells were not located (Blalock-Herod et al., 2005). Blalock-Herod et al. (2005) noted very severe decline and found live individuals at only one historical site within the Choctawhatchee River drainage as well as sites where the species was found in 1993 (finding none) and found no new sites. Pilarczyk et al. (2006) reports this species at only one of 24 surveyed sites.

NatureServe (2008) estimates total population size at 50 - 1000 individuals, but this may be an overestimate. At the best known site in 1988, ten individuals were detected, but only three were detected there in the later 1990's (Butler, pers. comm., 1998, cited in NatureServe 2008).

Blalock-Herod et al. (2005) noted very severe decline and found live individuals at only one historical site within the Choctawhatchee River drainage, and did not detect this species at sites where the species was extant in 1993.

Population Trends:

The Southern Kidneyshell is severely declining in the short term (decline of greater than 70 percent) and has experienced a very large long-term decline of greater than 90 percent (NatureServe 2008). This species has experienced severe range reduction and now occurs in low abundance within its limited range. There are only 1-2 sites with active populations of this species.

Status:

NatureServe (2008) ranks the Southern Kidneyshell as critically imperiled in Alabama (S1), and state historical in FLorida (SH). It is ranked as critically endangered by the IUCN. This mussel is in dire need of federal protection. NatureServe (2008) states: "This species is rapidly declining, has an extremely limited distribution (one or two sites), restricted habitat, low number of extant occurrences, overall deteriorating habitat and water quality, and reduction (perhaps to zero or one) of number of viable populations." Its rank is being changed from threatened (Williams et al. 1993) to endangered (2010 draft, in review) by the American Fisheries Society.

Habitat destruction:

Because there are only two remaining locations for this species, habitat loss and degradation is a dire threat to its survival. NatureServe (2008) states that the greatest threat to the Southern Kidneyshell is habitat loss and degradation, reporting the following threats: "siltation from poorly conducted agricultural and silvicultural activities; chicken farm litter nutrients (southern Alabama); localized gravel/sand mining, gas and oil exploration (Escambia River, Alabama); localized industrial (pulp mill on the Escambia River near the Alabama/Florida border) and municipal pollution; and general watershed development (e.g., transportation projects, dams). Logging and chicken farms are expanding industries in south Alabama. A proposed Army Corps of Engineers dam, being pushed by local politicians, threatens many miles of riverine habitat, particularly in Alabama. The stream and river habitats are vulnerable to habitat modification, sedimentation, and water quality degradation from a number of activities. Highway and reservoir construction, improper logging practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing often result in physical disturbance of stream substrates or the riparian zone, and/or changes in water quality, temperature, or flow. Sedimentation can cause direct mortality of mussels by deposition and suffocation (Ellis, 1936; Brim Box and Mossa, 1999) and can eliminate or reduce the recruitment of juvenile mussels (Negus, 1966; Brim Box and Mossa, 1999). Suspended sediment can also interfere with feeding activity of mussels (Dennis, 1984). Many of the confirmed extant populations of this species are in the vicinity of highway and unpaved road crossings due to ease of access for surveyors. Highway and bridge construction and widening could affect populations of these species unless appropriate precautions are implemented during construction to reduce erosion and sedimentation, and maintain water quality standards. The construction of reservoirs and the associated habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can directly impact mussel populations (Neves et al., 1997). Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams."

Overutilization:
NatureServe (2008) reports that overharvest by shell collectors and biologists is a potential threat to this species. This species is not commercially valuable, but due to very low population size, any collection poses a dire threat to its survival.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Southern Kidneyshell, and no occurrences are appropriately protected and managed (NatureServe 2008). It is a federal Candidate species and is dire need of ESA listing to protect the two remaining occurences. It is a Species of Greastest Conservation Need in Alabama but this designation does not confer regulatory protection.

Other factors:
Several other factors threaten the Southern Kidneyshell. Any factor which degrades water quality threatens this species. In addition, it is vulnerable to catastrophic events because remaining populations are generally small and geographically isolated. The loss and decline of host fishes threatens this mussel. Small population size is a threat because this mussel may be below the effective population size to maintain long-term viability. Invasive species such as Asiatic clam, zebra mussel, and black carp are also a potential threat (USFWS 2003).

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Williams, James D., Ph.D. Biological Research Division, U.S. Geological Survey. 7920 NW 71st Street, Gainesville, FL 32606. (352) 378-8181. FAX (352) 378-4956.

Scientific Name:
Pyganodon gibbosa
Common Name:
Inflated Floater

G Rank:	AFS Status:	IUCN Status:
G3	Special Concern	NT - Near threatened

Range:
The range of the Inlated Floater covers 250-1000 square km (about 100-400 square miles) in Georgia. This mussel has been detected in the Little Ocmulgee River, Ohoopee River, Ocmulgee River and the Altamaha River (G. Keferl, pers. obs., 1998 in NatureServe 2008). Clench and Turner (1956) report this mussel from the Apalachicola River system, but Brim Box and Williams (2000) did not detect this species in the Apalachicola River system. Clench and Turner (1956) reported this species from the Ochlockonee River, Flint River, Uchee Creek, Chipola River and the Choctawhatchee River in Georgia, Florida and Alabama, but these records have not been substantiated and this mussel might be endemic to the Altamaha River system (NatureServe 2008).

Habitat:
The Inflated Floater inhabits soft substrates including mud, silts, and fine sands in rivers (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are from 21 - 80 populations of Inflated Floater distributed through four rivers in Georgia: the Little Ocmulgee River, Ohoopee River, Ocmulgee River and the Altamaha River. NatureServe (2008) states: "In a survey of 131 stations (93 Altamaha River, 19 Ocmulgee River, 5 Oconee River, 4 Ohoopee River, 10 Little Ocmulgee River), 117 specimens were found at 29 stations (anonymous, 1995). It was found at 46 (16.8%) of the 273 sites examined from 1993-1997 (G. Keferl, pers. obs., 1998). It made up 1.2 percent of the 15,187 living mussels observed and 1.2 percent of the 3,155 shells collected."

Population Trends:
Based on a sample of a subset of known occurences, the Inflated Floater is experiencing rapid short-term decline (decline of 30-50 percent). Wisniewsky et al. (2005) state that this mussel has undergone significant recent decline. Pre-2000 site occupancy in the lower Ocmulgee and Altamaha basin in Georgia is estimated at 17 percent, and post-2000 site occupancy is estimated at 6 percent, indicating a significant recent decline (Wisniewsky et al. 2005).

Status:
NatureServe (2008) ranks the Inflated Floater as Vulnerable in Georgia. It is classified as Near Threatened by the IUCN. It is endemic to one river system, with recent surveys indicating decline (from 17 to 6 of 21 sites) since 2000. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Any major changes to the Altamaha River system could negatively alter this mussel's distribution (NatureServe 2008). The Inflated Floater occurs in small population segments in backwater habitats and is threatened by activities which change sediment conditions such as building or dredging (NatureServe 2008). Land adjacent to the Altamaha is being cleared for agriculture, and

mussels there are threatened by excessive sedimentation as a result of poor land practices, pollution, eutrophication, extremely low water levels, destabilized banks, and bank and stream bed destabilization (NatureServe 2008, Alasmidonta arcula species account). Keferl (1993) lists dams, sand and gravel mining, channelization, poor agricultural practices, poor timbering practices, siltation, increased run-off volume, municipal sewage, industrial wastes, and pesticides Wisniewski, J.M., G. Krakow, and B. Albanese. 2005. Current status of endemic mussels in the as threats to mussels in Georgia and the Carolinas, including the Altamaha River, stating, "It is lower Ocmulgee and Altamaha Rivers. In K.J. Hatcher (ed.) Proceedings of the Georgia Water possible that at least four of the seven endemics in the Altamaha River may be in trouble." The Resources Conference, 25-27 April 2005, Athens, Georgia. 2 pp.

Georgia Dept. of Natural Resources (2009) cites unmanaged recreation as a threat to rare mussels in the Altamaha drainage, stating: "unmanaged recreational use represents a serious problem. For example, ATV use in and adjacent to the Ohoopee River may represent a threat to populations of rare mussels such as the Altamaha spinymussel. The potential impacts from this type of recreational use include destabilization of streambanks, excessive sedimentation, pollution from fuel spills, and direct mortality from vehicular impacts."

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species.

Other factors:
This mussel is threatened by loss of host fish populations, which are threatened by habitat degradation and predation from non-native flathead catfish in the Altamaha basin (Nature Conservancy and SARP 2005).

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Scientific Name:
Quadrula asperata archeri
Common Name:
Tallapoosa Orb

Range:
This mussel is restricted to the Tallapoosa River above the Fall Line. This distinctive form of Quadrula asperata was described as Quadrula archeri by Frierson (1905). It remains unclear whether this mussel is a full species or is a subspecies of Q. asperata, but the rarity of this mussel has precluded genetic analysis (Williams et al. 2008). Williams et al. (2008) state, "At a minimum it warrants subspecific status, as it is morphologically distinct, occurs in a geographically defined area and was isolated by the falls at Tallassee, Elmore County, Alabama, prior to the impoundment of the Tallapoosa River" (p. 648). The Center is hereby petitioning for this mussel as either a species or a subspecies.

Populations:
Freeman et al. (undated) state: "Quadrula archeri is endemic to the Tallapoosa River system and is only known from mainstem collections in the Piedmont portion of the system, including one locale near the Fall Line, two locales between Harris Dam and Lake Martin, and four Alabama locales upstream from Harris reservoir (Irwin et al. 1998, J. D. Williams, personal communication). The records upstream from Harris were collected in 1997 and include recent dead shell material (Irwin et al. 1998)."

Population Trends:
In a recent survey of mussels in the Tallapoosa River drainage, no live individuals or shells of Q. asperata archeri were encountered (Johnson and DeVries 2002). Freeman et al. (undated) report that the most recent records (Irwin et al. 1998) are from shell material collected in the mainstem upstream from Harris reservoir, and current records of live specimens are lacking.

Status:
The Tallapoosa orb is possibly extirpated and in dire need of ESA protection.

Habitat destruction:
This mussel is threatened by impoundments. Williams et al. (2008) state, "Evaluation of Quadrula asperata archeri is especially critical because additional impoundments in the upper Tallapoosa River drainage could drive it to extinction" (p. 648). Freeman et al. (undated) report that this mussel has experienced substantial habitat destruction and modification within its limited range, stating, "Construction of mainstem impoundments (Thurlow, Yates, Martin, Harris reservoirs) destroyed habitat likely occupied by, at least, Cyprinella gibbsi, Fundulus bifax, Cottus sp., Percina sp., Etheostoma chuckwachatte, Etheostoma tallapoosae, Quadrula archeri and Elimia flava; all of these species are known from mainstem habitats in the vicinity of the impoundments. . . The range of Quadrula archeri, occurring upstream and downstream of the major reservoirs, strongly suggests that the species natively occurred in the now-impounded reaches. Quadrula archeri (and most likely Lampsilis altilis) has also experienced extensive habitat modification in the unimpounded mainstem between Harris dam and Martin reservoir. Flows and thermal regimes in this reach of river are strongly affected by operation of Harris dam, which results in rapidly fluctuating flow and water temperature corresponding to hydropower generation at the dam (Irwin and Freeman 2002). Cold-water releases from dams depress mussel growth and reproduction

(Layzer et al. 1993, Neves et al. 1997)."

This mussel is also threatened by urbanization and increasing demand for freshwater for human usage (Freeman et al. undated).

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Scientific Name:
Quadrula cylindrica cylindrica
Common Name:
Rabbitsfoot

G Rank:	**AFS Status:**	**IUCN Status:**
T3	Threatened	NT - Near threatened

Range:
Quadrula cylindrica cylindrica is a freshwater mussel found in Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, and Tennessee. Populations are present in 46 streams in the Ohio, Cumberland, Tennessee, lower Mississippi, White, Arkansas, and Red River systems, though historical reports place this species in 137 streams in 15 states (Butler 2005, NatureServe 2008).

It is found in 5 or 6 sites in Missouri's Tippecanoe River, and in the Vermillion, Lower Ohio, Spring, Black, and St. Francis Rivers, and likely extirpated from the Embarras and Wabash Rivers (Cummings and Berlocher 1990, Cummings and Mayer 1997, Oesch 1995). In Kansas it is rare in the Neosho and Spring Rivers, and extirpated from the Cottonwood River and Shoal Creek (Couch 1997). The rabbitsfoot is widespread but rare in Arkansas, with the most significant populations present in the lower Spring and Black Rivers, and others in the Ouachita and White River systems (Harris and Gordon 1990, Harris and Gordon 1987). It is patchily distributed in Kentucky's lower Ohio, Tennessee, lower Cumberland, and upper Green Rivers, though it has been extirpated from the remainder of the state (Cicerello et al. 1991, Cicerello and Schuster 2003). In Alabama, this species is present in the Paint Rock River system, and a small portion of Bear Creek (Mirarchi et al. 2004, Williams et al. 2008). In Tennessee, it is found in the Elk, Duck, the east fork Stones, and Tennessee Rivers, and likely extirpated from the Buffalo, French Broad, and Caney Fork Rivers (Parmalee and Bogan 1998). Populations are present in parts of Virginia's Clinch, Powell, and Holston Rivers (Parmalee and Bogan 1998), and in Louisiana's Bayou Bartholomeau and Ouachita Rivers, though it is likely extirpated from the upper Mississippi (Vidrine 1993). In Mississippi, it is known from the Yazoo, Tennessee, Lake Maurepas, and Tombigbee drainages (Jones et al. 2005). Though it was once widely distributed in Illinois's Vermilion, Wabash, and Ohio Rivers, it is now only sporadically noted in the North Fork Vermilion and Ohio Rivers (Cummings and Mayer 1997). It is largely extirpated from Indiana, where it was once widely present; small populations remain in the Tippecanoe and Eel Rivers (IN NHP as cited in NatureServe 2008), and the St. Joseph River (Watters 1988, Pryor 2005). Occurrences in Oklahoma are limited to the Upper Little, Glover, and Illinois drainages (Galbraith et al. 2008, Branson 1982). This species is largely extirpated from Pennsylvania, with remaining populations known only in the Shenango and French River drainages (Bursey 1987, PA NHP 2006 as cited in NatureServe 2008). Ohio's populations are found in Fish Creek, Little Darby Creek, and tributaries of the Scioto and Muskingum Rivers (Watters 1995).

Habitat:
The rabbitsfoot is found in large and medium-sized rivers with moderate gradients, often in shoal or riffle habitat (Gordon and Layzer 1989). In smaller streams in is most often found on sand or gravel bars or cobble close to areas of rapid current (Cummings and Mayer 1992).

Ecology:
Adults are filter feeders, consuming primarily organic detritus from the water column.
Populations:
It is estimated that there are 21-80 extant occurrences of this mussel, and total population is thought to number at least 10,000 individuals (NatureServe 2008). Populations are extant in 46 streams in 13 states. Many populations are small and isolated.

Population Trends:
The rabbitsfoot has experienced a long-term decline of up to 90 percent, and continues to decline very rapidly in the short-term by up to 70 percent (NatureServe 2008).

Status:
NatureServe (2008) lists the rabbitsfoot as critically imperiled in Alabama, Indiana, Kansas, Louisiana, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, imperiled in Kentucky, and vulnerable in Tennessee. Its conservation status is not ranked in Illinois or Arkansas. Butler (2005) reports that the rabbitsfoot is present at less than one-third of historically occupied sites, and that total range and population losses likely exceed 90 percent. Where this species is still present, populations are restricted and highly isolated. Its persistence in Alabama, Kansas, Louisiana, Mississippi, and Missouri is highly endangered, and recent population reports from Nebraska, Michigan, Iowa, and New York are dubious (Butler 2005). It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Habitat loss to impoundments, channelization, chemical contaminants, mining, and sedimentation is widely cited as the primary cause of decline for this species (Butler 2005, Neves 1991, 1993, Williams et al. 1993, Neves et al. 1997, Watters 2000). Impoundments are the primary factor in the historical decline of the rabbitsfoot; dams disrupt natural hydrological processes by modifying flood pulses, altering water flow, sediment levels, nutrients, decreasing habitat heterogeneity, and isolating mussel populations from their glochidial host species (Neves 1993). Impoundments also compromise riffle and shoal habitats that the rabbitsfoot relies on. The majority of large river habitat within the rabbitsfoot's range has been impounded, including the main stems of the Ohio, Cumberland, Tennessee, and White Rivers and their larger tributaries, leaving only short, isolated reaches that represent marginally suitable habitat (NatureServe 2008). Coal, gravel, and mineral mining threaten the rabbitsfoot in large portions of its range, through disrupted flow patterns, increased sedimentation and contamination, decline in macroinvertebrate prey base, and other changes. Agricultural activities contribute heavily to sedimentation and siltation, particularly in the Midwest and Southeast. Finally, residential and industrial development contribute to the degradation of aquatic habitat, both by outright destruction, increased regional water withdrawal, and pollutants, primarily in the form of stormwater runoff (NatureServe 2009).

Inadequacy of existing regulatory mechanisms:
Several populations occur within bioreserves owned by the Nature Conservancy, or within watersheds designated as protected by state legislation, but NatureServe (2008) still reports that few occurrences are adequately protected or managed. The rabbitsfoot is state listed as endangered in Ohio, Illinois, Mississippi, Indiana, and threatened in Kentucky, but these designations afford no substantial regulatory protection for the mussel or its habitat.

Other factors:

The rabbitsfoot is threatened by contaminants from both point and non-point sources which degrade water quality, increase sedimentation, and adversely affect or even completely destroy mussel populations. The effects of contaminants on juvenile mussels are especially acute. Runoff from coal mines is rich in heavy metals and has detrimentally affected many drainages that host rabbitsfoot populations, including but not limited to the upper Ohio River system in Kentucky, Pennsylvania, and West Virginia, the lower Ohio River system in Illinois, the rough River drainage in Kentucky, and the upper Cumberland River system in Kentucky and Tennessee (NatureServe 2008). The health of freshwater mussel populations reliant on glochidial hosts for larval development is clearly linked to the health of host fish populations, and the rabbitsfoot is thus threatened by any factor which threatens its host fishes.

The rabbitsfoot may also be threatened by invasive mussels. Zebra mussels are established in many rabbitsfoot streams, including the Ohio, Allegheny, Green, Tennessee, and White Rivers, and French and Bear Creeks. The Asian clam is also present in much of the rabbitsfoot's range, and has been identified as a competitor with native mussel species for food, nutrients, and space (Neves and Widlack 1987, Leff et al. 1990, Ricciardi et al. 1998).

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Scientific Name:
Fusconaia burkei
Common Name:
Tapered Pigtoe

G Rank: G2
AFS Status: Threatened

Range:
Also known as Quincuncina burkei, the range of the Tapered Pigtoe covers 250-1000 square km in Alabama and Florida. It is endemic to the Choctawhatchee River drainage (Clench and Turner 1956, Williams and Butler 1994, Blalock-Herod et al. 2005, USFWS 2003). NatureServe (2008) provides the following details on this species' distribution: "The historical distribution of the tapered pigtoe has recently been expanded, and a relic shell was found recently in Big Creek, Pike County, Alabama (Blalock-Herod et al., 2005). The tapered pigtoe is known from Horseshoe Lake (an oxbow lake with flowing connection to main channel of the Choctawhatchee River), Washington County; Limestone Creek, Walton County; East Pitman Creek, Holmes County; Choctawhatchee River, Washington, Walton, and Holmes Counties; Holmes Creek, Washington and Holmes Counties; and Tenmile Creek, Holmes County; all in Florida. In Alabama, the historical distribution of the tapered pigtoe included: Flat and Hurricane creeks, Geneva County; Pea River, Barbour, Coffee and Dale Counties; Choctawhatchee River, Dale County; Little Choctawhatchee River, Dale and Houston Counties; East Fork Choctawhatchee River, Dale County; Bear and Panther Creeks; Houston County; and West Fork Choctawhatchee River, Barbour County (Blalock-Herod et al.,2005). Blalock-Herod et al. (2005) list this species historically from 40 localities in the Choctawhatchee River drainage in Alabama and Florida (extant in 7) and 26 new locations in the drainage in isolated spots in the headwaters, the Flat Creek watershed, and the main channel and some tributaries in Florida."

Habitat:
The tapered pigtoe is found in medium-sized creeks to large rivers in slow to moderate current and stable sand or sand and gravel substrata, and occasionally in silty sand (Williams and Butler 1994).

Ecology:
Little is known about the ecology of this species, but it is thought to be a short-term brooder. Gravid females have been detected in May with all four gills used as marsupia and subcylindrical conglutinates (Ortmann and Walker 1922 in Mirarchi et al. 2004). Fish hosts are unknown (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 21-80 populations of Tapered Pigtoe, providing the following details: "The following locations known from historical museum records continue to support tapered pigtoe populations: Limestone Creek, Walton County; East Pittman Creek, Holmes County; Choctawhatchee River, Washington, Walton, and Holmes Counties; and Holmes Creek, Washington and Holmes Counties; all in Florida; and Flat Creek, Geneva County; Alabama (fide Blalock-Herod et al., 2005). During recent status surveys, the tapered pigtoe was found live and as shell material at 33 of 54 historical sites with an average of 7 individuals per site. Populations were inactive at 15 historical sites and status is undetermined at 6 sites. Four populations were represented by 10 - 20 individuals (fide Blalock-Herod et al., 2005). Recruitment status of the tapered pigtoe is unknown, and may be occurring at low levels within the

existing populations (USFWS, 2003; Williams and Butler, 1994; Blalock et al., 1998). In Alabama, it is extant in 9 locations scattered in tributaries of Choctawhatchee drainage, including headwaters of Pea River (Mirarchi et al., 2004). Blalock-Herod et al. (2005) list this species historically from 40 localities in the Choctawhatchee River drainage in Alabama and Florida (extant in 7) and 26 new locations in the drainage in isolated spots in the headwaters, the Flat Creek watershed, and the main channel and some tributaries in Florida. Pilarczyk et al. (2006) recorded recent collections (in 2004) of this species following surveys of 24 sites at four sites in Alabama including West Fork Choctawhatchee River, Eighmile Creek (in Florida), Pea Creek, and Big Creek compared to Flat Creek, Eightmile Creek (just over the border in Florida), Pea River, Pea Creek, Big Creek, West Fork Choctawhatchee River, and Judy Creek in surveys of the same sites in the 1990s. White et al. (2008) utilized specimens from Eightmile Creek in Walton Co., Florida for host suitability studies."

NatureServe (2008) states: "In 1987 at the the best known site, 37 specimens were found in one hour's time. However, its numbers are generally smaller, at least in Florida's recent records. During recent status surveys, the tapered pigtoe was found live and as shell material at 33 of 54 historical sites with an average of 7 individuals per site. Populations were inactive at 15 historical sites and status is undetermined at 6 sites. Four populations were represented by 10 - 20 individuals (fide Blalock-Herod et al., 2005). Pilarczyk et al. (2006) recorded recent collections (in 2004) of this species following surveys of 24 sites in Alabama at six sites historical and including West Fork Choctawhatchee River (5 live), Eighmile Creek in Florida (29 live), Pea Creek (5 live), and Big Creek (1 live)."

Population Trends:

The Tapered Pigtoe is declining in the short term (decline of 10-30 percent) and moderately declining in the long term (decline of 25 - 50 percent). This mussel has been extirpated from approximately 28 percent of its historic range. Populations appear to be extirpated from Hurricane Creek, Geneva County; Bear and Panther Creeks, Houston County; Little Choctawhatchee River, Houston and Dale Counties; Pea River, Coffee and Dale counties; Choctawhatchee River and East Fork Choctawhatchee River, Dale county, and probably Big Creek, Pike County, all in Alabama (USFWS 2003). Recruitment levels are thought to be low (NatureServe 2008).

Status:

NatureServe (2008) ranks the Tapered Pigtoe as critically imperiled in Alabama and imperiled in Florida. It is a Federal Candidate and merits immediate listing under the ESA. It appears to be extirpated from multiple, historical occurrences, and is confined primarily to main channel habitats within its narrow distribution. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

NatureServe (2008) provides the following information on threats to this species' habitat: "Habitat loss or degradation is the primary threat to this species. The stream and river habitats are vulnerable to habitat modification, sedimentation, and water quality degradation from a number of activities. Highway and reservoir construction, improper logging practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing often result in physical disturbance of stream substrates or the riparian zone, and/or changes in water quality, temperature, or flow. Sedimentation can cause direct mortality of mussels by deposition and suffocation (Ellis, 1936; Brim Box and Mossa, 1999) and can eliminate or reduce the recruitment of juvenile mussels (Negus, 1966; Brim Box and Mossa, 1999). Suspended sediment can also interfere with feeding activity of mussels (Dennis, 1984). Many of the confirmed extant populations of this species are in the vicinity of highway and unpaved road crossings due to ease of access for surveyors. Highway and bridge construction and widening could affect populations of these species unless appropriate precautions are implemented during construction to reduce erosion and sedimentation, and maintain water quality standards. The construction of reservoirs and the associated habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can directly impact mussel populations (Neves et al., 1997). Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams."

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Tapered Pigtoe, and it is unknown whether any occurrences are appropriately protected or managed as there are no known protected occurrences (NatureServe 2008). This mussel is a federal candidate. A population of this mussel may exist in Blue Springs State Park in Alabama. This mussel is a Species of Greatest Conservation Need in Alabama, but this designation does not confer regulatory protection. It has no state status in Florida. NatureServe (2008) provides the following management recommendations for the Tapered Pigtoe: "Protect populations through acquisitions and easements by working with government agencies and conservation organizations; establish buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; maintain high water and benthic habitat quality. Control/eradicate CORBICULA populations. Conservation activities have been limited to working with private landowners in south Alabama and west Florida to encourage the use of Best Management Practices to reduce the effects of agriculture and silviculture (see U.S. Fish and Wildlife Service, 2003)."

Other factors:

Any factor which degrades water quality threatens the Tapered Pigtoe. This species is also threatened by any factor which threatens the survival of host fishes. NatureServe (2008) states that deteriorating water quality throughout the Choctawhatchee drainage is a probable impact. Because remaining populations of Tapered Pigtoe are small and isolated, it is vulnerable to stochastic genetic and environmental events. This mussel is genetically vulnerable because some populations may be below effective population size to maintain long-term viability. The Tapered Pigtoe is also potentially threatened by invasive species such as Asiatic clam, zebra mussel, and black carp (USFWS 2003, NatureServe 2008).

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Scientific Name:
Rana okaloosae
Common Name:
Florida Bog Frog

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The Florida Bog Frog has a very narrow range in Florida, occuring at roughly 24 sites along tributaries of the East Bay, Shoal and Yellow rivers in Santa Rosa, Okaloosa, and Walton counties (NatureServe 2008). AmphibiaWeb (2009) reports that this species occurs only along small streams draining to Titi Creek, the East Bay River, or the lower Yellow River, all of which ultimately drain to Escambia Bay. The Titi Creek populations in Walton County, Florida, appear to be isolated by approximately 30 km from populations in the lower Yellow River basin.

Habitat:
The Bog Frog's habitat consists of early successional shrub bog communities. The species is found in or near shallow, nonstagnant, acidic (pH 4.1-5.5) seeps and along shallow, boggy overflows of larger seepage streams that drain extensive sandy uplands. This frog is associated with beds of sphagnum moss, black titi, and Atlantic white cedar. In mature forest areas, this species occurs in disturbed locations (Moler 1992). This frog breeds and permanently resides in the same habitats (NatureServe 2008, AmphibiaWeb 2009).

Ecology:
Rana okaloosae is syntopic with Rana clamitans, Acris gryluus, and sometimes Hyla andersonii. Breeding occurs from April–August, with occasional calling heard into early September (Moler, 1985, 1992). Eggs are laid in thin masses at the water surface in quiet pools in adult habitat. Males typically call from shallow water surrounded by sphagnum (Moler 1993). Some tadpoles overwinter (Moler, 1985, 1992). Bog Frogs have been observed eating moths attracted by photographers' lights at night. Predators likely include cottonmouths (Agkistrodon piscivorus) and southern water snakes (Nerodia fasciata) (NatureServe 2008, AmphibiaWeb 2009).

Populations:
The Florida Bog Frog is known from approximately two dozen sites. Population size is unknown (NatureServe 2008).

Population Trends:
Trend is unknown.

Status:
This species is imperiled in Florida (S2) (NatureServe 2008). It is ranked as Vulnerable by the IUCN. It lacks legal protective status.

Habitat destruction:
The greatest threats to the Florida Bog Frog are stream impoundment and habitat succession (Moler 1992). This frog is particularly vulnerable to habitat destruction and modification because of its limited range and habitat specificity (NatureServe 2008). This species' habitat has been degraded by improper watershed management, siltation stemming from poor road placement, and poor forest management in surrounding uplands (Moler 1992, NatureServe 2008). This frog is threatened by residential development of its habitat (Moler 1993).

Enge (2005) cites logging, groundwater use, siltation from dirt roads and cleared lands, impoundment, and poor management of adjacent upland habitat as threats to amphibian species in ravine habitats in the Florida Panhandle, including R. okaloosae.

The Florida Fish and Wildlife Conservation Commission (2009) cites threats to the Bog Frog as siltation, pollution, and excess surface runoff where roads cross slopes above streams, damming, and altered fire regime which allows hardwood succession along streams (http://www.fwc.state.fl.us/docs/FWCG/florida_bog_frog.pdf). The Commission cites altered fire regime, altered hydrologic regime, groundwater withdrawal, surface water diversion, and altered community structure as threats to the Bog Frog's habitat (http://myfwc.com/docs/WildlifeHabitats/Legacy_Shrub_Swamp.pdf).

The Florida Dept. of Environmental Protection lists the Florida Bog Frog as occurring at Rocky Bayou State Park where its habitat is threatened by potential loss of submerged and emergent vegetation due to increased residential housing along the preserve boundary, and by high use of the preserve as a water skiing area which may have an impact on the natural submerged and emergent vegetation. There are also recurring issues with high bacteria counts in the preserve waters adjacent to the state park (http://www.dep.state.fl.us/coastal/sites/rocky/info.htm).

There has been widespread destruction, degradation, and fragmentation of imperiled amphibian habitats in the Southeast (Vial and Saylor 1993, Pechmann and Wilbur 1994 in LaClaire 1997, p. 314). Dodd (1997) states: "The integrity of both aquatic and terrestrial habitats is important to amphibian survival, even among species that never venture beyond a single habitat type. Furthermore, the various life history stages (eggs, larvae, young, adults) may be differentially susceptible or sensitive to environmental perturbations . . . Although vast areas have been cleared in the Southeast for agriculture, industry, and urban use, there is virtually no assessment of the landscape effects of land conversion on amphibian populations. It seems evident, however, that habitat changes (see papers in Hackney et al. 1992, Boyce and Martin 1993), and with them changes in aquatic amphibian populations, have been enormous" (p. 177-8).

Habitat loss and degradation obviously negatively affects amphibian populations. LaClaire (1997) states: "There is a growing body of work documenting (amphibian) population declines on sites where habitats have been degraded or destroyed (Vickers et al. 1985, Enge and Marion 1986, Ash 1988, Dodd 1991, Raymond and Hardy 1991, Petranka et al. 1993, Phelps and Lancia 1995, Means et al. 1996). . . Clearly, when the habitat of a given population is destroyed, that population has gone or will shortly go extinct. Many species may be unable to recolonize areas after local extinctions, especially when unsuitable habitat exists between the extinct population and extant populations" (p. 325-326).

Habitat fragmentation can lead to amphibian population extirpation by disrupting metapopulation dynamics and preventing dispersal and rescue between source and sink habitat. Dodd (1997) states: "Land use patterns resulting in fragmentation can influence amphibian population genetic structure . . . if populations become overly fragmented, emigration and immigration may be inhibited or stopped, thus preventing recolonization from source populations. . . Small isolated populations are particularly susceptible to environmental perturbations and to stochastic variation in demography that can lead to extinction even without external perturbations. Isolation by habitat fragmentation thus becomes a threat to the regional persistence of species" (p. 178).

Aquatic amphibian populations are threatened by habitat destruction and water pollution from phosphate mining in Florida (Wallace et al. 1992, LaClaire 2007).
Dodd (1997) states: “Mining not only destroys aquatic amphibian habitats outright, it also results in toxic pollution, decreased pH, and siltation of streams and rivers” (p. 180).

Logging is detrimental for both aquatic and terrestrial amphibian habitat because it eliminates shade, increases soil and water temperature, alters stream flow, increases sedimentation, reduces the input of coarse woody debris and organic matter into streams, reduces forest floor litter (especially if litter is piled and burned), reduces soil moisture, reduces and eliminates burrows and hiding places, and destroys wetlands. Logging also frequently involves the use of herbicides which can be detrimental for amphibians (see http://amphibiaweb.org/declines/ChemCon.html). Logging is known to decrease amphibian abundance and reproductive success (Dodd 1997, LaClaire 1997). LaClaire (1997) states: “Habitat destruction and degradation resulting from timbering operations may create problems for long-term survival of imperiled amphibians (Kramer et al. 1993, Petranka et al. 1993)” (p. 327).

Road construction and repair and traffic degrade amphibian habitat. Roads can divide breeding locations from overwintering sites and increase mortality for migrating adults and dispersing juveniles, and can disrupt metapopulation dynamics and lead to population isolation, and light and noise from roads can disrupt breeding and feeding behaviors (Dodd 1997). Dodd (1997) states: “Transportation corridors, especially roads, can have serious deleterious effects on amphibian populations (Langton 1989). Road construction can lead to habitat destruction in both terrestrial and aquatic environments, and can negatively alter breeding habitats through increased siltation. Increased siltation can lead to increased amphibian mortality because of its own secondary effects. For example, nearly all aquatic life was eliminated downstream after U.S. HWY 441 was rebuilt in 1963 in the Great Smoky Mountains National Park” (p. 180).

Overutilization:
Amphibians are collected from the wild for use as food, pets, and for the biological and medicinal supply markets (AmphibiaWeb 2009: http://amphibiaweb.org/declines/exploitation.html). Dodd (1997) states: “Collecting specimens for the pet trade or biological laboratories probably has had some impact on local (Southeast) amphibian populations, but few data are available” (p. 183).

Disease or predation:
New diseases and increased susceptibility of amphibians to existing diseases are known to be contributing to the decline of amphibian species (Blaustein et al. 1994, Laurance et al. 1996, Berger et al. 1998, Daszak 2000, Kiesecker et al. 2001, reviewed in AmphibiaWeb 2009, http://amphibiaweb.org/declines/diseases.html). Stress from factors such as habitat loss and fragmentation, chemical pollution, climate change, invasion of exotic species, increased UV-B radiation, and natural population fluctuations may increase the susceptibility of amphibians to disease (Carey 1993, Dodd 1997, Fellers et al. 2001, Kiesecker at al. 2001, AmphibiaWeb 2009). Pathogens known to cause infectious disease in amphibians include bacterial, fungal, viral, metazoan, water mold, and trematode agents (Wright and Whitaker 2001 in AmphibiaWeb 2009). Chytridiomycosis (chytrid fungus, Batrachochytrium dendrobatidis), has had severe impacts on amphibian populations worldwide. Chytrid fungus is known to be present in the southeastern U.S. (AmphibiaWeb 2009) and potentially threatens the Florida Bog Frog. In addition to disease, there has been a widespread increase of amphibian deformities and malformations (http://amphibiaweb.org/declines/deformities.html).

Inadequacy of existing regulatory mechanisms:

The Florida Bog Frog is considered a Species of Special Concern in Florida, but this designation does not provide any regulatory protection for its declining habitat. Approximately 90 percent of the total range may be within Eglin Air Force Base, but national security concerns take precedence over wildlife management (NatureServe 2008).

Other factors:

Dodd (1997) lists rarity as a potential threat to the Florida Bog Frog. Rana okaloosae is potentially threatened by hybridization with R. clamitans clamitans (Gorman et al. 2009). Enge (2005) cites water pollution, recreation, and trash dumping as threats to amphibians in the Florida Panhandle. The Florida Wildlife Conservation Commission cites water pollution and invasive species as threats to the Bog Frog (http://myfwc.com/docs/WildlifeHabitats/Legacy_Shrub_Swamp.pdf). Enge (2005) cites feral hogs as a threat to amphibians in the Florida Panhandle.

Other factors which threaten imperiled amphibian populations in the Southeast include water pollution from acidification, toxins, and endocrine disrupting chemicals, reduced prey availability, climate change, UV-B radiation, invasive species, and synergistic effects from these and other threats.

Acidification of soils and water bodies is detrimental for amphibians. Acidification of amphibian habitat can result from acid precipitation and from acid mine drainage. Acid disrupts ion balance in both terrestrial and aquatic lifestages of amphibians, impairs chemosensory reception, and inhibits larval feeding (Dodd 1997). Embryos and larvae are particularly sensitive to decreased pH. Terrestrial salamanders avoid acidified soils. Acidification also has indirect effects which can kill embryos, larvae, and adults by interfering with egg development, disrupting trophic interactions, and inducing chronic environmental stress. Low pH also makes amphibians more susceptible to deleterious effects from heavy metals and increased UV-B radiation (Dodd 1997).

Environmental toxins pose a threat to amphibians in the Southeast due to lethal and sub-lethal effects which can include mortality, decreased growth rate, behavioral and developmental abnormalities, lowered reproductive success, weakened immunity, and hermaphroditism (see http://amphibiaweb.org/declines/ChemCon.html). Amphibians are particularly vulnerable to toxic substances because of the permeable nature of their skin. A wide range of chemical stressors are known to negatively affect amphibians including heavy metals, pesticides, phenols, carbon tetrachloride, nitrogen based fertilizers, and road salt (Dodd 1997, AmphibiaWeb 2009). The presence of toxins can also make amphibians more susceptible to disease (Dodd 1997).

Amphibians are also threatened by endocrine-disrupting chemicals in the environment (eg. Hayes et al. 2006). Dodd (1997) states: “Amphibians are likely to be especially sensitive to the action of endocrine mimics because they are in close direct contact with chemicals in their environment, and the amphibian skin and egg capsule are highly permeable. Because hormones normally function in minute quantities and are vital to normal development, susceptibility to xenobiotics could be devastating during the complex changes that occur during hormonally-induced amphibian metamorphosis” (p. 182).

Toxins and other chemicals can also harm amphibians by reducing food availability. Dodd (1997) states: “If species that are preyed upon by amphibians decline or disappear, amphibian populations may be expected to follow suit. The use of pesticides and the influence of toxics, pH, and habitat alteration all may be expected to affect amphibian prey populations" (p. 184).

Climate change poses a threat for amphibians because it will alter rainfall and temperature patterns and affect soil moisture (Dodd 1997, Field et al. 2007). Amphibians are particularly sensitive to minute changes in moisture and temperature, and changes in climate can affect breeding behavior, reproductive success, and immune function (see http://amphibiaweb.org/declines/ClimateChange.html). Amphibians which breed in temporary ponds or in water bodies that are sensitive to changes in groundwater level are particularly susceptible to climate change effects. Drought can lead to localized extirpation, which combined with habitat fragmentation and impaired dispersal, can contribute to extinction (Dodd 1997).

During the past few decades, levels of UV-B radiation in the atmosphere have significantly increased. For amphibians, UV-B radiation can cause direct mortality as well as sublethal effects including decreased hatching success, decreased growth rate, developmental abnormalities, and immune dysfunction (Dodd 1997, AmphibiaWeb 2009: http://amphibiaweb.org/declines/UV-B.html).

Southeastern amphibians are also threatened by the invasion of non-native species which prey on or compete with native amphibians. Nonnative fishes can negatively affect amphibian populations through predation, competition, and disease introduction. Introduced nonnative amphibians such as the marine toad (Bufo marinus) and Cuban treefrog (Osteopilus septentrionalis) are potentially harmful for native amphibians in the Southeast. Rossi (1981) found that anuran species richness was reduced in an area where B. marinus was established (in Dodd 1997). Introduced mammals, such as armadillos and wild hogs, and introduced birds like cattle egrets "may exact a substantial toll on amphibian populations" (Dodd 1997). Invasive fire ants (Solenopsis invicta) are also a potential threat for Southeastern amphibians. Dodd (1997) states: "Ground dwelling vertebrates are especially sensitive to this ravenous predator, and fire ants have been reported to kill endangered Houston toads (Bufo houstonensis) as they metamorphose. Fire ants are especially abundant in the moist perimeter surrounding ponds and lakes, and they can float in mats across ponds from vegetation clump to vegetation clump. Fire ants have few predators and have expanded their range throughout the Southeast" (p. 183). See: http://amphibiaweb.org/declines/IntroSp.html.

Synergisms between multiple threats could contribute to the extinction of Southeast amphibians. Multiple factors acting together have both lethal and sublethal effects (http://amphibiaweb.org/declines/synergisms.html). For example, increased UV-B radiation increases the susceptibility of amphibians to the effects of contaminants, pathogens and climate change. Dodd (1997): "The amphibians of this area (the Southeast), and particularly the fully aquatic species, face a multitude of threats to their long-term existence. These threats generally do not act independently, but instead act in concert to have potentially serious long-term effects" (p. 185).

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Scientific Name:
Remenus kirchneri
Common Name:
Blueridge Springfly

G Rank:
G2

Range:
NatureServe (2008) reports that this species is endemic to the Blue Ridge mountains of southwestern Virginia.

Habitat:
This springfly inhabits small spring-fed streams and seeps in the Blue Ridge mountains.

Populations:
There are less than ten occurrences of this fly. Population data are not available.

Status:
NatureServe (2008) ranks this species as imperiled. It is considered a Species of Concern by the state of Virginia.

Habitat destruction:
This species is threatened by increasing development and poor land management practices (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

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Scientific Name:
Rhexia parviflora
Common Name:
Small-flower Meadow-beauty

G Rank:
G2

Range:
Known variously as the Apalachicola meadowbeauty, white meadowbeauty, or small-flower meadowbeauty, this species is known from the Florida panhandle, southeastern Alabama, and southern Georgia (Chafin 2000, Weakley 2007, Kartesz 1999). Natural heritage records exist for Covington, Escambia, and Geneva Counties, Alabama, and for Bay, Calhoun, Franklin, Gulf, Liberty, Okaloosa, Santa Rosa, and Walton Counties, Florida, though not all have been recently confirmed (NatureServe 2008). This species is likely extirpated in Georgia.

Habitat:
This flower occurs along the margins of ponds and shallow, wet depressions, hillside seeps, and evergreen shrub ponds (Chafin 2000). It is associated with pine-palmetto flatwoods and savannahs (Schotz 2008), and seems to prefer sandy peat soils (Kral 1983).

Ecology:
The meadow-beauty is perennial, and flowers June - August (NatureServe 2008).

Populations:
Schotz (2008) reports 43 occurrences, 39 in Florida and four in Alabama. Several of these are of poor viability.

Population Trends:
NatureServe (2008) reports that R. parviflora has experienced substantial declines in recent decades and continues to decline rapidly because of habitat loss.

Status:
This plant's range is highly restricted, its habitat requirements are narrow, and existing populations are notably small. The species has been virtually eliminated from private lands by logging and wetland drainage (Chafin 2000). NatureServe (2008) ranks R. parviflora as critically imperiled in Alabama, imperiled in Florida, and reports that it is likely extirpated in Georgia (no occurrences confirmed in recent years). This species is state-listed as endangered in Florida.

Habitat destruction:
Urbanization and fire suppression are the primary threats to R. parviflora (Schotz 2008). Drainage or other hydrological alteration, timber harvest, and road construction are also significant destroyers of this species' habitat (Chafin 2000, NatureServe 2008). Off-road vehicle (ORV) recreation also threatens some sites (Chafin 2000).

Inadequacy of existing regulatory mechanisms:
Populations of this species in Apalachicola National Forest and on Eglin Air Force Base are somewhat protected. Though it is listed as endangered in Florida, this designation confers no substantial regulatory protections to R. parviflora; no existing regulatory mechanisms adequately protect this species.

Other factors:

Very small population size may compromise the long-term viability of some occurrences (NatureServe 2008).

References:

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Kartesz, J.T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill, N.C.

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Scientific Name:
Rhexia salicifolia
Common Name:
Panhandle Meadow-beauty

G Rank:
G2

Range:
Rhexia salicifolia is endemic to the Florida panhandle and southern Alabama (NatureServe 2008). It has been identified in Bay, Calhoun, Leon (easternmost), Okaloosa (westernmost), Wakulla, Walton, and Washington counties in Florida and Covington and Houston counties in Alabama (Coile 2000, Ward 1979). It has also recently been identified at one site in Georgia (NatureServe 2008). Its range only encompasses 250-1000 square km (100-400 square miles) (NatureServe 2008).

Habitat:
R. salicifolia is a wetland obligate. Under natural conditions, it occurs almost exclusively in wetlands (Chafin 2000). It prefers moist sandy or peaty soils and full sunlight (Ward 1979, Kral 1983). It can be found on the edges and exposed bottoms of limestone lakes, sinkhole ponds, depressed marshes, karst ponds, flatwood ponds, and in interdunal swales along the Gulf Coast (Chafin 2000, Kral and Bostick 1969, Tobe et al. 1998, Ward 1979). The surrounding forest is often long leaf pine-deciduous scrub oak or pine-evergreen scrub oak, but R. salicifolia is not found in this dense shade. It is also not found where herbaceous vegetation along the shoreline becomes too dense (Kral 1983).

Ecology:
R. salicifolia is an herbaceous perennial 8 to 22 inches in height (Chafin 2000). Tubers at its root tips allow it to survive season to season (Ward 1979). It produces flowers June through September (Chafin 2000).

Populations:
Only around 50 locations are known for R. salicifolia, with 21 to 80 estimated occurrences (Chafin 2000). Individual populations are scattered (Ward 1979). Though populations can be locally abundant, there are only 1000 to 2500 individual plants (NatureServe 2008).

Population Trends:
Panhandle meadow-beauty has declined by 10-30 percent because of human activities (NatureServe 2008).

Status:
NatureServe (2008) ranks the meadow-beauty as critically imperiled in Alabama, imperiled in Florida, and not ranked in Georgia. It is listed as threatened by the state of Florida, and is a Federal Species of Concern.

Habitat destruction:
The most significant threat to R. salicifolia populations is habitat alteration due to human intervention. Converting land to agriculture or silviculture, fragmenting habitat, and individual disturbances threaten this meadow-beauty (NatureServe 2008). Lakeside development and pine plantations create erosion, runoff, and sedimentation, which damage the shoreline and alter the hydrology of karst ponds (Chafin 2000). Bulldozing, root raking, bedding, chopping, filling,

ditching, or draining wetlands is detrimental to R. salicifolia (Chafin 2000, Kral 1983). Recreational use of lakes and ponds leads to the clear cutting of pines and the removal of scrub oak, leading to erosion and disturbing shorelines (Kral 1983). The margins of privately owned ponds are often scraped to create artificial beaches, destroying all vegetation along the water's edge (Chafin 2000). Frequent mowing during summer and fall months can prevent new seeds from maturing (Kral 1983). ATV use in the Panhandle meadow-beauty's habitat will also destroy populations (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

R. salicifolia is listed as a Species of Concern by the U.S. Fish and Wildlife Service, but this provides it no federal protection. It is also listed as threatened by the state of Florida, but this only prevents harvest, injury, or destruction of R. salicifolia on public lands or on the private land of another party. Panhandle meadow-beauty has no protection on private land from the land's owner, according to the Preservation of Native Flora of Florida Act.

References:

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Kral, R. and P. E. Bostick. 1969. The genus Rhexia (Melastomaceae). Sida. 3:6.

Tobe, J.D et al. 1998. Florida wetland plants an identification manual. University of Florida, Gainesville.

Ward, D.B. (ED). 1979. Rare and Endangered Biota of Floria, Vol. 5: Plants. University Press, Gainesvile.

Scientific Name:
Rhodacme elatior
Common Name:
Domed Ancylid

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The extant range of the Domed Ancylid consists of 100-250 square km (40-100 square miles) in Alabama, Kentucky, and Tennessee (NatureServe 2008). Basch (1963) reported this species as extant in the Cahaba River in Alabama, and as formerly occurring in the Tennessee River system. Burch (1989) cites both the Tennessee and Cahaba River systems. Mirarchi (2004) states that it is poorly known but reported from the Cahaba River system and possibly from the Tennessee River system.

Habitat:
The Domed Ancylid is found under boulders and slabs in fast to moderate current (NatureServe 2008). Branson and Batch (1970) collected this species from a stream that was 2.5 to 4 feet deep with sand, mud, and gravel substrate (cited in Bishop 2003).

Populations:
Pierson (1997 pers. comm. cited in NatureServe 2008) reports three extant occurrences of Domed Ancylid. This species is known from one site in the Little Cahaba in Shelby County and from three sites in the main channel of the upper Cahaba, though these site may not represent separate populations (Bogan and Pierson 1993, NatureServe 2008). Total population size for this species is unknown with a very crude estimate of 50 to 10,000 individuals (NatureServe 2008).

Population Trends:
NatureServe (2008) reports that this species is severely to rapidly declining (decline of 30 percent to greater than 70 percent).

Status:
The Domed Ancylid is critically imperiled in Alabama, Kentucky, and Tennessee (NatureServe 2008). The IUCN ranks this species as Vulnerable. It is described as very rare in Alabama, Kentucky, and Tennessee (NatureServe 2008). There are only three known extant occurrences of this species, not all of which may represent individual populations (Pierson 1997 pers. comm. in NatureServe 2008). Basch (1963) reports that this species may be extirpated from the Tennessee River system. This limpet is on the Alabama Natural Heritage Program Tracking List. It is a USDA Forest Service Sensitive Species.

Habitat destruction:
The watershed in Kentucky where the Domed Ancylid occurs has been degraded by runoff from logging, agriculture, oil drilling, and coal mining (Bishop 2003). Concerning water quality in this watershed, USFS (2001) states: “Sedimentation and acid mine drainage from abandoned surface and underground coal mines, brine and oil residue from oil drilling, sedimentation and runoff of agricultural chemicals and animal wastes from farm land, discharge from domestic wastewater systems, and sedimentation from roads and timber harvest constitute the primary water quality issues.” Habitat degradation resulting from recreational impacts also threatens this species (USFS 2001).

Herrig and Shute (2002) state that rare aquatic snails such as the Domed Ancylid are threatened by impacts to their habitats from dams and sedimentation. Dams degrade water quality and isolate populations. Sedimentation inhibits the growth of algae on which snails depend for food (Neves et al. 1997), causes the erosion of snail shells, and negatively affects the survival of snail eggs (Hart and Fuller 1974). Sedimentation of snail habitat results from a variety of sources and land-use activities (Neves et al. 1997).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that protect the Domed Ancylid, and no occurrences are appropriately protected and managed (NatureServe 2008). This species is on the Alabama Natural Heritage Program Tracking List, and is considered a Sensitive Species by the U.S. Forest Service, but these designations do not provide regulatory protection.

Other factors:

The Domed Ancylid is threatened by water quality degradation. Runoff, chronic pollution, and pollution events threaten aquatic snails such as the Domed Ancylid (Hart and Fuller 1974, Neves et al. 1997, Herrig and Shute 2002). Exotic species such as zebra mussels also threaten rare snail populations in the Southeast (Hart and Fuller 1974, Herrig and Shute 2002).

References:

Basch, P. 1963. A review of the recent freshwater limpet snails of North America. Bulletin of the Museum of Comparative Zoology, Harvard University, 129: 399-461.

Bishop, V.R. 2003. Viability Assessment Report for Lotic Water (Streams). Daniel Boone National Forest. July 15, 2003. Available online at: http://fs.fed.us/r8/boone/documents/planning/revplan/ams/viability_analysis/viaaquatic.pdf . Last accessed June 26, 2009.

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U.S. Forest Service, Center for Aquatic Technology Transfer. 2001. An assessment and strategy for conservation of aquatic resources on the Daniel Boone National Forest, interim report, April 2001. Center for Aquatic Technology Transfer, VPI. Blacksburg, Va. 166 pp.

Scientific Name:
Rhynchospora crinipes
Common Name:
Hairy-peduncled Beakrush

G Rank:
G2

Range:
Endemic to the Southeastern Coastal Plain, R. crinipes has been recently observed in Hoke and Moore Counties, North Carolina, Santa Rosa and Okaloosa Counties in Florida, Greene and Wayne Counties in Mississippi, and in Baldwin, Conecuh, Covington, Escambia, Mobile, and Washington Counties, Alabama (TNC 1991-93, NCNHP 1993, Kral 1993, NatureServe 2008). It was formerly found in Appling and Turner Counties in Georgia, but no recent confirmation of these occurrences is available and the species is reported as likely extirpated from the state (NatureServe 2008). It is widely scattered across its diminishing range and most populations are small.

Habitat:
The beakrush is found along stream- and riversides on narrow banks, sand or clay bars, and infrequently in streambeds. Preferred substrates may be clay, peat or peaty silt, and gravel (NatureServe 2008). It commonly occurs within forests composed of cypress (Chamaecyparis), red maple (Acer rubrum), and swamp titi (Cyrilla racemiflora), and less commonly among various species of Magnolia, Nyssa, Taxodium, Pinus, and Quercus (Anderson 1988) with a shrub layer often composed of Vaccinium, Rhododendron, Erigeron, and Carex species. The beakrush receives little direct sunlight.

Ecology:
The beakrush is perennial and forms dense clumps reaching 1 m in height. It fruits summer through fall (NatureServe 2008).

Populations:
There are currently roughly 35 known populations of R. crinipes: 17 in Florida, 11 in Alabama, four in North Carolina, and six from Mississippi. Most occurrences are small and comprised of just a few individual plants (NatureServe 2008).

Population Trends:
This species is in decline; several historical occurrences are no longer extant (NatureServe 2008).

Status:
Several historical populations of this plant are no longer extant, and those remaining are small and generally scattered. Florida and Alabama now represent the core of this species' range. NatureServe (2008) ranks R. crinipes as critically imperiled in Alabama, Florida, Georgia, Mississippi, and North Carolina. Is listed as endangered in Florida.

Habitat destruction:
Habitat loss and degradation are the primary threats to this species, which is principally imperiled by various development and construction projects. Damming of the Little River (North Carolina) altered streambank habitat so as to render it unsuitable for R. crinipes; anthropogenic alteration of regional hydrological regime is the most salient rangewide issue for the species. Timber harvesting, road construction and use, and pollution by agricultural and industrial sources are also

cited as threats (NatureServe 2008). Dredging for sand and gravel and military training activities may also destroy habitat or individuals.

Inadequacy of existing regulatory mechanisms:

Several populations of this plant occur on Elgin Air Force Base (Santa Rosa County, FL), but they may be threatened by military training activities. No other occurrences in Florida or Alabama receive any protection (NatureServe 2008). Though it is listed as endangered in Florida, this designation affords R. crinipes no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species or its habitat.

References:

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Anderson, L.C. Field Survey of Eglin Air Force Base, Okaloosa, Santa Rosa, and Walton Counties, Fla. Aug. 1992.

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Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life. Available at: http://www.natureserve.org/explorer. Accessed December 3, 2009.

Sandhills Field Office. 1991-93. The Nature Conservancy's Rare and Endangered Plant Survey for Fort Bragg and Camp MacKall. Contract #M67004-91-D-0010. Personal observations of staff, Southern Pines.

The Nature Conservancy. 1993. Rare and endangered plant survey and natural area inventory of Fort Bragg and Camp MacKall military reservations, North Carolina. Final report by The Nature Conservancy, Sandhills Field Office, December 1993.

Scientific Name:
Rhynchospora thornei
Common Name:
Thorne's Beakrush

G Rank:
G3

Range:
Known from widely scattered sites in the Southeast, natural heritage records exist for this species in Bibb, Cherokee, and Geneva Counties, Alabama, Clay, Jackson, Putnam, St. Johns, and Wakulla Counties, Florida, Baker, Calhoun, and Floyd Counties, Georgia, and for Brunswick, Onslow, and Pender Counties, North Carolina (NatureServe 2008).

Habitat:
This plant occurs along the fluctuating shoreline of limesink ponds, on seeps over calcareous rock substrate, in wet pine savannahs , and in seasonally wet limestone or dolomite glades (FNA 2003, NatureServe 2008). It is also frequently recorded in disturbed sites, around agricultural ponds or in utility corridors.

Ecology:
This perennial plant fruits in late spring and summer (FNA 2003).

Populations:
33 occurrences of this plant were reported as extant in 2003 (NCNHP 2003). Population sizes have not been reported.

Population Trends:
Trends have not been reported for this species, but it is widely considered to be threatened (NatureServe 2008).

Status:
NatureServe (2008) ranks the Thorne's beakrush as critically imperiled in Alabama, Florida, and Tennessee, and imperiled in Georgia and North Carolina (not ranked in South Carolina). R. thornei is also state-listed as endangered in North Carolina.

Habitat destruction:
This species' habitat is widely threatened by land-use change and habitat fragmentation resulting primarily from urbanization and forest management (Southern Appalachian Species Viability Project 2002). Because many populations are found along roadsides, they are exposed to road construction, mowing, and herbicide application used for vegetation management or control and may be thus extirpated.

Inadequacy of existing regulatory mechanisms:
Though it is state-listed as endangered in North Carolina, this designation affords the Thorne's beakrush no substantial regulatory protections. No existing regulatory mechanisms adequately protect this species.

References:

Flora of North America. 2003. Species account for Rhynchospora thornei. Accessed online February 1, 2010 <<http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242357925>>

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Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Scientific Name:
Rudbeckia auriculata
Common Name:
Eared Coneflower

G Rank:
G2

Range:
This species is almost entirely restricted to the coastal plains of Alabama, Georgia, and Florida, though populations have occasionally been reported in adjacent areas of Appalachian Alabama (NatureServe 2008, Kral 1983). Natural heritage records indicate this species is present in Alabama's Barbour, Blount, Covington, Crenshaw, Geneva, Jefferson, Pike, Shelby, and St. Clair Counties, in Florida's Okaloosa County, and in Georgia's Webster County.

Habitat:
The coneflower is found in full sunlight in open bogs, swamps, ditches, swales or wet woodlands, occasionally in partial shade along edges of hardwood swamps with alder (Alnus), bayberry (Myrica), buttonbush (Cephalanthus), titi (Cyrilla), and various sedges (Rhynchospora). Soils in which this species are found are generally high in organic matter and acidity, though basic soils also host R. auriculata (Diamond and Boyd 2004). Is intolerant of closed canopy conditions (Schotz 2002).

Ecology:
This perennial species exhibits moderate environmental specificity in that it requires mesic or wet soils and full or near-full sunlight. It reproduces quickly in suitable growing conditions, sometimes clonally (NatureServe 2008).

Populations:
NatureServe (2008) reports that there are 32 known occurrences of this flower-- 30 in Alabama, 1 in Florida, and 1 in Georgia. The size of individual populations ranges from fewer than 50 to more than 1,000 individuals, but in a 2002 survey, roughly one-third of surveyed populations were comprised of more than 10 individuals (Diamond and Boyd 2004).

Population Trends:
NatureServe (2008) reports that the eared coneflower is currently experiencing substantial declines, though long-term population trends are unknown. Occurrences in natural habitats are in decline as a result of the effects of unsustainable forestry and agricultural practices, but numerous populations have established in disturbed sites, e.g., utility corridors, pastures, and roadside verges that experience periodic mowing; the largest occurrences now reportedly occur in these disturbed sites.

Status:
This species is in decline across its range: habitat loss and degradation have forced it from much of its natural habitat, but populations are becoming established in disturbed anthropogenic habitat. Most remaining populations are small, and very few are considered to be of high quality (Boyd and Diamond 2004). NatureServe (2008) ranks the eared coneflowers as critically imperiled in Florida and Georgia and imperiled in Alabama.

Habitat destruction:

The eared coneflower is severely threatened by the conversion of habitat to agricultural use or to timber harvest plantations (Southern Appalachian Species Viability Project 2002). Changes to soil hydrology and successional patterns (encroachment of shrubs and trees into previously open areas) resulting from these land use practices are also of concern. Populations that become established in anthropogenic habitat are threatened by herbicide application and grazing.

Disease or predation:

Several populations of R. auriculata were found to be infected with a fungus, Fusarium semitectum, in the late 1990s, but this is no longer considered to be a major threat to this species (Diamond et al. 2006).

Inadequacy of existing regulatory mechanisms:

Only two populations of this species are reportedly protected at all (Diamond and Boyd 2004), and no existing regulatory mechanisms adequately protect the eared coneflower.

Other factors:

Invasive plant species, particularly privet (Ligustrum sinense) and Japanese stiltgrass (Microstegium vimineum) threaten R. auriculata in some parts of its range (Diamond and Boyd 2004).

References:

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Scientific Name:
Rudbeckia heliopsidis
Common Name:
Sun-facing Coneflower

G Rank:
G2

Range:
Also known as the Little River Black-eyed Susan, this species is endemic to the southeastern coastal plain, Piedmont, and Appalachian Plateau areas in Virginia, North Carolina, South Carolina, Georgia, and Alabama. Natural heritage records show this species in Prince George County, Virginia, Brunswick and Harnett Counties, North Carolina, Berkeley and Oconee Counties, South Carolina, Bartow, Floyd, Chattooga, and Chattahoochee Counties, Georgia, and in Dekalb, Cherokee, Macon, Monroe, and Lee Counties in Alabama (NatureServe 2008). This flower is rare throughout its range, and occurrences are widely disjunct.

Habitat:
This plant occurs in acidic swales, seeps, or bogs within pine-oak woodlands, peaty seeps in meadows, and sandy alluvium along streambanks, always within moist to wet habitat. It is also found in upland hickory-oak or oak-pine-hickory woodlands, or open pine/mixed hardwood forest. It is tolerant of a spectrum of light regimes from full sun to partial shade (Kral 1983, NatureServe 2008).

Ecology:
This flower is perennial and flowers July-September (Kral 1983).

Populations:
Currently confirmed occurrences include 17 in Alabama, 5 in Georgia, 5 in South Carolina, and none in North Carolina or Virginia where it occurred historically (NatureServe 2008). Population sizes are highly variable, and have not been reported for most populations. Some of the largest populations are located within utility corridors or along highway verges.

Population Trends:
The majority of recently confirmed occurrences are either stable or declining; fire suppression and habitat loss to development are cited as the principle causes of decline where it occurs (NatureServe 2008).

Status:
NatureServe (2008) ranks R. heliopsidis as critically imperiled in Georgia, Virginia, and South Carolina, and imperiled in Alabama. It is state listed as endangered in North Carolina.

Habitat destruction:
The primary threats to this species' habitat include the drainage of upland swales or ponds, fire suppression which leads to altered patterns of succession, construction and development, and other land management or land use change that destroys and degrades habitat (Kral 1983, Southern Appalachian Species Viability Project 2002, ALNHP 1994). Because some of the largest populations are located within utility corridors or along highway verges, they are potentially threatened by herbidice applications. Grazing by cattle, hogs, or other livestock may destroy habitat and/or individuals of R. heliopsidis (Kral 1983).

Inadequacy of existing regulatory mechanisms:

A few populations in Alabama and South Carolina occur on state or federal lands but these are not properly managed for the persistence and viability of R. heliopsidis. Though it is listed as endangered in North Carolina, this designation offers the sunfacing coneflower no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species or its habitat.

References:

Alabama Natural Heritage Program. 1994. Tri-state comprehensive study, Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins: Rudbeckia heliopsidis.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed January 19, 2010.

Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Scientific Name:
Salix floridana
Common Name:
Florida Willow

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The Florida Willow is endemic to the coastal plain of northern and central Florida and southern Georgia (Kral 1983, Ward 1979). It is known from Alachua, Columbia, Jackson, Jefferson, Lafayetta, Lake, Levy, Marion, Orange, Polk, Putnam, Seminole, and Suwannee counties, Florida, from Covington County, Alabama, and from Pulaski and Early counties, Georgia (Godfrey 1988, NatureServe 2008). It has not been collected in Georgia since 1948 (Patrick 1995). It is patchily distributed across its range.

Habitat:
S. floridana is found in forested floodplains, swamps, and hydric hammocks, and along the banks of springheads, spring runs, streams, and ditches (Chafin 2000, Clewell 1985, Ward 1979). It prefers mature riparian corridors with minimal weedy species (NatureServe 2008). It occurs in soils that are calcareous and usually inundated, and is often found in sandy silt (Kral 1983). It is rarely found outside of wetlands (Chafin 2000). Florida willow is shade-intolerant, and seedlings require wet soil and ample sunlight. Saplings are often found in cleared areas, sunny banks or sandbars, or blowdowns where sunlight penetrates beyond the canopy (Kral 1983).

Ecology:
Florida willow is a perennial, deciduous understory shrub or small tree, rarely over 4 m tall (NatureServe 2008, Ward 1979). It begins flowering mid-February to early April and produces fruit from April to May (Patrick 1995). It is sexually dioecious, producing male and female catkins on separate trees (Chafin 2000, Ward 1979).

Populations:
There were 15 known populations of S. floridana as of 2000 (Chafin 2000). Fewer than 1,000 individuals are known, as populations are rarely large.

Population Trends:
NatureServe (2008) reports that populations of S. floridana are experiencing substantial declines.

Status:
The Florida willow is now absent from several historical sites and is declining in most locations where it remains. Distribution is patchy across its range because the habitat it requires is naturally somewhat rare and is being destroyed by anthropogenic activities. NatureServe (2008) ranks the Florida willow as critically endangered in Alabama and Georgia and imperiled in Florida. Populations around Marianna, Florida and along the Chattahoochee River have likely been extirpated by habitat loss resulting from energy development (Argus 1986).

Habitat destruction:
Anthropogenic alteration of regional hydrology harms Florida willow populations, which are highly sensitive to changes in hydrologic regime (Patrick 1995). Draining of floodplains and wet hammocks, clearing of ditches and streambanks, or other alteration to hydrological patterns within this species' habitat make conditions inhospitable (Chafin 2000). Silviculture and agriculture also threaten this species (Chafin 2000, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

Of the 15 populations of S. floridana known in 2000, 10 are located on public lands: the Ocala National Forest, Ichetucknee Springs State Park, Cross Florida Greenway, Upper Lakes Basin Watershed, Spring Hammock Preserve, and Seminole State Forest host known populations (Chafin 2000, NatureServe 2008). It is listed as endangered in both Florida and Georgia, but this designation offers the Florida willow no substantial regulatory protections. No existing regulatory mechanisms adequately protect this species.

Other factors:

The use of herbicides, and pollution or sedimentation generated by agricultural or silvicultural land uses also significantly degrade habitat and may cause local extirpation (Chafin 2000, NatureServe 2008).

References:

Coile, N.C., and M.A. Garland. 2003. Notes on Florida's endangered and threatened plants. Florida Department of Agriculture & Consumer Services, Division of Plant Industry.

Godfrey, R.K. 1988. Trees, shrubs, and woody vines of northern Florida and adjacent Georgia and Alabama. Univ. Georgia Press, Athens. 734 pp.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

Kurz, H., and R.K. Godfrey. 1962. Trees of northern Florida. Univ. Florida Press, Gainesville. 311 pp.

Little, E.L., Jr. 1979. Checklist of United States trees (native and naturalized). Agriculture Handbook No. 541. U.S. Forest Service, Washington, D.C. 375 pp.

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Patrick, T.S., J.R. Allison, and G.A. Krakow. 1995. Protected plants of Georgia: an information manual on plants designated by the State of Georgia as endangered, threatened, rare, or unusual. Georgia Dept. Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program, Social Circle, Georgia. 218 pp + appendices.

Wildlife Resources Division, Georgia Rare Species and Natural Community Information. 2001. Special Concern Plant Species in Georgia. Georgia Department of Natural Resources. <http://www.georgiawildlife.com/content/specialconcernplants.asp>.

Scientific Name:
Sarracenia purpurea var. montana
Common Name:
No common name

G Rank:	**IUCN Status:**
T2	EN - Endangered

Range:
This plant is known from the Blue Ridge Mountains and adjacent piedmont area of North Carolina, South Carolina, and northeastern Georgia. Weakley (2000) reports this species from Greenville County, South Carolina, and from Rabun County, Georgia; counties are not listed for North Carolina.

Habitat:
This plant occurs in mountain and seepage bogs (Weakley 2000).

Ecology:
Sarracenia purpurea var. montana is carnivorous.

Populations:
"A few dozen" populations of this species have been reported (Weakley 2000). Total population size is unknown.

Population Trends:
Population trend has not reported for this carnivorous plant.

Status:
Rare throughout its small range, this species is threatened primarily by habitat loss and degradation resulting from human activities. NatureServe (2008) has not yet ranked this species. It is classified as endangered by the IUCN.

Habitat destruction:
Sarracenia purpurea var. montana is threatened by broad changes in regional hydrology, fire suppression, and outright habitat destruction (International Carnivorous Plant Society 2002).

Overutilization:
This carnivorous plant may be threatened by collection in some areas (Rice 2002).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

International Carnivorous Plant Society. 2002. Available: http://www.carnivorousplants.org/conservation/projects.html. Accessed August 5, 2002.

Rice, B.A. 2002. Carnivorous Plant FAQ v9.0. Available: http://www.sarracenia.com/faq.html. Accessed August 5, 2002.

Weakley, A.S. 2000. Flora of the Carolinas and Virginia: working draft of May 15, 2000. Unpublished draft, The Nature Conservancy, Southern Resource Office.

Scientific Name:
Sarracenia rubra ssp. gulfensis
Common Name:
Gulf Sweet Pitcherplant

G Rank:	**IUCN Status:**
T2	EN - Endangered

Range:
The Gulf sweet pitcherplant is restricted to the western portion of the Florida panhandle from approximately western Holmes County into Santa Rosa County (Schnell 1979). This plant's total range is likely less than 100 square miles (NatureServe 2008).

Habitat:
The pitcherplant is found in sandy springhead bogs, often along the headwaters of small streams or margins of small ponds or slow creeks and rivers. It prefers year-round inundation and full sunlight exposure (Schnell 1979).

Ecology:
The pitcherplant is an insectivorous perennial herb.

Populations:
Number of populations and total population size are not known for this species.

Population Trends:
The pitcherplant is in decline as a result of habitat loss (Schnell 1979, NatureServe 2008).

Status:
The pitcherplant is restricted to a very small range where it is threatened by anthropogenic habitat loss and is in decline. NatureServe (2008) ranks this subspecies as imperiled in Florida. It is ranked as endangered by the IUCN.

Habitat destruction:
Habitat loss threatens this species across its extremely narrow range. Anthropogenic changes to local hydrological patterns (dams, diversions, drainage), fire suppression, residential development, and conversion of habitat to agricultural or silvicultural uses are responsible for the habitat loss that imperils this species. Schnell (1979) reports that high quality occurrences have been extirpated by housing developments, shopping centers, road construction, and clearing for agriculture or forestry.

Inadequacy of existing regulatory mechanisms:
The pitcherplant occurs on Eglin Air Force Base (Santa Rosa County, FL) but may be threatened there by military training activities. No existing regulatory mechanisms adequately protect this species or its habitat.

References:

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life. Available at: http://www.natureserve.org/explorer. Accessed December 3, 2009.

Schnell, D.E. 1979. Sarracenia rubra Walter ssp. gulfensis: a new subspecies. Castanea. 44(4):217-223.

Scientific Name:
Sarracenia rubra ssp. wherryi
Common Name:
Wherry's Sweet Pitcherplant

G Rank:
T3

IUCN Status:
EN - Endangered

Range:
This pitcherplant is known from a very small range in Mississippi, Alabama, and possibly Florida. Its distribution is sporadic and localized. Numerous historical occurrences are no longer extant (NatureServe 2008). Natural heritage records exist for the following counties: Baldwin, Covington, Escambia, Mobile, Munroe, and Washington Counties, Alabama, Greene and Wayne Counties, Mississippi, and Escambia County, Florida (NatureServe 2008, Wunderlin and Hansen 2002).

Habitat:
The pitcherplant most frequently inhabits drier microsites within seepage or pitcher plant bogs, and is also found in open savannas, bay head forests, and some anthropogenic habitats such as ditches. It has a narrow range of tolerance for soil moisture levels (NatureServe 2008).

Ecology:
This carnivorous plant flowers March-April.

Populations:
There were 80 extant occurrences of this species in Alabama as of 2002, though only 21 of those were ranked as having either good or excellent viabiliity (NatureServe 2008). Six occurrences were reported as extant in Mississippi as of 1985. Population data for the other states in which these species occurs are not available.

Population Trends:
NatureServe (2008) determined that this species is in severe decline (defined as a decline of 70% or more in population, range, area occupied, and/or the number or condition of occurrences). Numerous historical occurrences are no longer extant, and habitat is widely threatened by various anthropogenic factors.

Status:
Few populations of this species have been recently confirmed; this species' range appears to be in decline and numerous records of the destruction of populations exist. NatureServe (2008) ranks this species as critically imperiled in Mississippi and vulnerable in Alabama. It is classified as endangered by the IUCN.

Habitat destruction:
Fire suppression is perhaps the greatest threat to Sarracenia rubra ssp. wherryi's habitat; in the past 60 years, wildfires have been increasingly suppressed because of concerns about timber production, agriculture, and human safety. Fire-maintained species like S. rubra ssp. wherryi have experienced substantial declines as a result (Southern Appalachian Species Viability Project 2002). Wholesale habitat destruction by the establishment of timber plantations, agricultural, residential, and commercial developments, and road construction are also a major factor in this species' decline (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

One occurrence of this species is found in Alabama's Conecuh National Forest, and may be appropriately protected. No existing regulatory mechanisms adequately protect the Wherry's sweet pitcherplant.

References:

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 13, 2010)

Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Wunderlin, R.P., and B.F. Hansen. 2002. Guide to Florida's vascular plants. University Press: Tampa, FL.

Scientific Name:
Schoenoplectus hallii
Common Name:
Hall's Bulrush

G Rank:
G2

Range:
Hall's bulrush is known from a fairly wide range throughout the eastern United States, but occurrences are widely disjunct and scattered, and the species is declining overall. Natural heritage records indicate that S. hallii is currently present in Alexander, Cass, Mason, and Morgan Counties, Illinois, Daviess, Lake, and Porter Counties, Indiana, Harper, Harvey, and Reno Counties, Kansas, Christian County, Kentucky, Allegan and Muskegon Counties, Michigan, Howell and Scott Counties, Missouri, Brown, Garfield, Holt, Loup, Rock, and Wheeler Counties, Nebraska, Comanche and Woods Counties, Oklahoma,and and Dane County, Wisconsin (NatureServe 2008, Stebbins 2003). It was formerly present in Iowa, Massachusetts, and Georgia but has not been observed in those states since the early to mid-20th century (FNA 2002, O'Kennon and McLemore 2004).

Habitat:
This bulrush is generally found on the shores and bottoms of shallow, ephemeral pools, sinkhole ponds, coastal plain marshes, sandy swales, and comparable habitats where annually variable water levels keep the sandy banks free of other competing vegetation (FNA 2002, Crispin and Penskar 1990, NatureServe 2008).

Ecology:
Though it is often considered an annual, S. hallii does not germinate reliably in the same site each year: seeds remain viable in substrate for several years and only germinate under specific conditions. Populations in one location may be large in one year and non-existent the next, and the factors that induce germination are not well-understood.
In the northern part of its range, S. hallii fruits between late August and late September (Crispin and Penskar 1990).

Populations:
The total number of occurrences of this rush is not known, but recent surveys put estimates at roughly 100, with the majority found in Illinois (Stebbins 2003). Because of the annual variation in population size at any given site, a reliable estimate of global population size is not available.

Population Trends:
NatureServe (2008) reports that this species has experienced substantial declines in recent decades as a reuslt of habitat destruction, though longer-term population trends are not known. The total number of sites observed in recent rangewide surveys is declining, but this may be attributable to the variable nature of annual germination rates.

Status:
Known from scattered locations across its range, this species is reportedly in decline and threatened by widespread habitat destruction, and has been extirpated from several states where it was historically present. Historical sites in Massachusetts were reportedly extirpated by sewage and industrial effluent, and sites in Kentucky were destroyed by construction of a truck stop

(Stebbins 2003). NatureServe (2008) ranks S. hallii as critically imperiled in Illinois, Indiana, Kansas, Kentucky, Michigan, Oklahoma, Texas, and Wisconsin, and imperiled in Missouri.

Habitat destruction:

Threats are variable across this species' range. Rangewide, the most significant threat is habitat destruction and/or degradation, largely caused by groundwater depletion for irrigation purposes, and dams, diversions, dredging, or other anthropogenic changes to regional hydrological patterns. Residential, commercial, agricultural, and recreational development are also substantial threats (McKenzie et al. 2007, Penskar and Higman 2002). ORV (off-road vehicle) recreation has caused significant damage to habitat occupied by S. hallii in Michigan and currently threatens the viability of several sites (Penskar and Higman 2002, MNFI 2000).

Disease or predation:

Excessive consumption by Canada geese (Branta canadensis) and mute swans (Cygnus olor) threatens some populations of S. hallii (McKenzie et al. 2007).

Inadequacy of existing regulatory mechanisms:

Populations occur in the Huron-Manistee and Mark Twain National Forests, on the Indiana Dunes National Lakeshore and in the Sand Prairie-Scrub Oak Nature Preserve (Illinois) - these receive some degree of protection (Stebbins 2003). NatureServe (2008) states: "All known populations should receive protection. Protection efforts must ensure the integrity of water within the watershed in which the element occurs. Sufficient buffer must exist to protect the site from herbicide drift, alterations in water table and similar potentially destructive actions."

Other factors:

Invasive plant species such as purple loosestrife (Lythrum salicaria) may outcompete or inhibit germination of S. hallii, and currently threaten sites in Indiana and Kansas (McKenzie 1998, Ostlie 1990). Population isolation is becoming an increasingly severe problem for S. hallii - isolated populations are more vulnerable to stochastic extinction and less resilient to environmental change because of low or nonexistent gene flow (McKenzie et al. 2007). Hybridization with S. saximontanus also threatens the integrity of this species in some areas (Stebbins 2003).

References:

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Michigan Natural Features Inventory. 2000. Element Occurrence Records for Scirpus hallii. Michigan Department of Natural Resources. 2 pp.

NatureServe. 2008. NatureServe explorer: an online encyclopedia of life. Available at: http://www.natureserve.org/explorer. Accessed December 3, 2009.

O'Kennon, R.J., and C. McLemore. 2004. Schoenoplectus hallii (Cyperaceae), a globally threatened species new for Texas. Sida 21(2): 1201-1204.

Ostlie, W.R. 1990. Element Stewardship Abstract for Scirpus hallii—Hall’s bulrush. The Nature Conservancy. Minneapolis, MN. 8 pp.

Penskar, M.R., and P.J. Higman. 2002. Special plant abstract for Schoenoplectus hallii (Hall's bulrush). Michigan Natural Features Inventory, Lansing, MI. 4 pp. [http://web4.msue.msu.edu/mnfi/abstracts/botany/Schoenoplectus_hallii.pdf]

Stebbins, S. 2003. Conservation assessment for Hall's bulrush, Schoenoplectus hallii. USDA Forest Service, Eastern Region. Accessed online December 16, 2009 <<www.fs.fed.us/r9/wildlife/.../plant_Schoenoplectus_hallii-Halls_Bulrush.pdf >>

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Scientific Name:
Scutellaria ocmulgee
Common Name:
Ocmulgee Skullcap

G Rank:
G2

Range:
The Ocmulgee Skullcap is endemic to areas near major rivers along Georgia's Fall Line and in parts of neighboring South Carolina (Patrick et al. 1995).

Habitat:
This plant occurs in mesic hardwood or bluff forests along river banks and ravine slopes (GADNR 1996). It is associated with old growth hardwood forest, prefers rich soil, and is often found with geranium, heartleaf, and lop-seed (USACE 2008).

Ecology:
This perennial herb reproduces vegetatively and sexually, and blooms June-October (NatureServe 2008).

Populations:
This plant is known from approximately ten widely-scattered locations along the Oconee, Ocmulgee, and Savannah Rivers (GADNR 1996, NatureServe 2008). Population sizes have not been reported.

Population Trends:
Population trends have not been reported for this species, but major habitat loss is widely documented.

Status:
This plant is endemic to a small range, within which it is known from relatively few (10) scattered locations, and significant habitat loss is ongoing. NatureServe (2008) ranks the Ocmulgee skullcap as imperiled in Georgia, where it is state-listed as threatened.

Habitat destruction:
Significant habitat loss in this region is a major threat to the survival of this species. Riverside residential development and recreational activities are ongoing and extensive (Patrick et al. 1995, NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Though it is listead as threatened in the state of Georgia, this designation offers the Ocmulgee skullcap no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species from ongoing threats.

Other factors:
Invasive exotic species like the Japanese honeysuckle, Lonicera japonica, potentially threaten the skullcap (Patrick et al. 1995, NatureServe 2008).

References:

Georgia Department of Natural Resources. 1996. Piedmont ecoregional overview. Accessed online February 2, 2010 <<www1.gadnr.org/cwcs/PDF/11_Piedmont.pdf>>

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U.S. Army Corps of Engineers (USACE). 2008. Threatened and endangered species of the Upper Savannah River Basin. Accessed online February 2, 2010 <<www.sas.usace.army.mil/endspec/T&E%20Manual%202008.pdf >>

Scientific Name:
Sideroxylon thornei
Common Name:
Swamp Buckthorn

G Rank:
G2

Range:
Also called the Georgia bully, S. thornei is known from southern Georgia and a few scattered occurrences in adjacent parts of Alabama and Florida. Natural heritage records show this species was recently confirmed in Early, Calhoun, Baker, Miller, Decatur, and Liberty Counties, Georgia, in Franklin, Escambia, and Jackson Counties, Florida, and in Houston County, Alabama (Anderson 1996).

Habitat:
This plant is found in low-lying oak flatwoods where soils remain saturated for long periods after rain or flooding, and also in wetlands overlying limestone formations (Chafin 2007, NatureServe 2008).

Ecology:
The buckthorn flowers during May and June, and fruits August-October (Patrick et al. 1995).

Populations:
This species is reported from 12 locations in Georgia, one in Alabama, and four in Florida (Anderson 1996). The size of individual populations is not reported.

Population Trends:
NatureServe (2008) determined that the swamp buckthorn is experiencing very rapid decline due to habitat loss.

Status:
NatureServe (2008) ranks this species as critically imperiled in Alabama and Florida and imperiled in Georgia. It is state listed as endangered in Georgia.

Habitat destruction:
S. thornei has already experienced substantial habitat loss to wetland drainage and subsequent conversion of habitat to agricultural use or timber plantations (Patrick et al. 1995). Continuing threats include drainage, road construction or maintenance, and other activities that affect local hydrological regimes (NatureServe 2008). At the Fort Steward site in Georgia, this species is potentially threatened by hydrological impacts caused by road construction or expansion and deer browsing (K. Lutz, pers. comm. cited in NatureServe 2008).

Disease or predation:
Browsing by white-tailed deer (Odocoileus virginianus) may threaten some populations, as evidenced by low fruit set in these areas (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
Several occurrences in Georgia occur on protected lands, though the status of these populations is not reported. While it is listed as endangered in the state of Georgia, this designation affords the swamp buckthorn no substantial regulatory protections; no existing regulatory mechanisms adequately protect S. thornei or its habitat.

References:

Anderson, L. C. 1996. New geographical and morphological data for Sideroxylon thornei (Sapotaceae). Sida 17(2): 343-348.

Chafin, L.G. 2007. Field guide to the rare plants of Georgia. State Botanical Garden of Georgia, Athens, Georgia.

McCollum, Jerry L., and David R. Ettman. 1977. Georgia's Protected Plants. Resource planning section, OPR; Endangered Plant Program, Georgia Dept. of Natural Res.; Soil Conserva- tion Service, Atlanta, GA. 64 p.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: November 9, 2009)

Patrick, T.S., J.R. Allison, and G.A. Krakow. 1995. Protected plants of Georgia: an information manual on plants designated by the State of Georgia as endangered, threatened, rare, or unusual. Georgia Dept. Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program, Social Circle, Georgia. 218 pp + appendices.

Scientific Name:
Sigmodon hispidus insulicola
Common Name:
Insular Cotton Rat

G Rank:
T1

IUCN Status:
NT - Near threatened

Range:
The total range of the insular cotton rat is less than 250 square km in Lee, Sarasota, and Charlotte counties, Florida. This species occurs on Captiva Island, Sanibel Island, Pine Island, Little Pine Island, and on Chadwick Beach near Englewood, all near Charlotte Harbor (Layne 1978, NatureServe 2008).

Habitat:
The insular cotton rat occurs in tidal marshes and maritime hammock edges where it constructs runways among dense vegetation (Layne 1978). On Sanibel Island, the insular cotton rat uses varied habitats which include drier areas of freshwater marshes with tall, dense emergent vegetation, open dry grass fields, and mixed grass and brushlands. On Captiva Island, it ocurrs in grassy areas. On Pine and Little Pine Islands it occurs in dense areas of Spartina patens, in pine-palmetto stands, and in wet areas in garbage dumps (Layne 1978, NatureServe 2008).

Ecology:
Lactating and pregnant females have been detected in May and August, with litter sizes of 2-4. Populations of this species apparently undergo large annual fluctuations (Layne 1978).

Populations:
NatureServe (2008) estimates that there are 6-20 populations of this subspecies. Abundance information is not available.

Population Trends:
Population trend data are not available for this rare subspecies.

Status:
The insular cotton rat has a limited range in southern Florida. This critically imperiled (T1S1) subspecies occurs in a heavily developed area. It is ranked as near threatened by the IUCN and as a Species of Greatest Conservation Need in Florida.

Habitat destruction:
Habitat destruction for development is a major threat for the insular cotton rat, which occurs in an area heavily developed for retirement and resort use (NatureServe 2008). This subspecies' coastal marsh habitat is threatened by commercial and residential development, dikes and marsh impoundments, invasive species, and residential sewage discharge (Scott 2004). Its dry prairie habitat is threatened by overgrazing, altered fire regime, invasive vegetation and invasive hogs and armadillos, and increasing development pressure (Scott 2004).

The Florida Fish and Wildlife Conservation Commission (2005) reports that the cotton rat's salt marsh habitat is very highly threatened by fragmentation, coastal development, and sedimentation, and highly threatened by the construction of roads, bridges and causeways, incompatible industrial operations, dam operations and the incompatible release of water, climate variability, inadequate stormwater management, surface water withdrawal, channel modification, and incompatible wildlife and fisheries management strategies.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which adequately protect the insular cotton rat. It is a species of greatest conservation need in Florida, but this designation conveys no regulatory protection. This animal is known to occur on Charlotte Harbor State Reserve, and it might occur on Ding Darling National Wildlife Refuge.

Other factors:

The insular cotton rat's coastal marsh habitat is threatened by sea-level rise resulting from global climate change (Scott 2004). Its habitat is also threatened by invasive vegetation and invasive hogs and armadillos (Scott 2004). Tidal inundation from tropical storms and hurricanes also threatens this subspecies (Enge et al. 2003).

References:

Enge, K. M., B. A. Millsap, T. J. Doonan, J. A. Gore, N. J. Douglass, and G. L. Sprandel. 2003. Conservation plans for biotic regions in Florida containing multiple rare or declining wildlife taxa. Final Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Florida Fish and Wildlife Conservation Commission. 2005. Florida's Wildlife Legacy Initiative. Florida's Comprehensive Wildlife Conservation Strategy. Tallahassee, Florida, USA.

Hall, E. Raymond. 1981. The Mammals of North America, Vols. I & II. John Wiley & Sons, New York, New York. 1181 pp.

Howell, A. H. 1943. Two new cotton rats from Florida. Proc. Biol. Soc. Washington 56:73-76.

Layne, J. N., editor. 1978. Rare and endangered biota of Florida. Vol. 1. Mammals. State of Florida Game and Freshwater Fish Commission. xx + 52 pp.

Peppers, L. L., and R. D. Bradley. 2000. Cryptic species in SIGMODON HISPIDUS: evidence from DNA sequences. Journal of Mammalogy 81:332-343.

Scott, C. 2004. Endangered and Threatened Animals of Florida and Their Habitats. University of Texas Press. 381 pp.

Scientific Name:
Simpsonaias ambigua
Common Name:
Salamander Mussel

G Rank:	**AFS Status:**	**IUCN Status:**
G3	Special Concern	CD - Conservation

Range:
The salamander mussel is a freshwater species native to the eastern United States; it is present in Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, possibly New York, Ohio, Pennsylvania, Tennessee, West Virginia, Wisconsin, and Ontario. Though it is widely distributed and locally abundant in some areas, this species is considered rare and local extirpations have been so widespread as to constitute a decline in the total area of occupancy. It is thought to be extirpated from Iowa, and possibly from New York as well (NatureServe 2008). Historically, this species was found throughout the upper Mississippi River drainage, and as far south as Tennessee's Cumberland River drainage, though Parmalee and Bogan (1998) reported it extirpated from this drainage since no new specimens had been found since 1965. It is considered rare in Ohio, where it is known from the lower Little Scioto River and from Salt Creek (Watters 1992). In Pennsylvania it is known from the middle Allegheny-Redbank drainage, and possibly from the French and Lower Monongahela River drainages (PA NHP 2007 as cited in NatureServe 2008). In Missouri it is known only from the Bourbeuse River (Oesch 1995). In Illinois, it was known from the Kankakee and Vermillion River drainages, but it has not been collected for over 30 years (Cummings and Mayer 1997). In Kentucky, it is sporadically found in the upper Green River, and also occurs in the north fork of the Red River drainage (Cicerello and Schuster 2003, Clarke 1988). In Indiana, it is still present in some Wabash tributaries, Graham Creek, and in the Maumee and Tippecanoe Rivers (Fisher 2006, Harmon 1989, Harmon 1992, Cummings and Berlocher 1990). Arkansas' populations are limited to the Spring and Little Red Rivers (Harris and Gordon 1987, Harris et al. 1997). In Canada, the only known remaining population is found in the Sydenham River, though another may still be present in the Thames River based on a single recent specimen (Metcalfe-Smith et al. 2003, Cudmore et al. 2004, Watson et al. 2000).

Habitat:
This species is primarily found in areas of swift current, in sand or silt substrate under large, flat stones (Buchanan 1980, Clarke 1985, Oesch 1984, 1995, Parmalee and Bogan 1998). Across its range, it also occurs in all types of freshwater habitat, including creeks, streams, and lakes (Cudmore et al. 2004).

Ecology:
Reproductive ecology is similar to that of most other freshwater mussels, but this mussel uses an amphibian as a glochidial host instead of a fish; the only known glochidial host for the salamander mussel is the mudpuppy, Necturus maculosus (Howard 1915, 1951, Bequaert et al. 1998).

Populations:
NatureServe (2008) estimates that there are 21-80 extant occurrences of this mussel, stating, "Although widely distributed and abundant in some areas, this species is still considered rare in all states where it is found and recently local extirpations have been occurring across nearly its

range to the point where declines in area of occupancy have occurred." In appropriate habitat this species can be locally abundant, and total population size is thought to be at least one million individuals. Numerous historical occurrences have been extirpated, and many remaining populations are small and isolated.

Population Trends:
NatureServe (2008) estimates that this mussel has declined by up to 50 percent in the long-term, and has continued to decline in the short-term by up to 30 percent, stating, "While this species is easily overlooked, intense searches in areas where the species has previously been indicate decline (Stansbery, 1970; Clarke, 1985). Sietman (2003) reports it extirpated from the Mississippi River below St. Anthony Falls and portions of the Minnesota River drainage in Minnesota. Cummings and Mayer (1997) report it may be extirpated in Illinois. In Canada, it has been extirpated from the Cedar and Detroit Rivers by the zebra mussel and only a single population remains in the Sydenham River in Ontario (Metcalfe-Smith and Cudmore-Vokey, 2004) and possibly Lower Thames (Watson et al., 2000; Cudmore et al., 2004). In the 19th Century, it was collected from several sites near Buffalo including Lake Erie, Buffalo Creek [River], and Cayuga Creek at Lancaster in New York (Strayer and Jirka, 1997)."

The Pennsylvania Fish and Boat Commission (2010) reports that a projected 80 percent population reduction is expected in the state within the next 10 years.

Status:
Though it is still widely distributed, this species is considered rare across its range, and continuing declines have resulted in a decline in the total area of occupancy (NatureServe 2008). NatureServe (2008) reports that the salamander mussel is critically imperiled in Arkansas, Illinois, Michigan, Missouri, Pennsylvania, Tennessee, and West Virginia, imperiled in Indiana, Kentucky, Minnesota, and Wisconsin, and vulnerable in Ohio. It is endangered in Canada, and is ranked by the IUCN as "conservation dependent." It is a federal Candidate (Category 2), and is endangered in Illinois, Michigan, Pennsylvania, and Missouri, threatened in Wisconsin, and a species of special concern in Indiana and Ohio. Its rank is being changed from special concern (Williams et al. 1993) to threatened by the American Fisheries Society (draft 2010, in review).

Habitat destruction:
The salamander mussel has been extirpated from many historical locations due to habitat loss and degradation, and many activities pose an ongoing threat to the species. A primary threat to this mussel is impoundment. For example, in Minnesota, this mussel is threatened by high stream-flow variations on the St. Croix River caused by a hydropelectric dam operating on a seasonal peaking regime (Minnesota Department of Natural Resources 2010).

Other known threats to this mussel include channelization, dredging, industrial and residential development, agriculture, forestry, sand and gravel quarrying, oil and gas drilling, and coal mining (Carman 2002, Kentucky Dept. of Fish and Wildlife Resources 2005, FWS 2006, Michigan Natural Features Inventory 2007, Minnesota Dept. of Natural Resources 2010).

The Pennsylvania Fish and Boat Commission (2010) reports that the Allegheny River pool 5 subpopulation of this mussel “is under direct threat from proposed commercial sand and gravel operations. . . . the lock and dam system in the Allegheny and Ohio Rivers, combined with maintenance/commercial sand and gravel dredging, have altered and destroyed Salamander mussel habitat, eliminated habitat continuity and genetically isolated subpopulations occurring in the Allegheny and Monongahela River systems. Allegheny River pool 5 has recently received authorization for dredging."

Inadequacy of existing regulatory mechanisms:

Though it is listed by several states, these designations do not protect the salamander mussel's habitat, and habitat degradation is the primary threat to its continued existence. No existing regulatory mechanisms adequately protect this species from the multitude of threats it faces.

Other factors:

The salamander mussel is threatened by water pollution from many sources (NatureServe 2008). It is sensitive to siltation and water quality changes resulting from impoundment (Carman 2002). Known threats to this mussel include industrial and residential discharge, siltation, herbicide and surface run-off, acid mine drainage, wastewater discharge, animal wastes, and toxic chemical spills (Carman 2002, Kentucky Dept. of Fish and Wildlife Resources 2005, FWS 2006, Michigan Natural Features Inventory 2007). The Pennsylvania Fish and Boat Commission (2010) states: "Anthropogenic disturbances (that is, disturbances derived from human activities) such as acute or chronic pollution events could destroy remaining live Salamander mussels in Dunkard Creek or either Allegheny River subpopulation. Sedimentation from oil and gas developments, forestry and agricultural practices could have an adverse effect on mussel/host interactions and reduce Salamander mussel recruitment. The Salamander mussel is the only known North American mussel to use an amphibian as a host. Any alteration or reduction to host habitat (for example, loss of large flat rocks, sediment burial of large flat rocks) is likely to alter host numbers or behavior and reduce Salamander mussel recruitment."

Invasive mussel species are also a known threat to the salamander mussel (FWS 2006, Michigan Natural Features Inventory 2007). In the Mississippi River and its tributaries, the salamander mussel is also being impacted by the infestation of nonnative zebra mussels, which attach themselves in large numbers to the shells of native mussels, eventually causing death by suffocation (Minnesota Department of Natural Resources 2010). Zebra mussel invasion has contributed to the extirpation of the salamander mussel from the Cedar and Detroit Rivers (Metcalfe-Smith and Cudmore-Vokey 2004). Zebra mussels have colonized the Allegheny River, Ohio River and French Creek, and salamander mussel mortality from zebra mussel infestation is expected (Pennsylvania Fish and Boat Commission 2010).

Any factor which threatens the mudpuppy also threatens the salamander mussel (Carman 2002, Michigan Natural Features Inventory 2007).

This mussel is also threatened by population isolation and low gene flow (Kentucky Dept. of Fish and Wildlife Resources 2005).The Pennsylvania Fish and Boat Commission (2010) reports that the Allegheny River pool 6 subpopulation of this mussel is threatened by genetic isolation, natural mortality, and the threat of catastrophic events.

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Scientific Name:
Solidago arenicola
Common Name:
Southern Racemose Goldenrod

G Rank:
G2

Range:
This flower is confirmed from a limited number of sites in Alabama and Tennessee. It is found along the Locust Fork River in Blount County, Alabama, and along Daddy's Creek, the Obed River, Clear Creek, the upper Emory River, and the Big South Fork River and its primary tributaries in Tennessee (D. Estes, pers. comm. as cited in NatureServe 2008). A closely related taxon in Kentucky has yet to be confirmed as S. arenicola, but if confirmed it would expand the species' range to include the Big South Fork, Rockcastle, and Cumberland Rivers in Kentucky (D. White pers. comm. as cited in NatureServe 2008).

Habitat:
In Alabama this plant occurs within a floodplain in shady, acidic woods in deep, sandy, alluvial soil. Its habitat is often inundated in winter and early spring, and is drier in summer and fall (Keener and Kral 2003). Tennessee occurrences are found on cobble bars in rivers. Possible Kentucky populations are found on boulder bars (NatureServe 2008).

Ecology:
This plant flowers from August-October (FNA 2006).

Populations:
Six occurrences of this flower are currently known, one in Alabama and five in Tennessee; total population size is not known (NatureServe 2008).

Population Trends:
Population trend is not reported for this rare species, but known populations appear to be healthy (NatureServe 2008).

Status:
NatureServe (2008) ranks S. arenicola as critically imperiled in both Alabama and Tennessee.

Habitat destruction:
Dredging, channelization, impoundments, and other human activities that result in altered hydrology may threaten this species' floodplain habitat (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect Solidago arenicola or its habitat.

Other factors:
Invasion of cobble or boulder bar habitat by Mimosa spp. or other changes in succession may be a threat to the goldenrod (D. White, pers. comm as cited in NatureServe 2008).

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Scientific Name:
Solidago plumosa
Common Name:
Yadkin River Goldenrod

G Rank:
G1

Range:
First discovered in 1894, S. plumosa was thought to be extinct for nearly 100 years until it was rediscovered in 1994. It is currently known from only two sites within the Yadkin River Gorge in North Carolina (NatureServe 2008). This species is also known as the plumed goldenrod.

Habitat:
This plant is found in rock crevices adjacent to rivers or streams (CPC 2004). It persists in areas that experience periodic scouring, and is not tolerant of longer periods of inundation (USFWS 2004).

Populations:
Only two occurrences of this species are known. One is composed of 62 juvenile and 3119 adult rosettes; the second contained only 9 rosettes in the most recent surveys (Bates 2004, 1998).

Population Trends:
This species has experienced major decline over the long-term; the construction of two dams on the Yadkin River were thought to have extirpated the species entirely until it was rediscovered in the early 1990s. Observational trends since its rediscovery also suggest that populations are declining (Bates 2004).

Status:
Known from just two populations of declining size and viability, this species merits protection against further losses and likely extinction. NatureServe (2008) ranks the Yadkin River goldenrod as critically imperiled. It is listed as endangered in North Carolina.

Habitat destruction:
Alteration to local flood regime is likely the greatest threat to this species; the construction of two hydroelectric dams destroyed historical populations. Future changes to these dams or the construction of other impoundments on the Yadkin River could extirpate this species. Recreational use of habitat may result in trampling of individual S. plumosa (Southern Appalachian Species Viability Project 2002).

Inadequacy of existing regulatory mechanisms:
Neither of the two sites where this species occurs is adequately protected, although USFWS is working with the relevant power companies to ensure that further habitat destruction does not occur. Though it is listed as a federal species of special concern and state-listed as endangered in North Carolina, these designations confer no substantive regulatory protections to the Yadkin River goldenrod; no existing regulatory mechanisms adequately protect this highly imperiled species.

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Weakley, Alan S. Former Botanist, North Carolina Heritage Program, now North Carolina Botanical Garden, Chapel Hill, N.C.

Scientific Name:
Somatochlora calverti
Common Name:
Calvert's Emerald

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
Somatochlora calverti has been found in the Florida Panhandle and adjacent Alabama, and there is a population in Allendale County, South Carolina that is probably disjunct (NatureServe 2008).

Habitat:
Larval and breeding habitat for this species is unknown, but is probably boggy forest seepages (NatureServe 2008). Adults feed over roads or among tree canopies. Mating pairs hang from tree twigs in the feeding areas.

Populations:
Eleven localities are known, but the species may occur in many small, discrete habitats. Population data are not available.

Population Trends:
In the short term, this species is considered stable, but over time small habitats will be likely destroyed, and adults may become more exposed to pesticides and loss of forest foraging habitat.

Status:
NatureServe (2008) ranks this species as critically imperiled in Alabama (S1S3), vulnerable in Florida, and in South Carolina it is not ranked. It is ranked as near threatened by the IUCN. Paulson (2007) reports that "S. calverti is relatively rare within its restricted range (it has an estimated Extent of Occurrence of less than 3,000 km^2. The species is rarely reported and its breeding habitat has not yet been determined. It remains poorly known but is sufficiently uncommon to be of some concern."

Habitat destruction:
NatureServe (2008) reports that this species is threatened by development, clear-cutting, and pesticide use.

Paulson (2007) states: "S. calverti is experiencing logging to the woodland where adults are seen and the threat of drought to small-sized breeding habitats is likely to occur in the future."

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), S. calverti occurs in Torreya State Park, Blackwater River State Forest, Apalachicola National Forest in Florida and Conecuh National Forest, Alabama. It is considered a Sensitive Species by the U.S. Forest Service (2007) but any protection afforded the species under this designation is discretionary. Logging is a primary threat to this species, and occurrences on state and national forests offer no actual protection from logging or clearcutting. This species may occur in the Nature Conservancy's Apalachicola Bluffs Preserve, but has not been confirmed.

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Scientific Name:
Somatochlora margarita
Common Name:
Texas Emerald

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
This dragonfly is found from East Texas to central Louisiana (NatureServe 2008). There are natural heritage records for the following Texas counties: Anderson, Houston, Sabine, San Augustine, San Jacinto, and Trinity.

Habitat:
NatureServe (2008) reports that larval habitat remains unknown, but is probably seepages and boggy forest trickles in loblolly and longleaf pine forests. This dragonfly probably breeds in small, discrete sites.

Populations:
S. margarita is known from ten sites in east Texas and two in Louisiana (NatureServe 2008).

Population Trends:
NatureServe (2008) reports a short term decline of up to 30 percent for the Texas Emerald, based on probable breeding seeps not being used when forest is clearcut.

Status:
This species is ranked as imperiled in Texas and not rated in Louisiana. It was a Federal C-2 Candidate Species until that list was abolished. It is ranked as vulnerable by the IUCN.

Habitat destruction:
This dragonfly is threatened by logging and agriculture (NatureServe 2008). It does not breed in areas that have been clearcut. The Boswell Timber Sale on the Sam Houston National Forest occurred in the habitat of the Texas Emerald, and impacted its habitat (USFS 2003).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), the Texas Emerald receives some protection because it occurs on National Forest lands. Occurring on National Forests, however, does not protect this species' habitat from logging. No existing regulatory mechanisms protect this species.

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Scientific Name:
Somatochlora ozarkensis
Common Name:
Ozark Emerald

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The Ozark Emerald is found in the Ozark and Ouachita Mountains of Arkansas, adjacent Oklahoma and Missouri, and eastern Kansas (NatureServe 2008).

Habitat:
This dragonfly is found in small forested streams (NatureServe 2008).

Populations:
This dragonfly is known from eight sites in Arkansas, two in Oklahoma, two in Kansas, and one in Missouri (NatureServe 2008). It is abundant in appropriate habitat.

Population Trends:
NatureServe (2008) reports that this species is stable in the short term, but will face an eventual decline from deforestation, development of vacation homes, and pollution.

Status:
NatureServe (2008) ranks this species as critically imperiled in Arkansas and Kansas, imperiled in Missouri, and not rated in Oklahoma. In Kansas, it is a Nongame Species in Need of Conservation (Kansas Admin. Regs. § 115-15-2 2010). It is ranked as near threatened by the IUCN.

Habitat destruction:
Deforestation, development, and pollution threaten the Ozark Emerald (NatureServe 2008).

The Kansas Department of Wildlife and Parks (2005) reports that "[s]tream channelization and clearing of riparian woodlands along streams are major threats to the Ozark Emerald Dragonfly."

Inadequacy of existing regulatory mechanisms:
S. ozarkensis can be found in Ozark and Ouachita National Forests, the Lake Sylvia Recreation Area in Arkansas, and in Woodson County State Lake Area in Kansas (NatureServe 2008). Occurrence on public lands does not necessarily protect this dragonfly from the threats of logging and pesticides, however.

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Scientific Name:
Somatogyrus alcoviensis
Common Name:
Reverse Pebblesnail

G Rank:
G1

IUCN Status:
EX - Extinct

Range:
This species is known from only two sites in the upper Ocmulgee System in Georgia (Georgia Dept. of Natural Resources 2009). The range of the Reverse Pebblesnail is less than 100 square km in the Alcovy and Yellow Rivers in Newton County (Burch 1989, Watson 1999, 2000).

Habitat:
This snail is restricted to shoals in two small to medium sized rivers where it uses bedrock, cobble, or boulder substrate. It does not occur on silt substrates. It can also be found on vegetation such as mats of riverweed in rapidly flowing water (Watson 2000, NatureServe 2008).

Populations:
There are two extant populations of this snail. A 1995 survey of 21 sites detected this species only at the Alcovy River at Factory Shoals and at Cedar Shoals in the Yellow River (Watson 2000). Total population size is unknown.

Population Trends:
NatureServe (2008) reports that this species is relatively stable, but it was detected at only 2 of 21 sites in a 1995 survey (Watson 2000).

Status:
The IUCN classifies this snail as extinct, but this needs to be revised. NatureServe (2008) ranks it as critically imperiled (G1S1).

Habitat destruction:
Watson (2000) reports that growth and development in the Atlanta area potentially threaten this snail. Metropolitan areas in the southeast are among the fastest growing in the nation. The human population of Atlanta, GA expanded by 24 percent from 2000-2007 (U.S. Census Bureau 2009). The Georgia Dept. of Natural Resources (2009) reports that aquatic species in the Piedmont are increasingly threatened by the rapid pace of residential and commercial development. Expansion of the Atlanta area has resulted in the development of subdivisions, roads, utility corridors, and retail centers (GDNR 2009). Indiscriminant use of herbicides and excessive ground disturbance along roads and in utility corridors is impacting aquatic habitats. Direct habitat loss and increased non-point source pollution threaten this snail. Point source discharges into streams in the Piedmont region include wastewater industrial facilities and municipal treatment facilities making water quality degradation a threat to this snail. There has also been extensive conversion of forest and woodland habitats to agriculture, contributing heavy sediment loads to waterways (GDNR 2009). Unmanaged recreational use, particulary by ATVs, is also a threat to this snail, as shoals and other aquatic habitats are being heavily impacted by off-road traffic and litter in this region (GDNR 2009).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species.

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Scientific Name:
Sporobolus teretifolius
Common Name:
Wire-leaved Dropseed

G Rank:
G2

Range:
Wireleaf dropseed is endemic to the Coastal Plain area of southeastern North Carolina, northeastern South Carolina, southern Georgia, and southeastern Alabama. Natural heritage records show this species has been recently confirmed in Houston County, Alabama, Berrien, Bulloch, Candler, Coffee, Colquitt, Crisp, Dodge, Emanuel, Jeff David, Jenkins, Screven, Telfair, Toombs, Treutlen, Turner, and Worth Counties, Georgia, in Brunswick and Columbus Counties, North Carolina, and in Georgetown and Horry Counties, South Carolina. It is reportedly extirpated from several counties where it was historically present (NatureServe 2008).

Habitat:
Found in permanently moist or wet savannas, this species' preferred habitat is usually underlain by clay soils. It is typically associated with a canopy complex of pond pine (Pinus serotina), longleaf pine (Pinus palustris) and sweetbay magnolia (Magnolia virginiana), though it may also occur in the ecotones between pine/oak/wiregrass and red maple/sweetgum/swamp tupelo communities (Weakley and Peterson 1998). In wetter habitat, S. teretifolius may be the dominant grass, or may be co-dominant with the Carolina dropseed (Sporobolus pinetorum), toothache grass (Ctenium aromaticum) and cutover muhly (Muhlenbergia expansa). It is occasionally found in seepage slopes or pitcherplant bogs (NatureServe 2008).

Ecology:
This species is perennial.

Populations:
There are approximately 46 currently known occurrences of this species, and 9 more may be extant but have not been confirmed for 30 years. Known populations are distributed as follows: Georgia: 26, South Carolina: 10, North Carolina: 9, and Alabama: 1 (NatureServe 2008). Population size varies widely across this species' range; at a few sites, S. teretifolius is dominant or co-dominant, while elsewhere it is sparsely distributed or sporadic. Abundance seems to be largely contingent on recent management actions (whether a site has been burned, mowed, cleared, or other).

Population Trends:
The total number of occurrences seems to be in decline based on county-level extirpations (NatureServe 2008).

Status:
Several historical occurrences of this species appear to have been extirpated. NatureServe (2008) ranks the wireleaf dropseed as critically imperiled in Alabama and South Carolina and imperiled in North Carolina and Georgia. It is state listed as endangered in North Carolina.

Habitat destruction:

The primary threat to this species is habitat destruction. The low-lying savannas preferred by S. teretifolius are frequently converted to pine plantations or agricultural fields, used as pasture, sited for development, or simply degraded by fire suppression and hydrological changes. Fire suppression is particularly damaging because fire stimulates flowering in S. teretifolius; if fires do not occur at 3-5 year intervals, either reproductive failure or encroachment by woody vegetation may exclude this species (McIver 1981). Dredging, damming, filling, or other alterations to the wetland hydrology may be harmful to to S. teretifolius if they inundate or dessicate its habitat. This species may establish in anthropogenic habitat (e.g., along roadside verges); if mowing occurs out of sync with the dropseed's reproductive cycle and/or period of dormancy (December-March), populations may be destroyed (Weakley, A.S. pers. comm. as cited in NatureServe 2008). Recreation also threatens this species. Individual plants may be crushed by visitors recreating in their habitat (McIver 1981). Plants can also be crushed by heavy equipment used in logging, military activities, or fire suppression (McIver 1981).

Inadequacy of existing regulatory mechanisms:

A few occurrences of this species are found on land owned by the Nature Conservancy in North Carolina, but most other populations occur on private lands where no protections are offered. Sustaining this species requires active management as it is clearly fire-adapted and highly sensitive to hydrological changes within its habitat (e.g., Cooper et al. 1977). Though it is listed as threatened in North Carolina, this designation offers S. teretifolius no substantial regulatory protections; no existing regulatory mechanisms adequately protect the wireleaf dropseed.

References:

Cooper, J.E., S.S. Robinson, and J.B. Funderburg (eds.). 1977. Endangered and threatened plants and animals of North Carolina. North Carolina State Museum of Natural History, Raleigh, North Carolina. 444 pp.

McIver, H. 1981. "Green Swamp Nature Preserve, Brunswick Company, North Carolina." Document prepared for North Carolina Field Office of The Nature Conservancy. February 1981.

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Sorrie, B.A. 1995. Status survey for Sporobolus teretifolius. Prepared for the North Carolina Natural Heritage Program and the U.S. Fish and Wildlife Service, Asheville, NC.

Weakley, A. S. 2008. Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas. Working Draft of 7 April 2008. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at Chapel Hill. Online. Available: http://herbarium.unc.edu/flora.htm (Accessed 2008).

Weakley, A.S. and P.M. Peterson. 1998. Taxonomy of the Sporobolus floridanus complex (Poaceae: Sporobolinae). Sida 18(1): 247-270.

Scientific Name:
Stellaria fontinalis
Common Name:
Water Stitchwort

G Rank:
G3

Range:
This regional endemic is restricted to the Interior Low Plateaus Province of central Tennessee to north-central Kentucky. It occurs along the Kentucky River and tributaries (NatureServe 2008).

Habitat:
This flowering plant occurs in open to partially-shaded wet areas with thin limestone soil. It is found where natural disturbances reduce competition from woody and weedy plants. It is associated with wetland plants, mosses, and algae, and occurs on stream banks, washouts, moss-covered cliffs overlooking streams, and calcareous seeps in glade woods.

Populations:
As of 1997, there were two extant populations in Kentucky, and 53 in Tennessee, but this number might be out of date (NatureServe 2008). This plant occurs in dense concentrations in very local areas.

Population Trends:
As this species has not been assessed since 1997, new populations may have been detected, and known populations have also likely been lost due to rampant development in its habitat (eg. Tennessee Valley Authority 2008, Elkhorn Intercounty Consortium and Conservation Districts 1995).

Status:
NatureServe (2008) ranks this species as imperiled in Kentucky and vulnerable in Tennessee, but this hasn't been updated since 1997 and there are only two known populations in Kentucky. It is listed as threatened by the states of Kentucky and Tennessee.

Habitat destruction:
Populations of this plant are particularly susceptible to being extirpated by habitat loss because it is distributed in dense concentrations in very localized areas. Industrial, residential, and commercial development is the greatest threat to this species. There is a known population of this plant which will be extirpated by a Tennessee Valley Authority (TVA) power supply improvement project substation, the Record of Decision for which was issued on June 5, 2008. In Tennessee, a population of this plant occurs within the area of a proposed vehicle manufacturing plant (U.S. DOE 2009). Another population in Tennessee occurs in the project area of a proposed transmission line (Tennessee Valley Authority 2007). In Tennessee, this plant also occurs within the project area of proposed natural gas transmission facilities (Midwestern Gas Transmission Company 2005). In Kentucky, one of only two known extant populations of this species is threatened by the proposed Smith coal-fired power plant in Clark County (Gilpin Group 2007, U.S. DOE 2002). Concerning development in a watershed where this species occurs in Kentucky, the Elkhorn Intercounty Consortium and Conservation District states, "The development activity in the watershed is practically increasing daily. This area is heavily used for industrial development and the expansion of existing factories." Impoundment also threatens this species, one population of which is threatened by a proposed TVA impoundment (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which currently protect this species. NatureServe (2008) reports that 1-3 occurrences are appropriately protected and managed. One population occurs in a State Natural Area in Tennessee. One of the two Kentucky occurrences is on a State Nature Preserve. This plant is listed as threatened by the states of Kentucky and Tennessee, but this designation does not confer regulatory protection, as numerous projects have been approved which will extirpate known populations of this plant.

Other factors:

Water stitchwort requires continual availability of water to survive and reproduce. It is thus threatened by drought, climate change, wetland draining and filling, and surface and groundwater withdrawal and diversion.

References:

Gilpin Group Environmental Consulting and Planning. 2007. Environmental Assessment for the Proposed Smith Station CT Units 9 and 10 and the Smith-West Garrard Electric Transmission Project. June 2007.

Midwestern Gas Transmission Company. 2005. Applicant Prepared Environmental Assessment. Eastern Extenstion Project. Docket No. CP05-372-000. Accessed Feb. 9, 2010 at: http://www.mgt.oneokpartners.com/pdf/MGTVolumeVPublicInformation.pdf

Tennessee Valley Authority. 2007. Final Environmental Assessment Murfreesboro-East Franklin and Pinhook Radnor 161-KV Transmission Lines. Accessed Feb. 9, 2010 at: http://www.tva.gov/environment/reports/murfreesboro_tl/ea.pdf

Tennessee Valley Authority. 2008. Rutherford-Williamson-Davidson Power Supply Improvement Project. Rutherford 500-kV Substation. Accessed Feb. 9, 2010 at: http://www.tva.gov/environment/reports/rutherford/RWD_FEIS_Ch4.pdf

U.S. Dept. of Energy. 2002. Kentucky Pioneer Integrated Gasification Combined Cycle Demonstration Project Final Environmental Impact Statement. Accessed Feb. 9, 2010 at: http://www.netl.doe.gov/technologies/coalpower/cctc/cctdp/bibliography/demonstration/pdfs/clnen/KyPioneerEIS.pdf

U.S. Dept. of Energy. Final Environmental Assessment for Department of Energy loan to Nissan North America, Inc. for advanced technology electric vehicle manufacturing project in Smyrna, Tennessee. DOE/EA-1678. Washington, DC. Accessed Feb. 9, 2010 at: http://www.gc.energy.gov/NEPA/documents/EA-1678.pdf

Scientific Name:
Stygobromus cooperi
Common Name:
Cooper's Cave Amphipod

G Rank:
G1

IUCN Status:
VU - Vulnerable

Range:
The range of Cooper's Cave amphipod is less than 100-250 square km (less than about 40 to 100 square miles). It is known only from the type locality in Berkeley Co., West Virginia (NatureServe 2008).

Habitat:
S. cooperi s found in mud-bottomed seep-fed cave pools, according to NatureServe (2008).

Populations:
S. cooperi is known only from one site in West Virginia. Only two specimens of this species have ever been collected, and it has not been reported in the last 20 years.

Status:
Stygobromus cooperis is critically imperiled (NatureServe 2008). It was a Federal C-2 Candidate Species until that list was abolished. In 1985, the US Fish and Wildlife Service determined that this species warranted listing under the Endangered Species Act, but was precluded by efforts to list other species (USFWS 1985). It is ranked as vulnerable by the IUCN.

Habitat destruction:
NatureServe (2008) reports that this species faces the possible threat of groundwater pollution or other disturbances. Recreation threatens this species. When not gated, Silers Cave is subject to significant accumulations of garbage and other pollution, and has been cleaned up by volunteers several times (National Speleological Society 2002, 2004).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

Fitzpatrick, J.F., Jr. 1983. How to Know the Freshwater Crustacea. Wm. C. Brown Co. Publishers. Dubuque, Iowa. 277 pp.

Holsinger, J.R. 1978. SYSTEMATICS OF THE SUBTERRANEAN AMPHI- POD GENUS STYGOBROMUS (CRANGONYCTIDAE), PART II: SPECIES OF THE EASTERN UNITED STATES. SMITHSONIAN CONTRIBUTIONS TO Z00- LOGY, 266:1-144.

Holsinger, J.R. 1978. Systematics of the subterranean amphipod genus Stygobromus (Crangonyctidae). Part II: Species of the Eastern United States. Smithsonian Contributions to Zoology 266:1-144.

Holsinger, John R. 1976. The Freshwater Amphipod Crustaceans (Gammaridae) of North America. Biological Methods Branch, Environmental Protection Agency, Cincinnati, Ohio. 89 p.

National Speleological Society. 2004. Sligo Grotto History. Available online at http://www.caves.org/grotto/sligo/history.htm. Last accessed December 14, 2009.

National Speleological Society. Sept. 2002.Update!!! Gate Repaired. Available online at http://www.caves.org/grotto/sligo/newgate2.htm. Last accessed December 14, 2009.

U.S. Fish and Wildlife Service. May 10, 1985. Endangered and Threatened Wildlife and Plants; Findings on Pending Petitions and Description of Progress on Listing Actions. 50 Federal Register 19761.

Scientific Name:
Stygobromus indentatus
Common Name:
Tidewater Amphipod

G Rank:
G3

IUCN Status:
VU - Vulnerable

Range:
S. araeus is a blind, cavernicolous amphipod whose distribution is restricted to a small portion of the southeastern United States' Coastal Plain. Populations are known in North Carolina and Virginia, and current range is thought to extend from New Kent and Matthews Counties in Virginia southward to Gates County, North Carolina (Holsinger 1978, Terwilliger 1991).

Habitat:
S. araeus is found in shallow groundwater habitat in the interstitial pores of unconsolidated sediments; also found in wells, seeps, and drains (Holsinger 1969, 1978, Terwilliger 1991).

Ecology:
Though individuals are motile, the species is non-migratory and does not disperse great distances. Reproduction occurs in spring months (Holsinger 1972). Both adults and juveniles are detrivores, scavenging food from their subterranean aquatic environment.

Populations:
Overall abundance is unknown, but there are reportedly 7 known occurrences in Virginia and only 1 in North Carolina (NatureServe 2008).

Population Trends:
No reports on population trends are readily available, but the extent of habitat destruction suggests that decline is likely.

Status:
NatureServe (2008) reports that this amphipod is critically imperiled overall (N1), vulnerable in Virginia, and unranked in North Carolina. It is ranked as vulnerable by the IUCN.

Habitat destruction:
The limited range within which this species occurs (primarily the Tidewater region of Virginia) is undergoing rapid urbanization, which both outrightly destroys habitat and contributes to the decline of remaining habitat by increasing local water demands and lowering the regional water table (NatureServe 2008). This species is highly sensitive to habitat loss and degradation because it is so specialized and cannot readily disperse to new habitat patches.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect this tidewater amphipod.

Other factors:
Pollution of groundwater habitat in urbanized and periurban areas threatens this species (NatureServe 2008).

References:

Holsinger, J.R. 1969. The Systematics of the North American Subterranean Amphipod genus Apocrangonyx (Gammaridae) with Remarks on Ecology and Zoogeography. American Midland Naturalist 81:1-28.

Holsinger, J.R. 1972. The Freshwater Amphipod Crustaceans (Gammaridae), of North America. GPO. IDENT. MANUAL #5 PP. 1-89.

Holsinger, J.R. 1978. Systematics of the subterranean amphipod genus Stygobromus (Crangonyctidae). Part II: Species of the Eastern United States. Smithsonian Contributions to Zoology 266:1-144.

Holsinger, J.R. 1978. Systematics of the subterranean amphipod genus Stygobromus (Crangonyctidae). Part II: Species of the eastern United States. Smithsonian Contributions to Zoology, 266: 1-144.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: November 9, 2009)

Terwilliger, Karen. 1991. Virginia's Endangered Species: Proceedings of a Symposium held at Va. Tech. April 1989. The McDonald and Woodward Publishing Company, Blacksburg.

Scientific Name:
Stygobromus morrisoni
Common Name:
Morrison's Cave Amphipod

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The range of Morrison's cave amphipod is very disjunct, and extends from Bath Co., Virginia, north-northeast to Hardy Co., West Virginia, and covers a linear distance of approximately 161 km (100 mi). Sites are in two different river drainages, the upper James river and the upper Potomac River. Additional populations of this species may eventually be discovered in the large disjunctions between the presently known localities (Holsinger 1978).

Habitat:
Stygobromus morrisoni is found in subterranean gravel-bottomed streams to mud-bottomed lakes (NatureServe 2008).

Ecology:
In the type locality, S. morrisoni occurs syntopically with S. mundus (Holsinger 1976). In Kenny Simmons Cave (West Virginia), a specimen was collected along with two specimens of S. Emarginatus. In Dyers Cave (WV), a single specimen was collected from a pool which also contained several specimens of S. Allegheniensis (Holsinger 1978).

Populations:
This species is only known from 4 occurrences, 2 sites in WV and 2 in VA, only one of which has been seen within the last 25 years (NatureServe 2010).

Population Trends:
Trend is unknown, but in the past 25 years this species has only been detected at one of four known locations.

Status:
NatureServe (2008) ranks this species as critically imperiled in Virginia and West Virginia. It was a Federal C2 Candidate species until that list was abolished. It is ranked as vulnerable by the IUCN.

Habitat destruction:
NatureServe (2008) warns that potential threats include groundwater pollution, depletion of groundwater by human use, and disturbance or destruction by spelunkers.

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms protect this species.

References:

Fitzpatrick, J.F., Jr. 1983. How to Know the Freshwater Crustacea. Wm. C. Brown Co. Publishers. Dubuque, Iowa. 277 pp.

Holsinger, J.R. 1978. Systematics of the subterranean amphipod genus Stygobromus (Crangonyctidae). Part II: Species of the Eastern United States. Smithsonian Contributions to Zoology 266:1-144.

Holsinger, John R. 1976. The Freshwater Amphipod Crustaceans (Gammaridae) of North America. Biological Methods Branch, Environmental Protection Agency, Cincinnati, Ohio. 89 p.

Linzey, Donald W., ed. 1979. Endangered and Threatened Plants and Animals of Virginia. Virginia Polytechnic Institute and State University, Blackburg, Virginia. 665 p.

Scientific Name:
Stygobromus parvus
Common Name:
Minute Cave Amphipod

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
The Minute cave amphipod is found in four caves in Randolph, Tucker and Pochahontas Counties, West Virginia in two or three drainages (Lewis 2001).

Habitat:
S. parvus occurs in mud-bottomed, drip, and seep pools in caves, as reported by NatureServe (2008). It is apparently tolerant of substrate but prefers standing water.

Ecology:
This species has been found to occur sympatrically with both S. Emarginatus and S. nanus. (Holsinger 1978).

Populations:
This species is known from 4 sites (Lewis 2001). It is not abundant at any site.

Population Trends:
Trend is unknown.

Status:
The status of Stygobromus parvus in West Virginia is critically imperiled. It was also a Federal C2 Candidate Species until that list was abolished. It is ranked as vulnerable by the IUCN.

Habitat destruction:
Lewis (2001) reports that S. parvus may be threatened by pollution of its cave pools due to sewage, agricultural chemicals, or chemical spills; road construction, logging, farming, and trail building near cave habitats; impoundments that backflood the caves; water contamination by smoke intrusion; quarrying and blasting; drilling for water, oil, or gas exploration; the introduction of exotic species; and vandalism caused by cave explorers.

Inadequacy of existing regulatory mechanisms:
All four caves where this species is known to occur are in the Monongahela National Forest, where the species is considered a Sensitive Species by the Regional Forester, but this designation confers no regulatory protection for the species habitat, and the amphipod could be threatened by authorized activities on the forest including logging and oil and gas exploration.

References:

Fitzpatrick, J.F., Jr. 1983. How to Know the Freshwater Crustacea. Wm. C. Brown Co. Publishers. Dubuque, Iowa. 277 pp.

Holsinger, J.R. 1978. SYSTEMATICS OF THE SUBTERRANEAN AMPHI- POD GENUS STYGOBROMUS (CRANGONYCTIDAE), PART II: SPECIES OF THE EASTERN UNITED STATES. SMITHSONIAN CONTRIBUTIONS TO Z00- LOGY, 266:1-144.

Holsinger, J.R. 1978. Systematics of the subterranean amphipod genus Stygobromus (Crangonyctidae). Part II: Species of the Eastern United States. Smithsonian Contributions to Zoology 266:1-144.

Holsinger, John R. 1976. The Freshwater Amphipod Crustaceans (Gammaridae) of North America. Biological Methods Branch, Environmental Protection Agency, Cincinnati, Ohio. 89 p.

Lewis, J.J. 2001. Conservation Assessment for Minute Cave Amphipod (Stygobromus parvus). Prepared for U.S. Forest Service. Available online at http://www.fs.fed.us/r9/wildlife/tes/ca-overview/docs/invertebrate_Stygobromus_parvus-minutecaveamphipod.pdf. Last accessed January 13, 2010.

Scientific Name:
Stylurus potulentus
Common Name:
Yellow-sided Clubtail

G Rank:
G2

IUCN Status:
VU - Vulnerable

Range:
This dragonfly is found in the Florida panhandle and coastal Mississippi (NatureServe 2008).

Habitat:
S. potulentus occupies pristine sand-bottomed forest streams and rivers. Adults forage low along shady forest edges (NatureServe 2008).

Populations:
NatureServe (2008) reports that this species is known from seven streams and one river in southern Mississippi and the Florida Panhandle. It is known from perhaps 200 miles of stream. It is estimated that there are probably hundreds to thousands of individuals per stream.

Population Trends:
NatureServe (2008) reports that S. potulentus is likely severely to rapidly declining (decline of 30 percent to more than 70 percent) in the short term. The actual trend is unknown and this estimate is based on the extreme sensitivity of this species to any alteration of water quality.

Status:
Stylurus potulentus is subject to a limited range, rarity, and susceptibility to alterations in stream flow and water quality (NatureServe 2008). It is ranked as vulnerable by the IUCN and as imperiled by NatureServe (2008).

Habitat destruction:
This species is extremely sensitive to water quality degradation is threatened by development, pollution, clearcutting, and pesticides (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
According to NatureServe (2008), ths species occurs in a state forest in Florida, but this does not necessarily offer any protection from clogging or pesticides. No existing regulatory mechanisms protect this species.

References:

Bick, G.H. 1983. Odonata at risk in conterminous United States and Canada. Odonatologica 12 (3):209-226.

Needham, James G., and Minter J. Westfall, Jr. 1954. A Manual of the Dragonflies of North America (Anisoptera). University of California Press, Berkeley, California. 615 p.

Paulson, D.R. and S.W. Dunkle. 1999. A Checklist of North American Odonata. Slater Museum of Natural History University of Puget Sound Occasional Paper Number 56:86 pp.

Scientific Name:
Symphyotrichum puniceum var. scabricaule
Common Name:
Rough-stemmed Aster

G Rank:
T2

Range:
The rough-stemmed aster is endemic to a small range in east-central Texas, and is possibly also found in Mississippi and Louisiana but is not confirmed in these states. Natural heritage records show this species was present, as of 2009, in Anderson, Franklin, Freestone, Henderson, Hopkins, Smith, Van Zandt, and Wood Counties (TPWD 2009), though NatureServe (2008) reports it only in Anderson, Smith, Van Zandt, and Wood Counties.

Habitat:
The aster is found in seepage bog or pond habitat (NatureServe 2008).

Ecology:
This perennial flower may reproduce clonally via rhizomes (NatureServe 2008).

Populations:
The rough-stemmed aster is known from eight small populations (size unreported) (NatureServe 2008).

Population Trends:
Trend information has not been reported for this rare species.

Status:
Known from just eight small populations in a small range in Texas, this flower is restricted to seepage bogs which are threatened by various human activities. NatureServe (2008) ranks the rough-stem aster as imperiled (T2).
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Habitat destruction:
Conversion of wetland/seep habitat to pasture is a major threat to the rough-stemmed aster and has reduced available suitable habitat for this species substantially (USFWS 1997).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the rough-stem aster or its habitat.

References:

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 19, 2010).

Texas Parks and Wildlife Department. 2009. Rough-stem aster. Accessed online January 19, 2010
<<http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx?tabindex=0&tabid=9&type=map&cname=Rough-stem%20aster&desc=relatively%20open%20sites%20in%20saturated%20soils%20associated%20with%20seepage%20areas,%20bogs,%20marshes,%20ponds,%20drainages,%20and%20degraded%20wetland%20remnants%20on%20the%20Queen%20City,%20Carrizo,%20and%20Sparta%20sand%20formations;%20flowering%20late%20September-early%20November&parm=PDAST0T2L4&sname=Symphyotrichum%20puniceum%20var%20scabricaule&usesa=&sprot=>>

U.S. Fish and Wildlife Service. 1995. Category and Listing Priority Form.

Scientific Name:
Tallaperla lobata
Common Name:
Lobed Roachfly

G Rank:
G2

Range:
This stonefly is known only from Washington and Russel counties, Virginia (NatureServe 2008). There are natural heritage records for the North Folk Holston and Upper Clinch watersheds.

Habitat:
Tallaperla lobata is restricted to small pristine headwater streams in forested areas (NatureServe 2008).

Populations:
NatureServe (2008) reports that T. lobata is known from fewer than ten ocurrences in Washington Co., Virginia.

Population Trends:
Trend has not been quantified for this species.

Status:
NatureServe (2008) ranks this species as critically imperiled (S1S2). This stonefly is restricted to pristine headwater streams and is threatened by logging and recreation within its very limited habitat.

Habitat destruction:
This species requires pristine forested headwater habitat and is threatened primarily by logging and recreation (NatureServe 2008).

Tallaperla lobata was collected from Little Moccasin Creek near Low Gap, but most of the original forest has been cleared for upland pasture (Kondratieff and Kirchner 1991).

Inadequacy of existing regulatory mechanisms:
The Lobed roachfly occurs primarily on the Jefferson National Forest (NatureServe 2008). Despite its occurrence on public land, this species is threatened by logging and recreation. The Forest Service maintains a Sensitive Species list, but protections offered to sensitive species are discretionary. No existing regulatory mechanisms adequately protect this species.

References:

Kondratieff, B. C. and R. F. Kirchner. 1991. Stoneflies. Pp. 214-225. In: Virginia's Endangered Species. K. Terwilliger (ed.). McDonald & Woodward Publ. Co., Blacksburg, VA.

Stark, B. P. 1983. The Tallaperla maria Complex of Eastern North America (Plecoptera: Peltoperlidae). Journal of the Kansas Entomological Society, Vol. 56, No. 3 pp. 398-410.

Stark, B.P. 1996. Last updated 16 February 2001. North American Stonefly List. Online. Available: http://www.mc.edu/campus/users/stark/Sfly0102.htm. Last accessed March 16, 2010.

Scientific Name:
Thalictrum debile
Common Name:
Southern Meadowrue

G Rank:
G2

Range:
Southern meadowrue is known from a few scattered occurrences in Mississippi, Alabama, and Georgia. Natural heritage records show that the southern meadowrue has been recently confirmed in Pickens, Sumter, and Wilcox Counties, Alabama (extirpated from Colbert, Greene, Lawrence, and Madison Counties), in Gordon County, Georgia (extirpated from Floyd County), and in Lowndes, Oktibbeha, and Wayne Counties, Missisissippi (extirpated from Noxubee County) (NatureServe 2008).

Habitat:
This plant is found in rich, rocky, limestone floodplain forest, often close to streams (Patrick et al. 1995, Chafin 2007).

Ecology:
This perennial plant blooms March-April, and fruits March-May (NatureServe 2008).

Populations:
Southern meadowrue is known from approximately 10 extant occurrences: total population size is not reported (NatureServe 2008).

Population Trends:
NatureServe (2008) determined that T. debile is significantly declining, largely due to habitat destruction.

Status:
This plant is known from very few widely scattered occurrences, threatened by invasive exotics and habitat destruction, and several populations have been recently extirpated. NatureServe (2008) ranks this species as critically imperiled in Georgia and Mississippi and imperiled in Alabama. It is state listed as threatened in Georgia.

Habitat destruction:
Activities associated with road construction have destroyed one population of southern meadowrue and threaten others (Chafin 2007). Additionally, any activities that threaten the integrity of local hydrological processes may harm this sensitive plant species.

Inadequacy of existing regulatory mechanisms:
Though it is listed as threatened in Georgia, this designation affords the southern meadowrue no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species.

Other factors:
Invasive exotics like Japanese honeysuckle (Lonicera japonica) outcompete and destroy populations of T. debile and represent an increasing threat across this species' range (Patrick et al. 1995).

References:

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Scientific Name:
Thamnophis sauritus pop. 1
Common Name:
Eastern Ribbonsnake - Lower Florida Keys

G Rank:
T1

Range:
The Lower Florida Keys population of the Eastern Ribbonsnake occurs on the Lower Keys, Monroe County. It is currently known from only a few of the mainline islands that are traversed by US highway 1, and is isolated from all other populations of this species (NatureServe 2008).

Habitat:
This snake is generally found along the edges of freshwater wetlands, but has also been detected in mangrove and spartina habitats (NatureServe 2008).

Populations:
NatureServe (2008) estimates that there are fewer than 20 populations of the Lower Florida Keys Eastern Ribbonsnake. It is known from fewer than ten islands in the Lower Keys. Total population size is unknown.

Population Trends:
It is estimated that this subspecies has declined by up to 30 percent due to continuing habitat destruction (NatureServe 2008).

Status:
This snake is critically imperiled (T1S1) (NatureServe 2008).

Habitat destruction:
Habitat loss and degradation poses the greatest threat to this species. This snake is associated with wetland habitats, which are vulnerable to destruction on all private lands within its very limited range (NatureServe 2008). Loss of habitats for urban and residential development is onging in the Keys (NatureServe 2008). The Florida Dept. of Environmental Protection reports that the Florida Keys has been a fast-growing area since the middle of the 20th Century and remains very vulnerable to habitat conversion for development (http://www.dep.state.fl.us/cmp/programs/files/final_proj_flkeys_08.pdf). In addition to habitat conversion, the wetland habitats which support this species are threatened by hydrologic changes and human use of freshwater resources (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that adequately protect this snake. There are a few occurrences on protected lands, at Key Deer Wildlife Refuge and at Coupon Bight Aquatic Preserve.

References:

Florida Dept. of Environmental Protection. 2008. Florida Keys. http://www.dep.state.fl.us/cmp/programs/files/final_proj_flkeys_08.pdf

Scientific Name:
Thoburnia atripinnis
Common Name:
Blackfin Sucker

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Vulnerable	LC - Least concern

Range:
The blackfin sucker is restricted to headwater streams of the Barren River System of Kentucky and Tennessee, including Long, Salt, and Big Trace Creeks (Timmons et al. 1983, Page and Burr 1991).

Habitat:
This fish occurs in small creeks with clear water, typically in pools with rocky bottoms and overhanging vegetation. It spawns in swift water (Timmons et al. 1983).

Populations:
NatureServe (2008) cites information indicating 13 locations for the blackfin sucker.

Population Trends:
NatureServe (2008) describes this fish as potentially stable. AFS (Jelks et al. 2008) list population trends as mixed with some declining and some increasing.

Status:
Within its very narrow range, this fish can be locally common. It is considered imperiled in Kentucky and critically imperiled in Tennessee (NatureServe 2008). AFS (Jelks et al. 2008) list it as vulnerable because of the present or threatened destruction, modification, or reduction of its habitat or range and a narrow range.

Habitat destruction:
NatureServe (2008) list siltation and eutrophication from agricultural runoff, as well as stream channelization as the most serious threats to this species' habitat. Jelks et al. (2008) list it as vulnerable because of the present or threatened destruction, modification, or curtailment of habitat or range.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) states that no blackfin sucker populations are protected. It is deemed as in need of management in Tennessee and a species of greatest conservation need in Kentucky, neither of which provides any protection for the species.

Other factors:
Jelks et al. (2008) list this fish as vulnerable because of a narrow, restricted range. It is threatened by pollution from agriculture (NatureServe 2008).

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Scientific Name:
Toxolasma lividus
Common Name:
Purple Lilliput

G Rank:	AFS Status:	IUCN Status:
G2	Special Concern	NE - Not evaluated

Range:
This mussel, also known as T. lividus, is found in the lower Ohio River drainage from southwest Ohio downstream nearly to the mouth of the Ohio. West of the Mississippi River, it occurs in southern Missouri, northern Arkansas, and potentially in eastern Kansas. In the Cumberland River drainage, it is widespread but sporadic downstream of Cumberland Falls. This mussel is found in most of the Tennessee River drainage from southwest Virginia, western North Carolina, and east Tennessee downstream to the mouth of the Tennessee River. It occurs across northern Alabama in the Tennessee River and some tributaries (Williams et al. 2008).

Habitat:
The Purple Lilliput inhabits a diversity of substrates including fine-particles, mud, sand, gravel, cobbles and/or boulders in riffles or flats immediatly above riffles (NatureServe 2008). It is known from the headwaters of small to medium sized rivers. Toxolasma lividus generally occurs at depths of less than 1 m, but can adapt to deeper lentic environments as evidenced by its occurrence in the Wheeler Reservoir in the Tennessee River Drainage (Roe 2002), but it is very rarely encountered in big river habitat or reservoirs (Gordon and Lazer 1989).

Populations:
Although this species has a wide geographic range, NatureServe (2008) estimates that there are only from 6-20 extant populations. The range of T. lividus is poorly understood because of confusion with T. glans, but both forms have undergone considerable declines in range. Total population size for this species is unknown. NatureServe (2008) reports that it is rarely detected in surveys, describing it as "quite rare but widely scattered," and providing the following details: "In the Maumee River drainage, it is rare and very sporadic in the headwater lakes of the St. Joseph River (Indiana/Ohio) (Grabarkiewicz and Crail, 2006). In Illinois, it is now restricted to the Little Wabash and Vermilion Rivers where it is sporadic but was formerly known from the Embarras River and Wabash River tributaries and Wabash River (Cummings and Mayer, 1997). In Missouri, it is known only in southern Missouri in a few sites (Oesch, 1995). In Arkansas, it is known from the Ouachita River system in South Fourche La Fave River, Poteau River, Illinois River but always in low population numbers (Harris and Gordon, 1997); also historically in the Cache River (Christian et al., 2005). In Tennessee, it was found throughout the upper Tennessee River system, including the Powell, Clinch, Emory, Holston, French Broad, Tellico, Little Pigeon, and Little Rivers, as well as the main channel of the Tennessee River below Knoxville. It was also found in the Duck and Elk Rivers and occurred in the Caney Fork, Stones and Harpeth Rivers and numerous tributaries of the Cumberland River system in Tennessee (Parmalee and Bogan, 1998). A recent study of the North Fork Holston River in Virginia (Jones and Neves, 2007) did not find this species and is likely extirpated there or is extremely rare. It was recently collected in the Middle Fork North Branch Vermillion River in Illinois and Jordan Creek in Indiana (Szafoni et al., 2000). In Indiana, Harmon (1989) reported it from seven of 12 sites surveyed in Graham Creek in the southeast portion of the state; as well as from Sugar Creek (east fork White River drainage) in central Indiana (Harmon, 1992) (most weathered shells but some living and fresh

dead) and Tippecanoe River (Cummings and Berlocher, 1990). It can still be found in Wabash River tributaries in Indiana (Fisher, 2006). In Ohio it is nearly extirpated (Watters, 1995) occurring in a few sites in the Little Miami and St. Josephs drainages as well as the Maumee drainage (Grabarkiewicz and Crail, 2006). In Kentucky, it is sporadic in the Green River and upper Cumberland River below Cumberland Falls (Cicerello and Schuster, 2003). In a 2004 survey of 24 sites in the Choctawhatchee, Yellow, and Conecuh-Escambia River drainages in southern Alabama, Pilarczyk et al. (2006) found this species (although acknowledged some confusion as to which species of Toxolasma it should be listed as) at 16 sites (including just over the border in Eightmile Creek in Florida). It is known from the Clinton River drainage in Michigan (Strayer, 1980)."

Population Trends:

The Purple Lilliput is declining (decline of 10-30 percent) in the short term and moderately declining (decline of 25 - 50 percent) in the long term (NatureServe 2008). In the Cumberlandian region, numbers and occurrences have declined drastically since 1979 and continue to decline. This mussel is extirpated in North Carolina in the French Broad River (LeGrand et al. 2006), and likely extirpated in Virginia from the Clinch (VA NHP, pers. comm., 2007 cited in NatureServe 2008) and the North Fork Holston (Jones and Neves 2006). Outside the Cumberlandian region, if considered to be the same species, it is secure but sporadically distributed with low densities at many sites.

Status:

NatureServe (2008) ranks the Purple Lilliput as extirpated in North Carolina, historical in Oklahoma and Georgia, critically imperiled in Illinois, Kentucky, Michigan, Ohio, Tennessee, and Virginia, and imperiled in Alabama, Arkansas, Indiana, and Missouri. It is classified as rare in Indiana and Missouri, and is state listed as endangered in Illinois, Kentucky, Michigan and Ohio. It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

NatureServe (2008) states that the Purple Lilliput has suffered "severe loss of habitat," reporting that this mussel's habitat has been degraded by "siltation from agriculture and clear-cutting, channel alteration and inundation, and acid coal mine run-off. Cattle wading in small streams have destroyed considerable habitat formerly used by this species." Roe (2002) states that this species is threatened by siltation, dams, and impoundments. The Michigan Natural Features Inventory (2007) reports that this mussel is threatened by natural flow alterations, siltation, channel disturbance, point and non-point source pollution, and exotic species. The Kentucky Dept. of Fish and Wildlife Resources (2005) reports that this species is threatened by gravel and sand removal and quarrying, coal mining, agricultural runoff, logging, urbanization, and impoundments. Martin (2008) reports that high fecal coliform levels, nutrient loading, and the potential disturbance of sediment and gravel budgets threaten mussels, including this species, in the South Fork of the Spring River in Arkansas (p. 12). Vana-Miller (2007) cites groundwater contamination, recreation, mining, invasive species, and channel alteration as threats to aquatic species such as the Purple Lilliput in the Ozarks. The Ohio Environmental Protection Agency (2007) identifies agricultural related channelization, streambank modification and destabilization, combined sewage overflows, thermal modification, development, and urban runoff as threats to water quality and aquatic species such as the Purple Lilliput in the Blanchard River. Virginia's Wildlife Action Plan (2006) identifies siltation, mine wastes, industrial and municipal effluent pollution, and agricultural and

urban runoff as threats to mussels in Virginia's northern ridge and valley province.
This species is also specifically threatened by mountaintop removal coal mining (EPA 2005). Mountaintop removal can fill in streams entirely and can cause significant downstream and groundwater pollution. Pollutants associated with mine runoff can disrupt water and ion balance in aquatic biota (Palmer et al. 2010). Mountaintop removal operations can extirpate entire orders of aquatic macroinvertebrates, disrupting food web dynamics (Wood 2009).

Disease or predation:

Neves and Odom (1989) cite muskrat predation as a threat to imperiled mussels in the North Fork of the Holston in Virginia.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Purple Lilliput, and no occurrences are appropriately protected and managed (NatureServe 2008). This mussel is considered rare in Indiana and Missouri, and is state listed as endangered in Illinois, Kentucky, Michigan and Ohio, but these designations do not provide this species with any substantial regulatory protection or habitat protection. NatureServe (2008) states: "No site appears to be protected in any way," and recommends, "All populations should receive protection through acquisition, easement, registry, and working with local, state, and federal government agencies on issues relating to development, water quality, river designation, etc. Watershed management with particular emphasis on control of acid coal mine run-off and agricultural induced siltation is critical. . . Stream modifications such as dredging and impoundment should be avoided, as well as any modifications to the natural fish communities in areas where the species may occur. Construction, mining, and agricultural activities in stream watersheds should be closely monitored in order to minimize siltation and acid runoff to streams. Point sources should be closely checked to insure compliance with discharge permit regulations."

Other factors:

Any factor which degrades water quality or negatively impacts host fish populations threatens the Purple Lilliput. This mussel is impacted by chemical and organic pollution from agricultural, domestic, and industrial sources (Roe 2002, NatureServe 2008). The North Fork of the Holston River has been severely impacted by mercury releases (Flebbe et al. 1996).The Purple Lilliput is also threatened by invasive species such as the zebra mussel (Roe 2002, NatureServe 2008). Sweet (2003) reports that the lone surviving population of this species is Michigan is severely threatened by zebra mussels.

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Scientific Name:
Toxolasma pullus
Common Name:
Savannah Lilliput

G Rank:	**AFS Status:**
G2	Threatened

Range:
The Savannah Lilliput is known from the Neuse River in North Carolina south to the Altamaha basin in Georgia (Johnson 1967, 1970), but very few historically disjunct populations remain extant (Alderman 1994, Bogan and Alderman 2004, Bogan 2002). This mussel occurred historically in the Ocmulgee and Altamaha Rivers in Georgia, in the Savannah River and the Wateree River in South Carolina, and in the Catawba River, Beaver Creek, and Cape Fear river systems in North Carolina (Johnson 1970).

Habitat:
This mussel is found in silty sand or mud in shallow water, generally at the edges of streams, rivers and lakes. It has also been detected in backwaters, but is rarely found in deeper lake waters. If water levels fluctuate, it will move up and down in the water column (Bogan and Alderman 2004, Bogan 2002).

Populations:
NatureServe (2008) reports that there are from 6-20 populations of Savannah Lilliput, but many historical populations are no longer extant. As of 1994, Alderman reported that there were seven extant populations with this species remaining in the Ohoopee River in Georgia, the Savannah River in South Carolina and Georgia, and Richardson Creek in the Rocky River basin, Densons Creek and the Little River in the Pee Dee River basin, and Lake Waccamaw and University Lake in the Haw River basin in North Carolina. Of these populations, only three have shown any evidence of recent reproduction. In North Carolina, the only population that appears stable is at University Lake in Orange County (Hanlon and Levine 2004). Price (2005) reports that this population appears to have exhibited recent decline. The Waccamaw, Cape Fear, and Neuse River basin populations may be extirpated (Bogan 2002, LeGrand et al. 2006). This mussel was known from four locations in South Carolina primarily in the Saluda River basin, one of these now consists only of relict shells, and only the Lake Marion population has been reported as extant recently. A 2004 extensive survey at the type locality in the Wateree River in South Carolina in 2004 failed to find any surviving individuals (Jennifer Price, SC DNR, pers. comm., October 2005 cited in NatureServe 2008). Specimens were recently collected from a single site in the Ogeechee River in Georgia, this mussel may be hanging on in the Altamaha (SC DNR, pers. comm., 2005 cited in NatureServe 2008). Catena Group (2007) detected this mussel at a single site in the Savannah River. FWS (2006) reports this mussel from "several sites" in the Savannah. Its distribution is very localized, and in very few locations. In 1999, this mussel made up 3.18 percent (relative abundance) of 14,873 mussels collected in surveys of 46 sites in 12 tributary streams of the lower Flint River Basin, Georgia (Gagnon et al. 2006). In 2004, only 7 individuals were detected in Lake Marion in South Carolina and 3 in the Ogeechee River in Georgia in 2004 (J. Price, SC DNR, pers. comm., 2005 cited in NatureServe 2008).

Population Trends:
The Savannah Lilliput is very rapidly to rapidly declining (decline of 30-70 percent) in the short term, and has experienced a large long-term decline of 75-90 percent (NatureServe 2008). This mussel is likely extirpated from the Neuse and Waccamaw River basins (Bogan 2002). Only three of seven extant populations reported by Alderman (1994) showed any signs of reproduction, and the other four were declining and may now be lost (Hanlon and Levine 2004). NatureServe (2008) reports a personal communication from Keferl (1996) indicating that this mussel is very rare in the Ohoopee River, but is reproducing. NatureServe (2008) states, "All the extant populations, except one, have very limited distributions and one change in the environment could cause a population to become extinct. Recent quantitative surveys indicate it represents only a few percent of the total individuals of all species of mussels present in the remaining river systems where it occurs."

Status:
The Savannah lilliput is a federal species of concern and a species of special concern in South Carolina, where it is ranked as critically imperiled by NatureServe. It is imperiled in Georgia and criticaly imperiled in North Carolina (NatureServe 2008). This mussel may now be limited to three or fewer reproducing populations (NatureServe 2008). It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
The Savannah River population of this mussel is threatened by habitat loss and modification due to dredging by the U.S. Army Corps of Engineers to straighten the river for navigability (Alderman 1994). NatureServe (2008) states, “This dredging work seriously impacts the best populations in the world.” The U.S. Army Corps of Engineers (2008) reports that this mussel’s habitat in the Savannah is lost or degraded due to loss of connectivity with the main river at low flows, especially during warmer seasons when dissolved oxygen levels are low and cutoff bends and sloughs where this mussel occurs experience stagnant conditions. Because of their very localized distribution, the Clouds Creek and Asbill Pond populations are threatened by nearby dam operations. Changes in flow or siltation resulting from the dam could extirpate these populations (Alderman 1994). The Asbill Pond population is also threatened by eutrophication (Alderman 1994). The small population in Richardson Creek is threatened by road improvements, wastewater treatment discharge, and development (Alderman 1994). The small populations at Densons Creek and Little River are also threatened by wastewater treatment plant outfall. The Lake Waccamaw population, if still extant, is threatened by poor water quality (North Carolina Wildlife Resources Commission cited in Alderman 1994). The University Lake population is very vulnerable to habitat degradation due to its limited distribution, and is threatened by quick changes in water levels and compaction and sedimentation from off-road vehicle riding along the banks (Alderman 1994, Hanlon and Levine 2004). Price (2005) reports that this mussel’s primarily shallow water distribution makes it particularly vulnerable to off-road vehicles, droughts, and drawdowns, citing a personal communication with Catena Group reporting numerous stranded mussels on the banks of Lake Marion when water levels were extremely low in 2005. Price (2005) also cites pollution as a threat to this species. Catena Group (2007) state that this mussel is threatened by channel modifications and altered river discharge patterns which create bank and sediment instability. The North Carolina Division of Water Quality (2009) reports that aquatic species in the Yadkin Pee-Dee River basin, including the Savannah Lilliput, are threatened by increasing development and decreasing water quality. The Georgia Dept. of Natural Resources (Wisniewski 2008) reports that

this mussel is threatened by excess sedimentation due to inadequate riparian buffer zones, and by all-terrain vehicles.

Disease or predation:

Alderman (1994) reports that this shallow water species is easy prey for raccoons which feed along the shoreline of various waterways (Alderman 1994). Because racoons are a synanthropic species, this threat will increase as development increases. Hanlon and Levine (2004) report that predation is the greatest threat to the only remaining viable population in North Carolina at University Lake in Orange County. The Georgia Dept. of Natural Resources (Wisniewski 2008) reports that this mussel is threatened by direct and indirect competition and predation by the introduced flathead catfish which both consumes mussels and their host fishes.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms which afford this species with meaningful protection.

Other factors:

Because this mussel is distributed in small isolated populations, it is vulnerable to stochastic events. Price (2005) states, "The extremely low numbers of this species at so few sites make it particularly vulnerable; entire populations may be lost due to one smallscale event." The dispersal of this species is limited by dams and navigational structures, making it difficult to impossible to escape in the event of habitat degradation.

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Scientific Name:
Triaenodes tridontus
Common Name:
Three-tooth Triaenodes Caddisfly

G Rank:
G2

IUCN Status:
EX - Extinct

Range:
NatureServe (2008) indicates that T. tridontus is only known from Oklahoma (historical original description, Ross, 1934), the Florida panhandle (historical, 1938), and the coastal plain of Alabama (a handful of sites in the 1980s). Surveys in Oklahoma in the 1990s did not detect the species, and some believe that it may never have occurred in the state and that the type specimen was mislabeled. Harris collected 17 specimens in Little Bassett Creek and Little Stave Creek, Clarke County, AL in 1985 and two in the Cahaba River at Sprott, Perry County, AL in 1991.

Populations:
This species is likely extant only in one to a few populations in Alabama (Harris and Lago 1990).

Population Trends:
NatureServe (2008) reports that this species is very rapidly declining in the short term (decline of 50-70 percent).

Status:
This species was thought to be extinct but its status has been changed by NatureServe (2008) from historical to critically imperiled (AL (S1), FL (SH?), OK (SH)). It is still rated as extinct by the IUCN. It was last detected in 1991 and NatureServe states "If extant population found (last in 1991), protect at all costs."

Habitat destruction:
Caddisflies are threatened by land-disturbing activities and run-off from a variety of sources. Because of this species' extremely limited range, it is highly vulnerable to any form of habitat degradation.

Inadequacy of existing regulatory mechanisms:
NatureServe (2008) reports that no occurrences of this species are protected.

References:

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Scientific Name:
Trillium texanum
Common Name:
Texas Trillium

G Rank:
G2

Range:
Also known as the Texas wakerobin, this species is restricted to a portion of east Texas and one neighboring Louisiana parish; natural heritage records show this species in Cass, Harrison, Nacagdoches, Rusk, Smith, and Wood Counties, Texas, and Caddo County, Louisiana. It is reportedly extirpated from Houston and Panola Counties, Texas (NatureServe 2008).

Habitat:
This flower occurs in low, swampy areas in hardwood forests, in baygalls and sandy uplands, and along the seep borders of woodland streams, often establishing in sphagnum mats (NatureServe 2008). In Louisiana, associated species include swamp blackgum (Nyssa biflora), sweetbay magnolia (Magnolia virginiana), sweetgum (Liquidambar styraciflua), bald cypress (Taxodium distichum), and various fern species (e.g., royal fern, Osmunda regalis, cinnamon fern, O. cinnamomea, and netted chain fern, Woodwardia areolata) (LNHP 2009).

Ecology:
The trillium flowers in March and April, before canopy has fully leafed out (LNHP 2009).

Populations:
There are eight existing occurrences of this flower in Texas, and three in Louisiana (NatureServe 2008). Population sizes are not specifically reported, but are known to be highly variable among sites.

Population Trends:
Trend has not been reported for this rare flower.

Status:
The Texas trillium is restricted to a relatively small range within which very few occurrences are known. Its habitat is widely threatened by conversion to timber plantations, and much has already been lost. NatureServe (2008) ranks this species as critically imperiled in Louisiana and imperiled in Texas.

Habitat destruction:
The trillium's habitat is widely threatened by drainage, clearcutting, and conversion to timber plantations, pasture, and other agricultural uses (LNHP 2009). Urbanization and unsustainable agriculture or forestry practices also cause watershed-wide erosion, which may eventually bury T. texanum's streamside habitat (Kral 1982). Trampling by livestock permitted to graze in this species' habitat is significant (LNHP 2009).

Inadequacy of existing regulatory mechanisms:
No existing regulatory mechanisms adequately protect the Texas trillium.

Other factors:

The Texas trillium may be threatened by exclusion by invasive exotic plants in some areas (NatureServe 2008).

References:

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Scientific Name:
Troglocambarus maclanei
Common Name:
Spider Cave Crayfish

G Rank:	**AFS Status:**
G2	Special Concern

Range:
T. maclanei is restricted to Florida, with all occurrences lying in a single arc about 80 miles long and extending from Suwannee County to Hernando County.

Habitat:
The Spider Cave crayfish occupies subterranean/karstic waters near sites of detrital input, particularly large sinkholes and areas under bat roosts in caves. Deyrup and Franz (1994) report that "Spider crayfishes have been found in caves, sinks, and spring caves. It has been suggested that the species is attracted to fine detritus that floats near the walls and ceilings of flooded cave passages."

Ecology:
Most of the time this species is observed hanging upside down from the ceilings of caves, rarely dropping to the floor. The cave floor is usually coated with fine silt and often with tree litter. According to Deyrup and Franz (1994) "[t]he species is cannibalistic in captivity and may be an active predator on small invertebrates in caves."

Populations:
Approximately sixteen occurrences of this species are known. Concerning population size, NatureServe (2008) states: "Population information is sketchy. In 1942, Hobbs recorded 42 T. maclanei in its type locality, but in a study by Doonan (2001), only two were recorded. Two individuals were recorded at a second cave also studied by Doonan (2001). There is no population data available for the remaining five caves, and no further studies have been conducted at the type locality or second cave in recent years."

Status:
NatureServe (2008) ranks this species as imperiled. Florida lists it as a Species of Greatest Conservation Need. AFS lists it as Vulnerable (Taylor et al. 2007).

Habitat destruction:
NatureServe (2008) reports that this species is susceptible to pollution of the aquifer and changes in inflow of detritus, and that it is threatened by urban development. The type locality is threatened by urban development of nearby Gainesville, which could be having adverse impacts on the groundwater quality. In at least three caves, it is threatened by disturbance by SCUBA divers (Doonan 2001). According to Deyrup and Franz (1994), "[t]his crayfish is restricted to groundwater habitats in caves, where it maintains small populations, usually in association with fine silt. The species is probably susceptible to groundwater pollution and may be affected by changes in land use."

Inadequacy of existing regulatory mechanisms:
T. maclanei occurs in the springs of Manatee Springs State Park (Florida DEP 2004). No existing regulatory mechanisms adequately protect this species.

References:

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Scientific Name:
Tsuga caroliniana
Common Name:
Carolina Hemlock

G Rank:
G3

IUCN Status:
NT - Near threatened

Range:
The Carolina hemlock is endemic to the Appalachian Mountains in North Carolina, Virginia, Georgia, South Carolina, and Tennessee; it has the most restricted range of any hemlock species in North America (Humphrey 1989, James 1959). Natural heritage records indicate the species is present in Georgia's Rabun County, and in Tennessee's Carter, Johnson, Sullivan, Unicoi, and Washington Counties (NatureServe 2008).

Habitat:
Carolina hemlock is generally considered a montane species, found on rocky slopes, cliffs, and ridges in the Appalachian Mountains (Humphrey 1989, USDA 2005). It is adapted to dry, exposed, and nutrient-poor habitats (Rentch et al. 2000). Carolina hemlock generally grows at elevations between 2,000 and 4,000 feet above sea level (NatureServe 2008, USDA 2005). It prefers acidic soils with low nutrient levels, often lithic, coarse, loamy, and containing a high percentage of cobbles and stones (Humphrey 1989, Rentch et al. 2000). Within this narrow habitat preference, T. caroliniana is generally dominant in the forest canopy over dense shrub strata and sparse herbaceous strata (NatureServe 2008, Rentch et al. 2000).

Ecology:
Carolina hemlock is a coniferous species that reaches between 40 and 70 feet in height. It begins producing wind-dispersed seeds at around 20 years of age. Hemlocks, including this one, only rarely layer and do not root-sprout. Cones are pollinated in March and April, ripen from August to September of the following year, and seed dispersal occurs from September until the end of winter (USDA 2005). They are most often found with Acer rubrum, Quercus prinus, and other maple or oak species (James 1959).

The Carolina hemlock exhibits ecological traits typical of slow-growth strategists: it is adapted to dry conditions, acidic, shallow soils low in nutrients, extreme temperatures, and thick shade. Its long life span, slow growth rate, and evergreen leaves make it well-adapted to harsh environments. Evergreen needles extend the growing season, minimize nutrient loss in the form of leaf litter, and reduce water loss through transpiration by reducing surface area (Rentch et al. 2000). Because of its long life span and slow growth rate, Carolina hemlock eventually replaces other canopy species, forming almost pure stands (Humphrey 1989, Rentch et al. 2000). Its shade tolerance allows it to establish itself even in dense shrub stratum (Humphrey 1989). Dominant in very late stages of succession, Carolina hemlock has a significant influence on local environmental conditions. As stands grow older, the slow release of nutrients from Carolina hemlock's leaf litter results in podzolization (USDA 2005).

Carolina hemlock is an important component of the forest ecosystem. Its seeds provide food for numerous birds and mammals, its bark is eaten by beavers, porcupines, and rabbits, and its foliage supplements the diet of white-tailed deer, providing shelter and bedding as well, during the winter months (USDA 2005).

Populations:
Though exact numbers are not known, the Carolina hemlock is of "limited occurrence and distribution" (Humphrey 1989). There is only one naturally occuring population left in Georgia (Ceska 2003).

Population Trends:
This species is reportedly in serious decline (NatureServe 2008).

Status:
The Carolina hemlock's range is restricted to five states in the Southeast, and its habitat is further restricted in this range to small mountainside areas (Elias 1980). Though still used in some capacity as an ornamental species, it is so limited in extent that the species is no longer considered commercially viable (USDA 2005). Though it dominates in late successional stages, these pure stands of Carolina hemlock are extremely rare and rapidly disappearing.

NatureServe (2008) ranks the Carolina hemlock as critically imperiled in Georgia and vulnerable in North Carolina, South Carolina, Tennessee, and Virginia.

Habitat destruction:
The Carolina hemlock is vulnerable to habitat destruction because it is somewhat of a habitat specialist, thus protection of the rocky outcroppings and slopes it prefers from oil or gas extraction, timber harvest, or other anthropogenic threats is essential (NatureServe 2008).

Disease or predation:
The hemlock woolly adelgid (Adelges tsugae), an introduced insect pest, is the greatest threat to Eastern hemlock populations. Since its introduction to the region, it has killed thousands of trees. This aphid-like insect feeds on sap from hemlock foliage, simultaneously injecting toxins that accelerate dieback and decline; infested trees may be killled within four years of infection. The HWA is further dispersed by humans through logging, recreation, and by wind, birds, and other natural means (Malinoski 1998).

The Carolina hemlock is also threatened, though less so, by the elongate hemlock scale (Fiorinia externa), which depletes moisture reserves within needles, causing them to be prematurely dropped (VA NHP 2008).

Inadequacy of existing regulatory mechanisms:
The Carolina hemlock is listed as threatened in Tennessee, but this designation affords it no substantive regulatory protection; no existing regulatory mechanisms protect this tree from habitat loss, the hemlock woolly adelgid, or the various other threats it faces.

References:

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Scientific Name:
Urspelerpes brucei
Common Name:
Patch-nosed Salamander

Range:
Camp et al. (2009) report this salamander from a single stream at the foot of the Blue Ridge escarpment in Stephens County, Georgia. It has since been detected at six additional sites in Georgia and South Carolina (C. Camp, pers. comm., January 2010).

Habitat:
This salamander was discovered in a first-order stream, either within or along the banks of the non-inundated portion of the streambed. It occurs under rocks and in loose leaf litter. This species was discovered during a severe drought and it is possible that it could utilize terrestrial microhabitats under suitably mesic conditions (Camp et al. 2009). Based on additional occurrences, it is associated with headwater streams in steep, mesic ravines (C. Camp, pers. comm., January 2010).

Populations:
Camp et al. (2009) report one known population of this salamander. The authors have since detected six other occurrences (C. Camp, pers. comm., January 2010).

Population Trends:
No trend information is available for this recently discovered species. Camp et al. (2009) state "It seems likely that this species may be extremely rare, perhaps occurring in such few numbers as to be in danger of extinction" (p. 93).

Status:
NatureServe (2009) classifies this salamander as critically imperiled (G1) in Georgia where it is apparently very rare.

Habitat destruction:
The Patch-nosed Salamander is very vulnerable to habitat loss and degradation due to its limited range. Because this salamander is associated with headwater streams in steep, mesic ravines, it is highly vulnerable to logging operations, which result in increased sedimentation, increased water temperature, and decreased water quality. The State of Georgia no longer requires stream buffer zone protections for headwater streams, heightening the threat to this rare species from timbering activities.

Overutilization:
Because this salamander is extremely rare, overutilization for scientific purposes or illegal harvest by herpetological collectors seeking rare species poses a serious threat to its survival.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this species. Concerning the need for regulatory protection for this newly discovered salamander, Camp et al. (2009) state: "It seems likely that this species may be extremely rare, perhaps occurring in such few numbers as to be in danger of extinction. Protection of this remarkable new species should be of paramount concern."

Other factors:

The Patch-nosed Salamander is inherently vulnerable to extinction because of its extremely limited range. Camp et al. (2009) state, "It seems likely that this species may be extremely rare, perhaps occurring in such few numbers as to be in danger of extinction." Any factor which decreases water quality also threatens the survival of this salamander.

References:

Camp, C.D. Personal communication. January 2010.

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Scientific Name:
Vicia ocalensis
Common Name:
Ocala Vetch

G Rank:
G1

Range:
The Ocala vetch has a very restricted range and is known only from Lake and Marion counties, Florida (NatureServe 2008).

Habitat:
This plant grows in sandy peat substrate in open, wet thickets, marshlands, or along streambanks (Chafin 2000, Wunderlin and Hansen 2003).

Ecology:
Ocala vetch is a perennial vine.

Populations:
Four occurrences of this plant had been reported as of 1997, one of which has not been recently confirmed (NatureServe 2008).

Population Trends:
Population trend has not been reported for this species.

Status:
This plant is restricted to an extremely small range, and only four populations are known. Its habitat is threatened by hydrological changes. NatureServe (2008) ranks the Ocala vetch as critically imperiled, and it is state listed as endangered in Florida.

Habitat destruction:
Because all known occurrences are found on National Forest land, this species is not as vulnerable to urbanization or agriculture as many other wetland species. Logging and related site preparation may still pose a threat, and any resultant hydrological changes could destroy V. ocalensis' limited habitat (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
All known occurrences are found in the Ocala National Forest and considered by resource management plans, but may still be vulnerable to hydrological changes that destroy habitat. Though it is state-listed as endangered, this designation offers the Ocala vetch no substantial regulatory protections; no existing regulatory mechanisms adequately protect this species.

Other factors:
Invasive exotic plants are problematic in parts of the Ocala National Forest and may eventually threaten this species (Miller 2002).

References:

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Scientific Name:
Villosa arkansasensis
Common Name:
Ouachita Creekshell

G Rank:	**AFS Status:**
G2	Special Concern

Range:
The Ouachita Creekshell occurs in the Ozark region (Johnson 1980), in the headwaters of the Red River including the Little River and the Kiamichi River, and the headwaters of the Ouachita River including the Saline River, and the Arkansas drainage (Anderson 2006, NatureServe 2008). It also occurs in the Glover River and the Mountain Fork River (Vaughn 2003, Spooner and Vaughn 2007) and in the Poteau River (Harris et al. 1997).

Habitat:
This mussel is found in headwater streams in flowing water conditions.

Populations:
There are an estimated 6-20 populations of this mussel (NatureServe 2008). In Arkansas, this species is extant in the Poteau, Ouachita, and Saline River systems (Harris et. al. 1997). In Oklahoma, this mussel occurs in the headwaters of the Little River (C. Mather pers. comm. cited in NatureServe 2008, Vaughn and Taylor 1999, Vaughn 2000, Galbraith et al. 2008), eight sites in the Glover River (Vaughn, 2000, 2003), eight sites in the Mountain Fork River (Spooner and Vaughn 2007) and potentially in the Kiamichi River. Surveys in Arkansas found catch per unit effort ranges of 0.004 to 0.183 per minute for this mussel.

Population Trends:
This mussel is rapidly declining (decline of 30-50 percent) in the short term and has experienced a long-term decline of 25-50 percent (NatureServe 2008). A statistical test comparing 1988 to 2004 populations of this species found a significant decrease in creekshell population size, with 14 stations showing population decline (Seagraves et al. 2005). This species has become more rare across its range, and now occurs at fewer sites and in lower numbers than in previous surveys (Anderson 2006). At some sites, this species has become uncommon (NatureServe 2008).

Status:
This regional endemic is restricted to headwater streams in a handful of sites. It is critically imperiled in Oklahoma (S1S2) and imperiled in Arkansas (NatureServe 2008). It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
Vaughn (2003) states that habitat degradation and fragmentation threaten mussels in the Glover River, particularly siltation resulting from timber harvest and gravel mining. Vaughn states that gravel mining is occurring within 30 m of the richest mussel site in the Glover River, where this mussel was detected, posing a serious threat to the continued existence of the mussel bed. Galbraith et al. (2008) report that mussel populations in the Little River are declining and are threatened by proposed reservoirs. Spooner and Vaughn (2007) report that in the Mountain Fork River, this mussel is threatened by siltation from timber harvest and runoff from agricultural activities and second homes. The Arkansas Wildlife Action Plan (2005) reports that this mussel is

threatened by pollution from municipal and industrial point sources, by recreation, development, nutrient loading, confined animal feeding operations, grazing, sedimentation, and road construction.

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect the Ouachita Creekshell.

Other factors:
Harris et al. (1997) cite zebra mussel invasion as a threat to native mussels in the Arkansas and White Rivers.

References:

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Scientific Name:
Villosa choctawensis
Common Name:
Choctaw Bean

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Threatened	NE - Not evaluated

Range:
The Choctaw Bean is endemic to the Escambia, Yellow, and Choctawhatchee River drainages in Alabama and Florida with one of the most restricted ranges for its genus (Johnson 1967, Williams and Butler 1994, NatureServe 2008). Recent surveys have expanded the historical range of this mussel (Williams et al. 2000, Blalock-Herod et al. 2005). In the Escambia watershed, it has now been detected in rivers in Escambia County, Florida, and in Conecuh, Crenshaw, and Butler counties in Alabama. In the Yellow River watershed, it has been detected in the main stem of the Yellow River in Okaloosa County, Florida, and in Covington County, Alabama. In the Choctawhatchee River watershed, it has been detected in the main channel of the Choctawhatchee River in Washington and Holmes counties in Florida, and in Geneva County, Alabama (Williams et al. 2000, Blalock-Herod et al. 2005).

Habitat:
The Choctaw Bean is found in large creeks and rivers with moderate current over sand to silty-sand substrates (Deyrup and Franz 1994, Williams and Butler 1994).

Ecology:
Little is known about the ecology of the Choctaw Bean, but it is presumed to be a long-term brooder. Gravid females have been detected in August. Fish hosts are unknown (Mirarchi et al. 2004).

Populations:
NatureServe (2008) estimates that there are from 21-80 populations of Choctaw Bean, providing the following details: "Johnson (1967) lists historical sites in: Choctawhatchee River System-Pea River drainage: Pea River, Alabama; Choctawhatchee River drainage: Florida. The Choctaw bean appears to be extirpated from Murder Creek, Conecuh County; Pigeon Creek, Butler County; and Little Patsaliga Creek, Crenshaw County, all Alabama, all Escambia River basin; and Choctawhatchee River, Holmes County, Florida. Butler (1989) listed the following sites: Yellow River mainstem, Alabama; east of Blackman, Florida. Butler (1989) also listed Escambia River localities including Piegeon Creek, Alabama; Patsaliga River, Alabama; Little Patsaliga Creek, Alabama. Due to recent status surveys the historical range of the Choctaw bean has been expanded (Williams et al., 2000; Blalock-Herod et al., 2005). Within the Escambia River drainage, it is known from the Escambia River, Escambia County, Florida; Murder Creek, Conecuh County, Patsaliga and Little Patsaliga Creeks, Crenshaw County; and Pigeon Creek, Butler County, all in Alabama. Within the Yellow River drainage, it is known from the main channel Yellow River in Okaloosa County, Florida, and Covington County, Alabama. Within the Choctawhatchee River drainage, the Choctaw bean is known from the Choctawhatchee River main stem in Washington and Holmes Counties, Florida; and the Pea River, Geneva County, Alabama (Williams et al., 2000; Blalock-Herod et al., 2005) (see USFWS, 2003; Butler, 1989). Recent mussel status surveys found that populations (live and shell material only) of the Choctaw bean have declined from 13 historic sites to 7 currently active sites, 4 inactive, and 2 with an undetermined population status within the Escambia River drainage; it has declined from 6

historic sites to 5 currently active sites and 1 with an undetermined population status within the Yellow River drainage; and from 26 historic sites to 22 currently active sites, 1 inactive site, and 3 sites with undetermined population status within the Choctwhatchee River drainage (fide Williams et al., 2000; Blalock-Herod et al., 2005). In totality, the Choctaw bean has declined from a total of 45 historic sites to its remaining distribution of 34 sites. It has been extirpated from approximately 11% of its historic range. An average of 2 individuals were found live per site (fide Williams et al., 2000; Blalock-Herod et al., 2005. Two gravid individuals have been detected, but recent recruitment has not been confirmed (fide Williams et al., 2000). The longterm viability of the Choctaw bean is questionable (see USFWS, 2003). Blalock-Herod et al. (2005) listed it in 6 historical (found in 2 of 3 recently resurveyed) and 20 new sites in the Choctawhatchee River drainage of Alabama (mostly) and Florida. Pilarczyk et al. (2006) recorded recent collections (in 2004) of this species following surveys of 24 sites at three sites in Alabama including West Fork Choctawhatchee River, Pea Creek, and East Fork Choctawhatchee River compared to Patsaliga Creek, Yellow River, Pea River, Pea Creek, West Fork Choctawhatchee River, Judy Creek, and East Fork Choctawhatchee River in surveys of the same sites in the 1990s."

Total population size of Choctaw Bean is estimated at to be at least 2500 individuals. At the best known site at the time in 1988, eleven per hour were collected (NatureServe 2008). This mussel is known from fair numbers from most sites represented in museum lots. Heard (1975) considered it to be rare in the Choctawhatchee River. Pilarczyk et al. (2006) found 31 live mussels in the West Fork Choctawhatchee River, 10 live mussels in Pea Creek, and 3 live mussels in the East Fork Choctawhatchee River. In 1990s surveys, an average of two live individuals were detected per site in Patsaliga Creek, Yellow River, Pea River, Pea Creek, West Fork Choctawhatchee River, Judy Creek, and the East Fork Choctawhatchee River (Blalock-Herod et al. 2005).

Population Trends:

The Choctaw Bean is declining in the short-term (decline of 10-30 percent) and moderately declining to relatively stable in the long-term (NatureServe 2008). Recent status surveys indicate that this species has experienced range reductions and occurs in low abundance within its limited range. Overall, the Choctaw bean has declined from a total of 45 historic sites to its remaining distribution of 34 sites. It has been extirpated from approximately 11 percent of its historic range (USFWS 2003, NatureServe 2008).

Status:

NatureServe (2008) ranks the Choctaw Bean as imperiled in Alabama and critically imperiled in Florida. This mussel has a limited distribution, restricted habitat, decreasing number of extant occurrences, and the viability of some occurrences is questionable (NatureServe 2008). It is a Federal Candidate for protection under the Endangered Species Act. It is a Species of Greatest Conservation Need in Alabama. It is ranked as threatened by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:

The primary threat to the Choctaw Bean is habitat loss and degradation, with this mussel's habitat known to be deteriorating overall (NatureServe 2008). This species is threatened by sedimentation and water quality degradation from a number of activities including highway and reservoir construction, improper logging practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing which cause physical disturbance to stream substrates and riparian areas, and alter water quality, temperature, and flow (NatureServe 2008).

Sedimentation can cause direct mortality of mussels by suffocation and substrate alteration (Ellis 1936, Brim Box and Mossa 1999), can interfere with feeding (Dennis 1984), and can preclude or reduce juvenile recruitment (Negus 1966, Brim Box and Mossa 1999). Many of the extant populations of this mussel are in the vicinity of highway and unpaved road crossings, and highway and bridge construction and widening could thus negatively impact these populations. Impoundments and resulting changes in sediment, flow, water temperature, and dissolved oxygen threaten mussel populations (Neves et al. 1997). Nutrients from agricultural fields, lawns, feedlots, poultry operations, and leaking septic tanks cause eutrophication and reduced oxygen levels in small streams which also threaten mussel populations (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms that adequately protect the Choctaw Bean, and no occurrences are appropriately protected and managed. This species is a federal Candidate and merits full ESA protection. It has no state status in Florida, and is a Species of Greatest Conservation Need in Alabama, but this designation does not confer regulatory protection. One occurrence may border the Conecuh National Forest, but this does not provide habitat protection. NatureServe (2008) provides the following management recommendations for this species: "Protect species by federal listing, acquisitions and easements by working with government agencies and conservation organizations; establish buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; propagate for reintroduction into restored habitats; maintain high water and benthic habitat quality; control/eradicate Corbicula populations. Conservation activities have been limited to working with private landowners in south Alabama and west Florida to encourage the use of Best Management Practices to reduce the effects of agriculture and silviculture (see U.S. Fish and Wildlife Service, 2003)."

Other factors:

Several other factors threaten the Choctaw Bean. Any factor which degrades water quality or negatively affects host fish populations is a threat to this mussel. This species is vulnerable to catastrophic events because populations are generally small and geographically isolated. Some populations may not be genetically viable in the long-term. Invasive species also potentially threaten the Choctaw Bean, including the Asiatic clam, zebra mussel, and black carp (U.S. Fish and Wildlife Service 2003, NatureServe 2008).

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Scientific Name:
Villosa fabalis
Common Name:
Rayed Bean

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	NE - Not evaluated

Range:
The rayed bean is present in Alabama, Illinois, Indiana, Kentucky, Michigan, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Ontario. Current natural heritage records indicate that the rayed bean is present in Alabama's Lauderdale County, Indiana's Allen, Carroll, De Kalb, Johnson, Kosciusko, Pulaski, Tippecanoe, and White Counties, Michigan's Hillsdale, Oakland, St. Clair, and Wayne Counties, and from New York's Cattaraugus and Chautauqua Counties. Though it was historically present in these locations, it is now considered extirpated from Illinois' Vermilion County, Indiana's Delaware, Fulton, Hamilton, Huntington, LaGrange, Marshall, Miami, Posey, and Wabash Counties, Kentucky's Campbell, Gallatin, Grayson, Green, Hardin, Hart, Kenton, Owen, Pendleton, Scott, Spencer, and Warren Counties, and from Michigan's Lenawee, Macomb, and Monroe Counties.

Habitat:
The rayed bean is primarily found in small headwater creeks near shoal or riffle areas, and also occurs in the shallow areas of glacial lakes, including Lake Erie, where it is associated with islands. It prefers gravel and sand substrates, and is often associated with aquatic vegetation such as water willow Justicia americana, water milfoil, Myriophyllum spp., among whose roots it commonly buries itself (Butler 2003, Watters 1988, Parmalee and Bogan 1998, Watters et al. 2000).

Ecology:
This species is reportedly a long-term breeder, retaining glochidia over the winter and releasing them in the spring. The only confirmed glochidial host is the Tippecanoe darter, Etheostoma tippecanoe, which is itself imperiled (Strayer and Jirka 1997, Butler 2003).

Populations:
NatureServe (2008) estimates that there are 21-80 occurrences of rayed bean. This once widespread species is now llimited to ten streams in the lower Great Lakes system, and twelve streams and one lake in the Ohio River system. Total abundance is estimated at only 1000-2500 individuals. Its current distribution is highly fragmented, and remaining populations are generally small and isolated.

Population Trends:
Over the long-term, the rayed bean has declined by over 75 percent. It has been extirpated from 78 percent of the total number of streams and other water bodies from which it was historically known (22 streams and a lake currently compared to 106 water bodies historically) (NatureServe 2008). It is also very rapidly declining in the short-term, by up to 70 percent (NatureServe 2008).

Status:
NatureServe (2008) reports that the rayed bean is critically imperiled in Indiana, Michigan, New York, Ohio, Ontario, Tennessee, and Pennsylvania, and likely extirpated from Alabama, Illinois, Kentucky, and Virginia. It is listed as endangered in New York, Ohio, and Virginia, and in Canada.

It is a federal candidate in dire need of ESA protection to ensure its survival. Its rank is being changed from special concern (Williams et al. 1993) to endangered by the American Fisheries Society (2010 draft, in review).

Habitat destruction:

Loss and degradation of habitat is the greatest threat to the rayed bean. Known threats to this mussel include impoundments, channelization, dredging, mining, agriculture, logging, and residential and industrial development (Williams et al., 1993; Neves, 1993; Neves et al., 1997; Watters, 2000). NatureServe (2008) states, "The threats to the rayed bean are significant and present throughout the species range, and thus are high in magnitude. Threats to the remaining populations are imminent and will likely not lessen in the future (Butler, 2003; U.S. Fish and Wildlife Service, 2003)."

Inadequacy of existing regulatory mechanisms:

Though it is listed as endangered in New York, Ohio, and Virginia, this designation affords the rayed bean no substantial regulatory protection. No existing regulatory mechanisms adequately protect this species or its habitat.

Other factors:

The rayed bean is threatened by point and non-point source pollution from many sources including industrial and residential discharge, siltation, herbicide and fertilizer run-off, and agricultural runoff and sewage discharge. Lowered dissolved oxygen levels and elevated ammonia levels are known to be lethal to some species of freshwater naiads (Horne and McIntosh 1979). Rotenone, a toxin used to kill undesired fish, can also kill mussels (Heard 1970). The rayed bean is also threatened by contaminants from mine runoff and other sources (NatureServe 2008).

In some parts of its range, this mussel is threatened by invasive species such as Asiatic clam, zebra mussel, and black carp. The rayed bean is also threatened by stochastic genetic and environmental events due to the geographic and genetic isolation of most extant populations (NatureServe 2008).

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Scientific Name:
Villosa nebulosa
Common Name:
Alabama Rainbow

G Rank:	**AFS Status:**
G3	Threatened

Range:
The Alabama Rainbow occurs in Alabama, Georgia, North Carolina, and Tennessee. In Alabama it occurs in the Mobile Basin in small streams upstream of the Fall Line (Mirarchi 2004). It does not occur in the Tallapoosa River system (Williams et al. 2008). Historically, this mussel was widespread in the Black Warrior, Cahaba, and Coosa River drainages above the Fall Line, but is now extant only in a few isolated tributary populations, including scattered tributaries of the Coosa and the headwaters of Sipsey Fork in the Bankhead National Forest (Williams et al. 2008). Johnson et al. (2005) report extant populations from the Conasauga River inside and adjacent to the Cherokee and Chattahoochee National Forests in Polk and Bradley counties in Tennessee, and in Murray County, Georgia. Johnson and Ahlstedt (2005) report this species from the Luxapallila drainage on the Mississippi/Alabama border. Parmalee and Bogan (1998) tentatively restrict the use of Villosa nebulosa to the species occurring in the headwaters of the Mobile Bay Basin, including the Conasauga River in the southeastern part of Tennessee.

Habitat:
NatureServe (2008) states that this mussel inhabits riffles in areas of moderate current with sand and gravel substrate. USFS (2007) states that the Alabama Rainbow primarily inhabits small headwater streams and likely requires clean gravel riffles, low turbidity, some flow, and habitat stability including substrate stability and water quality.

Ecology:
Haag and Warren (1997) found gravid females with mature glochidia from late February to early April in 8-13 degree C water. They identified the following fish hosts for V. nebulosa in the laboratory: Lepomis megalotis, Micropterus coosae, M. punctulatus, and M. salmoides.

Populations:
There are an estimated 21-80 populations of Alabama Rainbow (NatureServe 2008). It was historically widespread in the Black Warrior, Cahaba, and Coosa River drainages above the Fall Line, but survives in only a few isolated tributary populations (Williams et al. 2008). McGregor et. al (2000) report this species as absent from the Cahaba. Few live individuals have been reported recently in the Coosa Basin (Williams and Hughes 1998), with the exception of the Conasauga where it was recently detected (Johnson et al. 2005). A population was recently reported in the Luxapallila drainage on the border of Alabama and Mississippi (Johnson and Ahlstedt 2005). Total population size for this species is estimated at more than one million individuals.

Population Trends:
The Alabama Rainbow is considered to be stable in the short-term and relatively stable in the long-term (NatureServe 2008). Few live individuals have been recently reported from Georgia, except from the Conasauga River. It is absent from the Cahaba River in Alabama (NatureServe 2008). In the Alabama and Mobile Basin where it was once widespread, it is now extant only in a few isolated populations (Williams et al. 2008).

Status:

The Alabama Rainbow is ranked by NatureServe as imperiled in Tennessee and Georgia, vulnerable in Alabama, and not assessed in North Carolina. This mussel has a somewhat narrow range and is frequently uncommon to rare at any given locality. In 1993, the American Fisheries Society classified this mussel as threatened (Williams et al.), but its status is being changed to endangered (draft, in review).

Habitat destruction:

The Alabama Rainbow is threatened by impoundment; channelization and dredging operations; sedimentation from agriculture, silviculture, mining, urbanization, road construction, and land-use activities; and water withdrawals (Neves et al. 1997, Herrig and Shute 2002, NatureServe 2008). This species was extirpated from much of its habitat by impoundment (Williams et al. 2008). USFS (2007) states that the Alabama Rainbow is sensitive to water quality degradation and sedimentation from ground-disturbing activities within a watershed. This species occurs in the Bankhead National Forest and is thus potentially threatened by silvicultural and recreational activities.

Inadequacy of existing regulatory mechanisms:

There are no existing regulatory mechanisms to protect the Alabama Rainbow. It does not have protective status in any state. NatureServe (2008) reports that few occurrences of this species are appropriately protected and managed, stating that this mussel occurs in the Conasauga River inside and adjacent to the Cherokee and Chattahoochee National Forests in Polk and Bradley Cos., Tennessee, and Murray Co., Georgia (Johnson et al., 2005). Occurrence in a National Forest does not necessarily provide this mussel with habitat protection, and potentially places it at risk from habitat degradation due to silvicultural and recreational activities.

Other factors:

Other factors which threaten the Alabama Rainbow include degraded water quality and invasive species. Because the Alabama Rainbow is a filter feeder, it is highly susceptible to poor water quality. The Alabama Rainbow is threatened by petroleum spills; pesticide and nutrient run-off from agriculture, silviculture, and urban areas; chemical, manufacturing, and wood product wastes, industrial discharges; and highway salts (Abell et al. 2000, Hart and Fuller 1974, Neves et al. 1997, Herrig and Shute 2002). Herrig and Shute (2002) state that exotic mussel species, such as Asian clams and zebra mussels, directly compete with native mussels for food and space, attach to native mussels in large enough numbers to cause mortality, and accumulate in such high numbers that they can modify the physical characteristics of the substrate and water quality. The Alabama Rainbow is also threatened by any factor which threatens the host fish on which it is dependent for reproduction. Increasing population isolation (Williams et al. 2008) heightens the susceptibility of this species to extirpation from stochastic genetic and environmental events.

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Scientific Name:
Villosa ortmanni
Common Name:
Kentucky Creekshell

G Rank:	**AFS Status:**	**IUCN Status:**
G2	Special Concern	NE - Not evaluated

Range:
The range of the Kentucky Creekshell consists of 250-1000 square km in the Green River system in Kentucky where it inhabits a few sites in the Green River and in a direct tributary, as well as a limited number of tributaries of the Nolin, Rough, and Barren rivers, and peripheral sites which support a smaller, chunkier form in the Nolin, Gasper, and Red Rivers. This species occurred historically in Beaver Creek, but that population is likely extirpated (R. Cicerello, KY NHP, pers. comm., 1998, cited in NatureServe 2008).

Habitat:
This mussel occurs in small, medium-sized, and large rivers with gravel, cobble, sand, or mud substrate. In the Green River, this mussel was found in deep flowing riffles and runs with sand, gravel, and some cobble substrate (Cicerello and Hannan 1990, Cicerello and Schuster 2003).

Populations:
There are fewer than 20 populations of this mussel represented by over 100 occurrences in approximately 12 counties (R. Cicerello, pers. comm., 1998; KY NHP, pers. comm. 2007 cited in NatureServe 2008). Total population size is unknown.

Population Trends:
Within its extremely limited range, this mussel is declining in the short-term and relatively stable in the long-term. The Beaver Creek population is likely extirpated. The Kentucky State Nature Preserves Commission (2006) reports this species as declining.

Status:
The Kentucky State Nature Preserves Commission (2006) lists this species as endangered. It is ranked as imperiled by NatureServe (2008). It is ranked as special concern/vulnerable by the American Fisheries Society (Williams et al. 1993, 2010 draft, in review).

Habitat destruction:
NatureServe (2008) lists threats to this species as pollution, dredging, channelization, and quarrying, citing a personal communication from the Kentucky Natural Heritage Program (2007). The Kentucky State Nature Preserves Commission (2006) lists this species as endangered, citing habitat degradation and loss as the reason for this mussel's state status. Kentucky's Comprehensive Wildlife Conservation Strategy (2005) reports that this mussel is threatened by habitat degradation from gravel and sand removal and quarrying, stream channelization, and agricultural runoff. Suitable habitat for this mussel is fragmented (NatureServe 2008).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanisms that protect this mussel.

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Scientific Name:
Villosa umbrans
Common Name:
Coosa Creekshell

G Rank:	**AFS Status:**
T2	Special Concern

Range:
Formerly known as Villosa vanuxemensis umbrans, the range of the Coosa Creekshell covers 100-250 square km (about 40-100 square miles) in Tennessee, Georgia, and Alabama. It is endemic to the upper Coosa River system occurring in the Conasauga River of the Coosa River basin in Polk Co. (Parmalee and Bogan 1998). This species was once fairly widespread, but now likely persists only in a few tributarires in the uppermost reaches of the system, primarily in Georgia (Mirarchi et al. 2004). McGregor et al. (2000) reported this species as absent from the Cahaba River, Alabama (NatureServe 2008). Williams et al. (2008) report that this mussel is known only from the Coosa River drainage above the Fall Line.

Habitat:
Mirarchi et al. (2004) describe the Coosa Creekshell's habitat as "creeks and small rivers, generally in gravel and sand substrata in shoal and riffle habitats, sometimes associated with water willow (Justicia americana) beds (Parmalee and Bogan 1998)." Williams et al. (2008) describe this species' habitat as small to medium rivers in mixtures of sand, gravel, and cobble substrate in moderate current.

Ecology:
The Coosa Creekshell is a long-term brooder. Known glochidial hosts include bluegill and banded sculpin, with higher transformation rates on bluegill (Mirarchi et al. 2004).

Populations:
NatureServe (2008) reports that there are from 6-20 populations of Coosa Creekshell. This mussel appears to be in decline rangewide (Mirarchi et al. 2004). It persists in the Coosa River drainage in Georgia, and might be extant in the Coosa in Alabama. In the Coosa River basin in Georgia, it is known historically from the Coosa, Etowah, Oostanaula, Conasauga, and Coosawattee River drainages (Williams and Hughes 1998). This species was recently reported from the Conasauga River inside and adjacent to the Cherokee and Chattahoochee National Forests, Polk and Bradley Cos., Tennessee, and Murray/Whitfield Cos., Georgia; as well as Holly Creek, adjacent to the Chattahoochee National Forest, Murray Co., Georgia (Johnson et al. 2005). McGregor et al. (2000) reported it absent from the Cahaba River, Alabama. Williams et al. (2008) report that it is extant only in small isolated populations in Coosa tributaries.

Population Trends:
The Coosa Creekshell is very rapidly declining (decline of 50-75 percent) in the short-term, and has also experienced a large long-term decline (decline of 75-90 percent). It appears to be in decline rangewide (Mirarchi et al. 2004).

Status:
NatureServe (2008) ranks the Coosa Creekshell as critically imperiled in Georgia, and imperiled in Alabama and Tennessee. This once widespread species now persists only in a few tributarires. It is a Species of Greatest Conservation Need in Alabama and Tennessee. Its rank is being changed

from special concern (Williams et al. 1993) to threatened (2010 draft, in review) by the American Fisheries Society.

Habitat destruction:
Mirarchi et al. (2004) state that specific habitat requirements make this species vulnerable to extinction. Many factors contribute to the loss and degradation of mussel habitat in the region where the Coosa Creekshell occurs. Flebbe et al. (1996) state: "The common factors affecting the status of aquatic species populations in the Southern Appalachians are habitat degradation and loss. Major threats to aquatic habitats and aquatic fauna include dams and the resulting reservoirs, channelization, sedimentation, and mining. Point source pollution, such as industrial waste, livestock feed lots, human sewage, and water treatment waste; and nonpoint source contaminants like fertilizer, pesticides, septic system leakage, household chemical waste, roadwash residues, and urban area runoff also contribute to the degradation and loss of aquatic resources."

Swift et al. (1996) report that human activities which degrade mussel habitat in the Southern Appalachians include the development of human habitation and service facilities at urban, suburban, and rural sites; agricultural facilities and operations; construction, maintenance, and use of roads and highways; mining and petroleum extraction and processing sites; industrial facilities; water resources development; and forestry operations, with the majority of water quality degradation resulting from nonpoint sources, such as agricultural runoff, stormwater discharges, and landfill and mining leachate (Swift et al. 1996). The aquatic mollusk fauna in the Coosa River system has been decimated by dams, with many species having been pushed into very small ranges (Van der Schalie 1981, Neves et al. 1994, McDougal 1995 in Flebbe et al. 1996).

The Coosa Creekshell is declining on the Cherokee National Forest, where aquatic habitats have experienced degradation from logging and off-highway vehicle use (USFS 2006).

The Biological Assessment for the Alabama Power Company Coosa River Relicensing Projects states that the project is likely to adversely affect listed freshwater snails and mussels in the Coosa River, and that mussels in the Coosa have declined due to habitat modification, sedimentation, eutrophication, and water quality degradation (Alabama Power Company 2007).

Inadequacy of existing regulatory mechanisms:
There are no existing regulatory mechanims that protect the Coosa Creekshell. It is a Species of Greatest Conservation Need in Alabama and Tennessee, but this designation does not provide the species with any regulatory protection. It has no state status in Georgia. It occurs in the Conasauga River inside and adjacent to the Cherokee and Chattahoochee National Forests in Tennessee and Georgia, but this does not necessarily confer any habitat protection (Johnson et al., 2005, NatureServe 2008).

Other factors:
The Coosa Creekshell is threatened by any factor which degrades water quality or negatively impacts host fish populations. This species is potentially threatened by invasive species. Flebbe et al. (1996) state: "Introduced species, such as the zebra mussel (Dreissena polymorpha), will play a major role in determining the composition and decline of native aquatic communities (in Southern Appalachia) in the future. Industrial pollution and contaminants also threaten mussels in the region where the Coosa Creekshell occurs (Swift et al. 1996, Flebbe et al. 1996). There is a PCB fish consumption advisory for the Coosa River in Alabama and Georgia (Swift et al. 1996).

References:

Alabama Power Company. 2007. Biological Assessment for Threatened and Endangered Species for the Coosa River (ferc no. 2146), Mitchell (ferc no. 82), and Jordan (ferc no. 618) Projects. January 2007. 128 pp.

Flebbe, P.A., J. Harrison, G. Kappesser, D. Melgaard, J. Riley, and L.W. Swift Jr. 1996. Status of Aquatic Resources: part 1 of 2, pp. 15-63. In Southern Appalachian Man and the Biosphere (SAMAB). The Southern Appalachian Assessment Aquatics Technical Report. Report 2 of 5. USDA Forest Service, Southern Region, Atlanta, GA.

Johnson, P.D., C. St. Aubin, and S.A. Ahlstedt. 2005. Freshwater mussel survey results for the Cherokee and Chattahoochee districts of the United States Forest Service in Tennessee and Georgia. Report to the U.S. Fish and Wildlife Service, Daphne, Alabama. 32 pp.

McGregor, S.W., P.E. O'Neil, and J.M. Pierson. 2000. Status of the freshwater mussel (Bivalvia: Unionidae) fauna of the Cahaba River system, Alabama. Walkerana, 11(26): 215-237.

Mirarchi, R. E., J. T. Garner, M. F. Mettee, and P.E. O'Neil. 2004. Alabama wildlife. Volume 2. Imperiled aquatic mollusks and fishes. University of Alabama Press, Tuscaloosa, Alabama. xii + 255 pp.

Parmalee, P.W. and A.E. Bogan. 1998. The Freshwater Mussels of Tennessee. University of Tennessee Press: Knoxville, Tennessee. 328 pp.

Swift, Lloyd W., Jr.; Flexner, Morris; Burns, Ridiarf; et al. 1996. Impacts of human activities. In: Southern Appalachian Man and the Biosphere (SAMAB). The Southern Appalachian Assessment Aquatics Technical Report. Report 2 of 5. Atlanta, GA.: U.S. Department of Agriculture', Forest Service, Southern Region: 89-120. Chapter 5.

U.S. Forest Service. 2006. 2005 Annual Monitoring & Evaluation Report Cherokee National Forest. Last accessed Jan. 25, 2010 at: http://www.fs.fed.us/r8/cherokee/planning/mon_eval/ME092006.pdf

Williams, J.D. and M.H. Hughes. 1998. Freshwater mussels of selected reaches of the main channel rivers in the Coosa drainage of Georgia. U.S. Geological report to U.S. Army Corps of Engineers, Mobile District, Alabama. 21 pp.

Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. Freshwater Mussels of Alabama and the Mobile Basin in Georgia, Mississippi, and Tennessee. University of Alabama Press, Tuscaloosa. 908 pp.

Scientific Name:
Waldsteinia lobata
Common Name:
Lobed Barren-strawberry

G Rank:
G2

Range:
Also known as the Piedmont barren strawberry, this species is endemic to a small range within the Piedmont and Blue Ridge Mountains of Georgia, adjoining areas of South Carolina, and Alabama. Historic records indicate W. lobata was once present in North Carolina, but recent confirmation is unavailable. This species is currently confirmed in Lee County, Alabama, Carroll, Dawson, DeKalb, Douglas, Fulton, Gwinnett, Habersham, Heard, Morgan, Pickens, Stephens, Taylor, Upson, and Wilkinson Counties, Georgia, and in Oconee County, South Carolina (NatureServe 2008, AL NHP 2008).

Habitat:
This strawberry is found in rocky, acidic woodlands along or above streams, and often forms part of the layer of moss that forms in conditions of high humidity and shade. It often occurs with Rhododendron spp. and mountain laurel (Kalmia latifolia) (NatureServe 2008). More rarely it can be found iin drier upland oak-hickory-pine woodlands (Patrick et al. 1995).

Ecology:
This perennial berry blooms in May and June.

Populations:
No reports of total number of occurrences or overall population size are available.

Population Trends:
This species is in decline (NatureServe 2008).

Status:
This plant is endemic to a small range, declining, and threatened by numerous anthropogenic factors. NatureServe (2008) ranks W. lobata as critically imperiled in Alabama and North Carolina, imperiled in Georgia, and vulnerable in South Carolina. It is also listed as threatened in Georgia.

Habitat destruction:
This species is threatened by habitat destruction, primarily caused by logging, which in addition to outrightly destroying habitat, alters patterns of succession - weedy, fast-growing species favored by forest clearing outcompete W. lobata and contribute to local extirpation. Threats are especially severe on private lands (Southern Appalachian Species Viability Project 2002).

Inadequacy of existing regulatory mechanisms:
Though it is listed as threatened in Georgia, this designation affords W. lobata no significant regulatory protection; no existing regulatory mechanisms adequately protect this species.

Other factors:
This plant is threatened in parts of its range by invasive exotics such as Japanese honeysuckle (Lonicera japonica) (Southern Appalachian Species Viability Project 2002).

References:

Alabama Natural Heritage Program (AL NHP). 2008. Annual report. Accessed online December 16, 2009 <<www.alnhp.org/ann-rpt_2008.pdf >>

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: August 11, 2009).

Patrick, T.S., J.R. Allison, and G.A. Krakow. 1995. Protected plants of Georgia: an information manual on plants designated by the State of Georgia as endangered, threatened, rare, or unusual. Georgia Dept. Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program, Social Circle, Georgia. 218 pp + appendices.

Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

Scientific Name:
Xyris longisepala
Common Name:
Kral's Yellow-eyed-grass

G Rank:
G2

Range:
This plant is endemic to a small range in the Florida panhandle and adjacent areas of Alabama. Most documented occurrences are from Washington and Bay Counties, Florida, but natural heritage records also show this species to be present in Leon and Okaloosa Counties, Florida, and in Covington County, Alabama (NatureServe 2008).

Habitat:
This grass is found on the moist or wet sandy shores of limesink lakes, sandhill upland lakes, and sinkhole ponds (Kral 1983). It occurs amongst other shrubby vegetation, though under suitable conditions, X. longisepala may form dense or more extensive meadows (NatureServe 2008).

Ecology:
This grass germinates easily during periods of low water, and may then become abundant at the waterline. It flowers July-November (NatureServe 2008).

Populations:
There seems to be no strong consensus on the the total number of occurrences of this species across its range, but certainly fewer than 100 are known, and there are probably fewer than 50. The vast majority of these populations are in Florida; only 2 occurrences are currently documented in Alabama (NatureServe 2008).

Population Trends:
Populations are in decline across this species' range, particularly in Alabama (NatureServe 2008).

Status:
This grass is restricted to a small range within which it is declining. Habitat specificity makes it highly sensitive to the loss of habitat. NatureServe (2008) ranks this species as critically imperiled in both Alabama and Florida. It is also listed as endangered in Florida.

Habitat destruction:
This species is threatened by a variety of anthropogenic factors that destroy and degrade habitat: conversion of habitat to residential developments, silvicultural plantations, or agricultural fields or pasture are the primary causes of outright habitat destruction, but negative ecological effects emanate from these land uses to degrade peripheral habitat through sedimentation, pollution, and dispersed human activity. Recreational ORV use on or near pond shores destroys habitat and/or individual plants, and is reportedly a significant threat to X. longisepala in some parts of its range (NatureServe 2008). Very restrictive habitat preferences limit this species' ability to recover from habitat loss.

Inadequacy of existing regulatory mechanisms:
This species occurs in the Apalachicola National Forest and on the Eglin Air Force Base, but these sites not be adequately protected from human disturbance. Though it is listed as endangered in Florida, this designation offers X. longisepala no significant regulatory protections; no existing

regulatory mechanisms sufficiently address the protection of this species or its habitat.

References:

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Dept. of Agriculture Forest Service Technical Publication R8-TP2, Athens, GA. 1305 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed December 16, 2009.

Southern Appalachian Species Viability Project. 2002. A partnership between the U.S. Forest Service-Region 8, Natural Heritage Programs in the Southeast, NatureServe, and independent scientists to develop and review data on 1300+ regionally and locally rare species in the Southern Appalachian and Alabama region. Database (Access 97) provided to the U.S. Forest Service by NatureServe, Durham, North Carolina.

From: Charlotte Cade
To: Integrated Resource Plan
Subject: Dickerson Petroleum_Red Hills Coal Mine & Power Plant
Date: Wednesday, April 11, 2018 5:49:19 PM
Attachments: 3287_001.pdf

TVA External Message. Please use caution when opening.

Ms. Pilakowski,

Per Mr. Dickerson's request, I am sending you the attached letter.

Thank you,

Charlotte Cade
Executive Assistant
Dickerson Petroleum, Transportation & Services
662-289-4103 Office
662-792-8037 Direct

Dickerson
Petroleum, Transporation & Services
www.dickersonpetroleum.com

From: Scanner
Sent: Wednesday, April 11, 2018 4:36 PM
To: Charlotte Cade <ccade@dickersonpetroleum.com>
Subject: Dickerson Petroleum

Dickerson
Petroleum, Transportation, and Service

PHILLIPS 66

MARATHON Fueling the American Spirit.

April 11, 2018

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, Dickerson Petroleum is a multifaceted petroleum companying specializing in Petroleum, Transportations and Services related to the industry. Dickerson has been in business for over 20 years, has 128 employees, 9 locations and has supplied Red Hills mine with fuel, oil and grease since its inception. Red Hills mine is and has been our largest customer for over 15 years.

Dickerson wants to help you promote the interest and general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people and the many companies of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge TVA to consider the many positive impacts that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer TVA and the TVA customers a low-risk diverse fuel source. Red Hills is environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Yours for Success,

Steven K. Dickerson

Name: Joe Diedrich

Comments: TVA operates numerous coal-fired power plants and will likely continue to do so for the foreseeable future. Fly Ash produced as a by-product of burning coal is a critically important resource for the ready mix concrete industry, as well as related concrete production industries. As recent events in Tennessee and elsewhere have demonstrated the fly ash produced by the production of electricity through the burning of coal places significant liability on the operators of such power plants, and can become a significant financial liability to the operators and by extension to the rate-payers who use this electricity. The historical methods of landfilling coal combustion byproducts have proven to create significant and ongoing environmental concerns for both the power plants and surrounding communities.

TVA should move quickly to embrace existing technology that allows landfilled (either dry or wet) fly ash to be beneficiated and sold to industry. While not all landfilled fly ash can be beneficiated and sold as a commercial product, a significant portion of such landfilled fly ash can be recovered and sold to industry. This permanently reduces the need to landfill and manage fly ash while improving the quality of the construction in which such fly ash is utilized. In addition, some beneficiation process can be used to treat both landfilled fly ash as well as the fly ash resulting from current electricity production. In these cases, the cost of landfilling fly ash is avoided on the front end and revenue can be realized to offset any additional cost related to the specific beneficiation process.

The concrete industry is currently facing persistent and recurring shortages of commercial grade fly ash even in areas such as Tennessee where much of our electricity is produced from burning coal. This is due primarily to the variability in the fly ash that results from current operational practices utilities employ as they produce electricity. This type of variability can be addressed by various beneficiation processes that are already commercially available in the marketplace.

A key factor here is that commercial grade fly ash has a definitive market-value and a well-established market demand throughout the Southeast. The ongoing need for such fly ash is real and well recognized within the concrete industry where fly ash has become a critical component in the production of everyday commercial concrete as well as high-performance concrete for tall buildings, bridges and other structures that utilize concrete. TVA should recognize and embrace their responsibility to better manage fly ash produced at it's power plants by making this product available to industry as a first priority rather than using landfilling as the first option.

Landfilled fly ash represents an ongoing liability for utilities that is quite likely to grow over time and one that will never completely disappear. Employing technology to beneficiate fly ash and make it available to industry represents a permanent and responsible solution that creates an additional revenue stream for the utility and eliminates the creation of a lingering and potentially immense liability from landfilling fly ash.

TVA's future Integrated Resource Plan should recognize and immediately begin to implement the existing technology described above. This clearly meets the objectives outlined in the request for comments on the 2019 IRP as shown below:

The 2019 IRP will consider many views of the future to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Valley over the next 20 years. As part of the IRP decision-making process, and in alignment with the National Environmental Policy Act (NEPA), TVA will analyze potential environmental implications associated with an updated IRP by issuing an environmental impact statement (EIS).

Implementing a long-term strategy to beneficiate currently produced fly ash and to recover (where feasible) landfilled fly ash meets every criteria listed above:

1. Beneficiated fly ash is commercially viable product with a demand that extends at least 20 years into the future and can help reduce the cost of electricity produced by TVA.

2. Diverting fly ash to beneficial industrial use that safely incorporates the fly ash into the

product (like concrete) is a far preferable method for TVA to demonstrate environmental stewardship.

3. A steady, consistent source of fly will allow concrete producers to provide higher-quality, lower cost concrete for construction that will aid in economic development for the communities served by TVA.

close window

Name: Dustin Embrey

Comments: Please continue to keep our air and water clean by investing heavily in renewable energy sources, to give the Tennessee Valley area a bright future. Encouraging energy efficiency with low availability rates and higher tiered usage rates would be ideal. Also, please look into rebates for electric vehicle and charging station purchases, as many other utilities have done to promote more efficient vehicles which are tied to the grid rather than oil.

Thank you,
Dustin Embrey

close window

Emerson, Jill 33 Old Hickory Blvd, Jackson, TN 03/05/18 TVA Public Site Business

TVA/ IRP and EIS Questions and Comments:

- **How do you think energy usage will change in the next 20 years in the Tennessee Valley region?**

  Consumers will demand that a large proportion of energy that they use be derived from renewable resources due to ongoing environmental concerns and their desire to generate and manage their own electricity. Consumers and new suppliers/investors must be properly compensated for the energy contributed to the grid.

- **Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?**

  It should change based upon consumer demand and opportunities for additional suppliers/investors to fund and generate economic, diversified, and equally distributed sources for renewable energy across the state. *35% Solar PV for Distributed Generation; 20% Natural Gas; 20% Nuclear; 10% Coal-fired; 15% Hydro.* Modernization of our aging grid is imperative for the future. The diversity of the current power generation mix will create demand for more infrastructure investments. This could delay or even replace the need for some traditional distribution assets such as feeder lines or substation upgrades.

- **How should distributed energy resources be considered in TVA planning?**

  Everywhere a distributed generation (Solar PV) resource can be funded across the TVA foot print. Distributed energy resources should be considered in areas where grid modernization is needed or to help meet peak electricity demand. If well planned it can also be a useful tool that resource planners at utilities can incorporate to help meet a region's increased electricity demand.

- **How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?**

  TVA can directly affect electricity usage by the consumer by providing diverse options across the TVA footprint and provide economically feasible incentives for clean energy usage and conservation.

- **And how will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?**

  Here it would be beneficial for TVA to consult with progressive leading power supply entities such as Duke Energy or Georgia Power, who are already far advanced in this process of reliably distributing and diversifying their power supplies, and research the answers to these questions presented here and apply to the energy grid in TVA's footprint.

April 16, 2018

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, Hydra Service Inc is a privately-owned pump rental and supply company covering Mississippi, Alabama, and Florida. We employee 100+ people from management, to sales people, to service technicians. We have been doing business with the Red Hills Mine since the mine started. We have a wonderful client/vendor relationship. The Red Hills Mine is a great partner and has without a doubt contributed to our growth as a company.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Jeremy Fletcher
Hydra Service Inc
Pelahatchie, Ms

From:	Amanda Garcia
To:	Integrated Resource Plan
Subject:	SELC Comments on TVA 2019 IRP Scoping
Date:	Monday, April 16, 2018 9:27:17 PM
Attachments:	2018_04_16_SELC Comments on 2019 IRP Scoping.PDF

TVA External Message. Please use caution when opening.

Dear Ms. Pilakowski,

Please see attached.

Amanda

Amanda Garcia
Staff Attorney
Southern Environmental Law Center
1033 Demonbreun St., Ste. 205
Nashville, TN 37203
615-921-9470
agarcia@selctn.org

*Please note our new address effective October 1, 2017

SOUTHERN ENVIRONMENTAL LAW CENTER

Telephone 615-921-9470

1033 DEMONBREUN STREET, SUITE 205
NASHVILLE, TN 37203

Facsimile 615-921-8011

April 16, 2018

Ms. Ashley Pilakowski
NEPA Compliance Specialist
400 West Summit Hill Drive
WT 11D
Knoxville, TN 37902-1499
Submitted via email to IRP@tva.gov

Re: Notice of Intent to Prepare an Environmental Impact Statement for 2019 Update to the Integrated Resource Plan

Dear Ms. Pilakowski:

Thank you for this opportunity to comment on the scope of issues to be evaluated in the Tennessee Valley Authority's 2019 Integrated Resource Plan ("2019 IRP") and accompanying environmental impact statement. The Southern Environmental Law Center ("SELC") is a non-profit, regional environmental organization dedicated to the protection of natural resources throughout the Southeast. SELC works extensively on issues concerning energy resources and their impact on the people, culture, environment and economy in six Southeastern states—Tennessee, Virginia, North Carolina, South Carolina, Georgia and Alabama. Over the past several years, representatives from SELC have contributed our knowledge and experience to the development of the 2015 IRP through participation in the Regional Energy Resource Council and Integrated Resource Plan Working Group ("IRPWG"). We have also contributed to stakeholder processes regarding renewable energy resources, including the Tennessee Valley Renewables Information Exchange, Distributed Generation-Integrated Value, and, most recently, the Distributed Generation Information Exchange.

We write today to offer two fundamental and interrelated concerns with the approach TVA is taking regarding the 2019 IRP. First, TVA appears to be proceeding exactly backward in its planning approach to integrating distributed energy resources (DER) into the Valley. TVA asserts that it has embarked on a new IRP in part to revisit its long-range plans in light of flat and declining sales and growing demand for distributed energy resources.[1] Yet before it even begins to evaluate DER as a resource for the Valley in the 2019 IRP, TVA has proposed an unjustified

[1] TVA, Notice of Intent, Environmental Impact Statement for 2019 Update to the Integrated Resource Plan, 83 Fed. Reg. 6668 (February 14, 2018).

rate structure change specifically intended to stymie the growth of DER in its service territory.[2] In addition, few if any of the local power companies in TVA territory have engaged in robust distribution resource planning, which would provide much-needed information regarding the benefit of DER to these distribution-level utilities. In TVA territory, the local power companies are municipal utilities and electric member cooperatives. As fellow public power providers, their ability to benefit from DER should be—and indeed is required to be—taken into account in TVA's planning. To appropriately plan for DER in the Valley, distribution-level planning should occur first, followed by TVA generation and transmission planning. Only after TVA and the local power companies have taken these steps should any conversation about rate structure changes to address purported DER-related impacts occur.

Second, TVA's approach runs counter to its least-cost planning obligation in the TVA Act. The TVA Act requires TVA to treat demand and supply resources "on a consistent and integrated basis."[3] The purpose of this provision is to ensure that demand-side resources, such as energy efficiency and distributed solar, receive a fair evaluation in planning to provide TVA customers with reliable electric service at the lowest system cost. Designing rates for the express purpose of diminishing DER immediately prior to engaging in an IRP that purports to evaluate DER as a resource surely does not satisfy this standard. The TVA Act also requires TVA to provide local power companies an opportunity to recommend energy efficiency and rate structure incentives and to assist them in planning and implementation of such measures.[4] Without having facilitated distribution resource planning, it is not clear how TVA can meet these obligations. For these reasons, we urge TVA to abandon its unfounded rate change proposal, engage the local power companies in distribution resource planning, and use the information it gathers such planning efforts to inform a future IRP process that genuinely treats demand and supply resources on a consistent and integrated basis as required by the TVA Act.

Sincerely,

Amanda Garcia
Staff Attorney

[2] TVA, 2018 Wholesale Rate Change, Draft Environmental Assessment, i (March 2018) (asserting that "TVA's current energy prices over-incentivize consumer installation of DER" and that rate change is needed to "mitigate[e] the effects").
[3] 16 U.S.C. § 831m(b)(2)(C).
[4] *Id.* § 831m(c).

From: Angela Garrone
To: Integrated Resource Plan
Subject: TVA 2019 IRP Scoping Comments - Southern Alliance for Clean Energy
Date: Monday, April 16, 2018 7:12:39 PM
Attachments: SACE_TVA 2019 IRP Scoping Comments_041618.pdf

TVA External Message. Please use caution when opening.

Please find attached scoping comments, submitted on behalf of the Southern Alliance for Clean Energy, regarding TVA's 2019 Integrated Resource Plan.

Please feel free to contact me with any questions about the attached comments.

Best,
Angela Garrone

--
Angela Garrone | Southeast Energy Research Attorney
Southern Alliance for Clean Energy
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April 16, 2018

Hunter Hydas
Enterprise Planning
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Ashley Pilakowski
NEPA Project Manager
400 W. Summit Hill Dr., WT 11D
Knoxville, TN 37902

Re: Scoping Comments for TVA's 2019 Integrated Resource Plan

Dear Mr. Hydas, Ms. Henry, and Ms. Pilakowski:

On behalf of the Southern Alliance for Clean Energy (SACE), we submit the following comments in response to TVA's public comment period for the scope of the Tennessee Valley Authority's (TVA) 2019 Integrated Resource Plan (hereinafter referred to as the 2019 IRP") and accompanying Environmental Impact Statement (EIS). SACE is a regional organization that promotes responsible energy choices that create global climate change solutions and ensure clean, safe and healthy communities throughout the Southeast.

Resource planning has long played an important role in the electric generation industry, largely due to the unique physical characteristics of electricity itself: the need to meet supply with demand in real time and the historically long lead times needed to build new power generation. Resource planning in this sector is even more important in the midst of current energy and energy market transitions. The new reality for many utilities is that load growth is flat or negative, customers are demanding more choices and generation resources that cause less pollution, technologies are advancing rapidly, and low and zero carbon technology costs are continually declining. These realities represent the current and future state of the power sector. It's critical that TVA address these trends throughout TVA's upcoming 2019 IRP process. TVA has both the opportunity and the responsibility to use its 2019 IRP to be proactive in addressing the opportunities and challenges presented by the energy transition.

Input Assumptions

Renewable Costs

Initial model assumptions on renewable energy costs in TVA's 2015 IRP were excessively high compared to market offerings. TVA recently received a significant number of high quality renewable energy bids in response to Request for Information (RFI) and Request for Proposals (RFP). In its 2019 IRP modeling inputs, TVA should incorporate these realistic cost metrics, wherever and whenever possible.

National Renewable Energy Lab Annual Technology Baseline (ATB)

The National Renewable Energy Lab (NREL) publishes its Annual Technology Baseline (ATB) as a resource for "realistic and timely set of input assumptions (e.g., technology cost, fuel costs), and a diverse set of potential futures (standard scenarios) to inform electric sector analysis in the United States. The products of this work, including assessments of current and projected technology cost and performance for both renewable and conventional electricity generation technologies, as well as market projections of more than a dozen scenarios produced with NREL's Regional Energy Deployment Systems (ReEDS) model,"[1] is one of the most comprehensive and accurate resources for various energy resource inputs. NREL's ATB is used by regional transmission organizations (RTOs) including Midcontinent Independent System Operator (MISO)[2] and PJM.[3] NREL's ATB should provide a starting point for model inputs in TVA's 2019 IRP. Given that future purchases of renewable energy resources would take several years before power production, it is recommended that NREL ATB data starting in 2019, as well as incorporating future pricing and performance levels.

Wind Energy

NREL's ATB evaluates wind energy resources as "techno-resource groups" (TRGs) that effectively provides a scale of quality.[4] For example, TRG 1 resources are anticipated to be the lowest cost and highest performance wind energy resources and are mostly concentrated in the Central US. A fair amount of wind energy capacity potential in the Southeast opens up in TRG 5, with the entire

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[1] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.
[2] Midcontinent Independent System Operator (March 20, 2018). "MTEP19 Futures Development Workshop." [https://cdn.misoenergy.org/20180320%20MTEP19%20Futures%20Workshop%20Presentation150635.pdf]
[3] Muhsin K. Abdur-Rahman (April 25, 2016). "PJM's Clean Power Plan Modeling Reference Model and Sensitivities," PJM. [https://www.pjm.com/-/media/committees-groups/committees/mc/20160425-webinar/20160425-item-02-clean-power-plan-reference-model-results.ashx]
[4] National Renewable Energy Lab (November 2016). Regional Energy Deployment System (ReEDS) Model Documentation: Version 2016. [https://www.nrel.gov/docs/fy17osti/67067.pdf]

region opening up with TRG 7. Evaluating these three different wind energy resources provides an appropriate range of wind energy resources available to the Southeast. These base costs would need to include the additional cost of transmission to bring them to the TVA system, particularly TRG 1 resources from the Midwest.

Figure 1. Wind Costs from NREL ATB

	TRG1	TRG5	TRG7
Overnight $/kW (2019)	$1,422	$1,469	$1,612
Capacity Factor	49%	42%	33%
LCOE $/MWh (no PTC)	$36	$43	$58

Source: NREL ATB 2017[5]

Solar Energy

The NREL ATB evaluates utility-scale solar photovoltaic (UPV) only based on fixed-tilt projects with three different capacity factors (14%, 20% and 28%). Fixed-tilt UPV projects have a slightly lower installed and operating cost, but also have a lower capacity factor and an even more significant capacity equivalent value, when compared to single-axis tracking UPV projects. To provide a better range of pricing and performance, it is recommended that the "Low" and "Mid" overnight costs for UPV from NREL's ATB be used as inputs in the 2019 IRP, along with the 28% and 20% capacity factors, respectively. These figures should be indexed to costs for single-axis tracking projects based on RFP responses (see "Real World Examples" section below for more discussion).

Figure 2. Solar Costs from NREL ATB

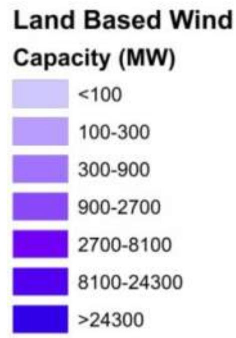
	Low	Mid
Overnight $/kW (2019)	$944	$1093
Capacity Factor	28%	20%
LCOE $/MWh (no ITC)	$34	$54

Source: NREL ATB 2017[6]

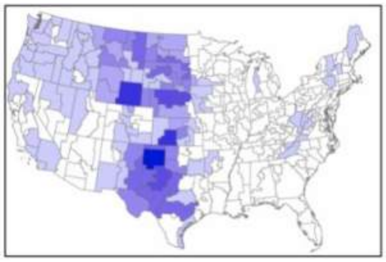
[5] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.

[6] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.

Figure 3. Wind Cost and Operational Information from NREL REEDS

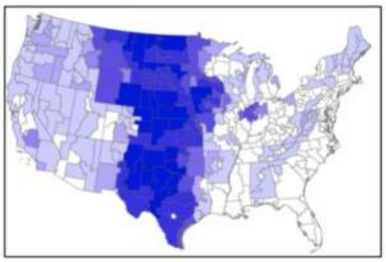


TRG1



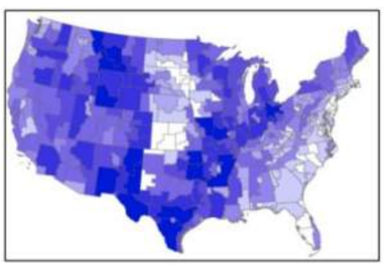
Overnight $/kW (2019)	$1,422
Capacity Factor	49%
LCOE $/MWh (no PTC)	$36

TRG5



Overnight $/kW (2019)	$1,469
Capacity Factor	42%
LCOE $/MWh (no PTC)	$43
Overnight $/kW (2019)	$1,612
Capacity Factor	33%
LCOE $/MWh (no PTC)	$58

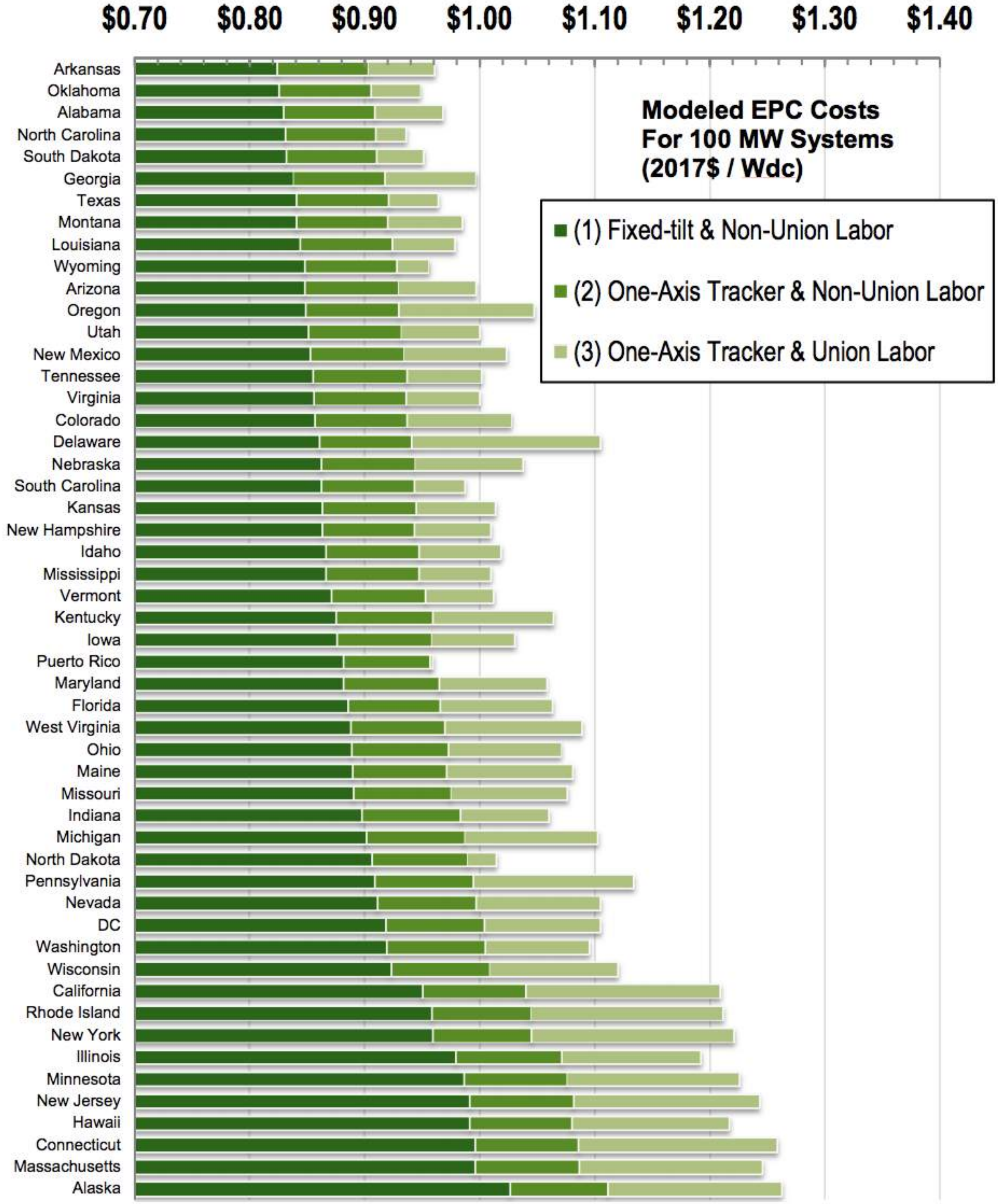
TRG7



Overnight $/kW (2019)	$1,612
Capacity Factor	33%
LCOE $/MWh (no PTC)	$58

Image Source: NREL ReEDS 2016
Data Source: NREL ATB 2017

Figure 4. Q1 2017 benchmark by location: 100-MW utility-scale PV systems, EPC only (2017 USD/Wdc)



Source: NREL 2017[7]

[7] Ran Fu (September 2017). "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017," National Renewable Energy Lab. [https://www.nrel.gov/docs/fy17osti/68925.pdf]

<u>Lazard Associates</u>

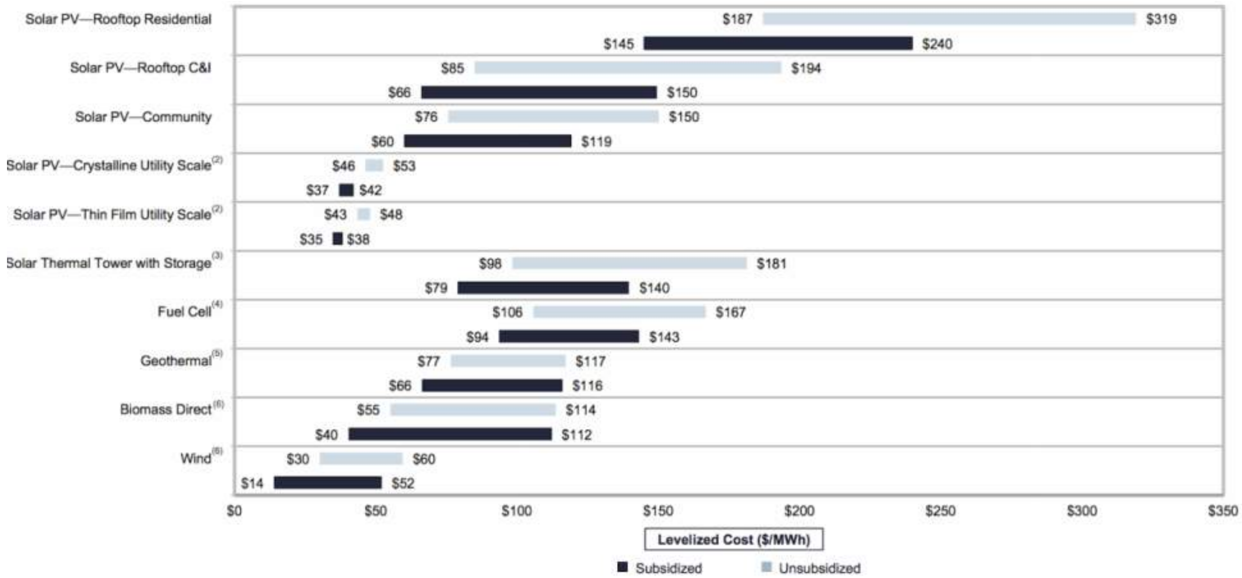
Lazard Associates develops an annual estimate of levelized cost of energy (LCOE) for a variety of generation technologies including wind energy, solar power, battery storage and others. In November 2017, Lazard Associates published its *Levelized Cost of Energy Analysis, Version 11.0*.[8] Costs are provided without subsidies or incentives, and are backwards looking, therefore the estimates used by Lazard should be evaluated and incorporated into the 2019 IRP as a current-year benchmark, with cost reductions and improvements projected for forecasts.

Current Renewable Energy Market

For wind and solar energy, Lazard's LCOE analysis is fairly straightforward. Unsubsidized utility-scale wind power prices likely range from $30-$60/MWh; adding the federal production tax credit reduces these prices to $14-$52/MWh. Unsubsidized utility-scale solar power prices likely range from $43-$53/MWh; adding the federal investment tax credit reduces these prices to $35-$42/MWh. Lazard did not include analysis of the impact of import tariffs on these prices. (See the "Tarrifs" section below for further discussion). There are technological, geographic, financial and other considerations that may slightly increase or decrease the overall LCOE for specific projects; however, Lazard's analysis should provide a clear set of bright-lines for current market benchmarks.

[8] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]

Figure 5. Subsidized and Unsubsidized Levelized Cost of Energy 2017



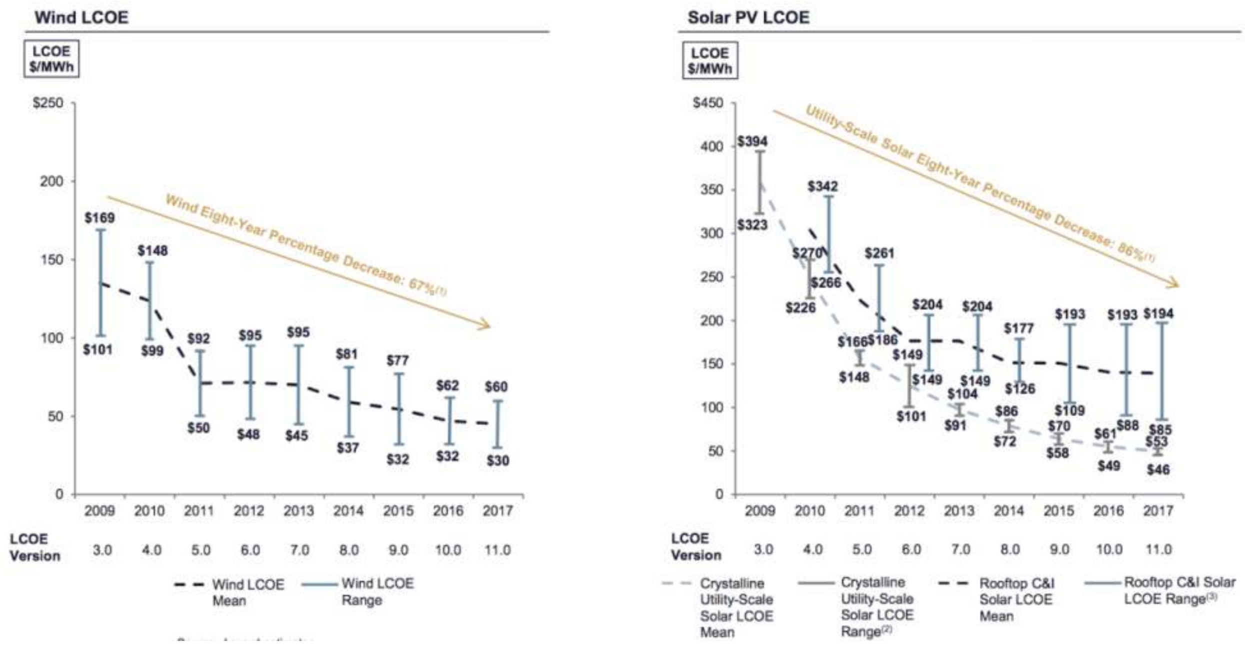
Source: Lazard Associates 2017[9]

Forward Projections

Over the last decade, wind energy and solar power prices have plummeted. According to Lazard Associates, wind energy prices have declined by 67% since 2009, while solar energy prices have declined by 86%.[10] The vast majority of subject matter experts agree that renewable energy resources are anticipated to continue to decline in the near-to-long terms. TVA's IRP modeling should reflect an anticipated decline in renewable energy costs over time.

[9] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]
[10] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]

Figure 6. Unsubsidized Wind Energy and Solar Photovoltaic Levelized Cost of Energy (2009-2017)



Source: Lazard Associates 2017[11]

Federal Tax Credits

As stated in TVA's Security and Exchange Commission filings, "TVA is not subject to federal income taxation."[12] Additionally, "neither TVA nor its property, franchises, or income is subject to taxation by states or their subdivisions."[13] Other tax-exempt public power entities have structured power purchase agreements (PPAs) for wind and/or solar projects in order to enable monetization of federal tax credits. For TVA's 2019 IRP, the discussion below about tax equity is particularly relevant.

The federal Production Tax Credit (PTC) and Investment Tax Credit (ITC) are the primary incentives for the wind energy industry and solar energy industry, respectively. As a result of congressional action in 2015, the PTC and ITC are currently phasing-out. Renewable energy developers can qualify projects for specific PTC/ITC vintages by commencing construction in a particular year and bringing such project online within four calendar years. For example, a wind energy project that commences construction by the end of 2016 has until the end of 2020 to begin operation and still qualify for the full PTC. Renewable energy project developers frequently safe harbor qualified clean energy equipment, in anticipation of a future contract.

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[11] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]
[12] Tennessee Valley Authority, 2017 Form 10-K
[13] *Id*; this section goes on to state that "Section 13 of the TVA Act, however, does require TVA to make tax equivalent payments to states and counties in which TVA conducts power operations or in which TVA has acquired properties previously subject to state and local taxation."

The PTC is awarded on a generation basis at a rate of $23/MWh for the first ten years of a project's operation. Because the PTC is a tax credit, it frequently exceeds a project developer's total tax liability causing developers to frequently monetize the PTC with tax equity. Tax equity erodes the full dollar value of the PTC. According to the Lawrence Berkeley National Lab (LBNL), a developer with a tax appetite can achieve a 100% PTC value reduction to $19.8/MWh.[14] For the ITC, the total credit amount is based on total expenditure, beginning with a credit for 30% of the total cost. The ITC will begin to decline in 2020. Most utility-scale solar energy projects elect to receive the ITC.

As shown by Lazard Associates, incorporating the federal PTC or ITC results in estimated LCOE's of $14-$52/MWh for wind energy and $35-$42/MWh for solar energy.

Figure 7. Schedule of PTC/ITC Project Qualification Commence Construction Dates

	2019	2020	2021	2022	2023	2024+
Wind PTC	$19.8/MWh	$19.8/MWh	$16.9/MWh	$14.2/MWh	$11.5/MWh	0
Solar ITC	30%	26%	22%	10%*	10%*	10%*
+Storage ITC	30%	26%	22%	10%*	10%*	10%*

** Residential = 0%*
Source: Adaptation from LBNL 2014[15]

Tariffs

In February 2018, tariffs were imposed on imported solar cells and modules. Modeling the impact of such tariffs in utility forecasting or resource planning, however, is exceptionally difficult. The tariffs, which expire in 2022, are set at 30%, declining 5% each year with 2.5 gigawatts of imports exempted and potential further exclusions. The tariffs also have a mid-term review, which will take place in early 2020. For impacted exporting countries, the World Trade Organization may offer a form of relief. Also, some solar cell and module companies may begin to ramp up domestic manufacturing.[16] In anticipation of the tariffs, a number of solar energy development companies began to stockpile pre-tariff cells and modules.[17] In the first year of the tariffs, industry experts estimate a negligible increase in the cost of module panels, due to the likelihood that any increase in demand resulting from this stockpiling activity would likely be equivalent to the increase in the costs of modules resulting from the tariff. Due to the complexity and ambiguity surrounding these solar tariffs,

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[14] Mark Bolinger (April 2014). "An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives," Lawrence Berkeley National Lab.
[15] Mark Bolinger (April 2014). "An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives," Lawrence Berkeley National Lab.
[16] Solar Energy Industries Association (January 2018). Section 201 Solar Tariffs. [https://www.seia.org/sites/default/files/2018-02/SEIA-Section201-Trade-Factsheet-Feb2018.pdf]
[17] Joe Ryan (September 12, 2017). "Solar Developers Hoard Panels as U.S. Tariff Threat Looms," Bloomberg. [https://www.bloomberg.com/news/articles/2017-09-11/solar-developers-hoarding-panels-as-threat-of-u-s-tariffs-looms]

TVA should not explicitly include these tariffs in its IRP model inputs. Any impacts may make their way into the modeling through the use of real world examples.

In March 2018, additional tariffs were announced for steel and aluminum.[18] Given the recentness of these new tariffs, significant changes to the original tariffs have already been made and will continue to be made. Given all power generators and facilities use significant quantities of steel and aluminum, these tariffs would cut across the entire power sector. Taking into consideration the uncertainty and complexity surrounding the steel and aluminum tariffs, TVA should not explicitly include these tariffs in its IRP model inputs. Just as with the solar module tariffs, potential impacts can enter the modeling assumptions via real world examples.

Real World Examples

Over the past year, several utilities have released renewable and/or storage system pricing information. TVA should include these real word examples in the benchmarking of its model input assumptions, particularly when looking at how renewable and storage costs will decline in the future.

In December 2017, Xcel Energy, a Colorado electric utility, published the results of its 2017 All-Source Solicitation request for proposals.[19] Xcel received over 400 bids representing more than 100,000 MW of capacity from a wide variety of technologies; however, most bids provided wind energy or solar power resources. The median bid price or equivalent for stand-alone wind energy resources was $18.10/MWh, suggesting a number of projects below and above that price. Adding battery storage to wind energy resulted in median bids of $21/MWh. For stand-alone solar energy resources, the median bid was $29.50/MWh. Adding battery storage to solar energy resulted in median prices of $36/MWh. While these particular prices may be specific to Xcel, that these resource prices represent real world project bids and are also aligned with projections by NREL's ATB, Lazard Associates, and these comments.

[18] United States Department of Commerce (March 18, 2018). "U.S. Department of Commerce Announces Steel and Aluminum Tariff Exclusion Process." [https://www.commerce.gov/news/press-releases/2018/03/us-department-commerce-announces-steel-and-aluminum-tariff-exclusion]

[19] Xcel Energy (December 28, 2017). 2016 Electric Resource Plan, 2017 All Source Solicitation 30-Day Report (Public Version) CPUC Proceeding No. 16A-0396E. [https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf]

Figure 8. Overview of Responses to Xcel 2017 All-Source RFP

RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451	[redacted]	$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317	[redacted]	$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5	[redacted]	$/MWh
Waste Heat	2	21	1	11	[redacted]	$/MWh
Biomass	1	9	1	9	[redacted]	$/MWh
Total	430	111,963	238	58,283		

Source: Xcel Energy 2017[20]

Arizona's state utility regulator, the Arizona Corporation Commission (ACC), announced in March 2018 that it refused to acknowledge several electric utilities' IRPs.[21] ACC ordered that any future IRPs submitted by the offending utilities include evaluation of scenarios where:

1) no more than 20% of generation is from fossil fuels[22]
2) new natural gas power plants in excess of 150 MW are prohibited until 2019[23]
3) 1,000 MW of energy storage is developed in their next IRPs.[24]

Storage Costs

Energy storage is an increasingly important resource for consideration in power supply planning. Storage technologies have the capability to ease the integration of variable renewable resources onto the grid and provide valuable ancillary services traditionally provided by fossil fuel generators but without additional air and water pollution. There are a wide variety of storage

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[20] Xcel Energy (December 28, 2017). 2016 Electric Resource Plan, 2017 All Source Solicitation 30-Day Report (Public Version) CPUC Proceeding No. 16A-0396E. [https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf]
[21] Arizona Corporation Commission (March 13, 2018). Commissioner Burns Proposed Amendment No. 1. [http://images.edocket.azcc.gov/docketpdf/0000186395.pdf]
[22] Arizona Corporation Commission (March 13, 2018). Commissioner Burns Proposed Amendment No. 2, Docket E-00000V-15-0094. [http://images.edocket.azcc.gov/docketpdf/0000186398.pdf]
[23] Arizona Corporation Commission (March 13, 2018). Commissioner Tobins Proposed Amendment No. 4, Docket E-00000V-15-0094. [images.edocket.azcc.gov/docketpdf/0000186484.pdf]
[24] Arizona Corporation Commission (March 13, 2018). Commissioner Tobins Proposed Amendment No. 3, Docket E-00000V-15-0094. [images.edocket.azcc.gov/docketpdf/0000186485.pdf]

technology options, from small and modular options like the many different types of batteries to large options like pumped hydro and flywheel technologies. It is critical that TVA's 2019 IRP include the latest cost figures and technology capabilities for a wide spectrum of these storage types.

Current Energy Storage Market

In November of 2017, Lazard published its *Levelized Cost of Storage Analysis, Version 3.0*.[25] Lazard Associates' estimated capital costs for various energy storage technologies as low as $1,152/kW in 2018. It is more difficult to assign a particular LCOE for energy storage solutions; not only because of the variety of technology (batteries, fly wheels, etc.) and rapidly declining prices, but because energy storage project finances are highly dependent on the type of services being provided. For example, Lazard Associates notes that, "Although energy storage developers/project owners often include Energy Arbitrage and Spinning/Non-Spinning Reserves as sources of revenue for commissioned energy storage projects, Frequency Regulation, Bill Management and Resource Adequacy are currently the predominant forms of realized sources of revenue."[26] For example, an energy storage project that predominately provides frequency regulation may appear to be exceptionally costly, on an LCOE basis, compared to a traditional power plant.; Such a facility, however, would be providing a highly valued service that may not be accurately reflected in current integrated resource planning processes, models, or specific utility markets.

The design of an energy storage project can also vary based on the specific services desired. For example, a recent presentation by GTM Research showed four-hour and eight-hour energy storage resources compared to peaking power resources. The researchers found that 82% of planned future peaking plants would be at risk of being uneconomic when compared to eight-hour storage projects (e.g., 100 MW/800 MWh).[27]

Due to limitations in resource planning practices, LCOE or even capital costs alone will not adequately assess the full benefits of energy storage. TVA should explore additional models or methodologies that better reflect the value of storage on the grid in their 2019 IRP process.

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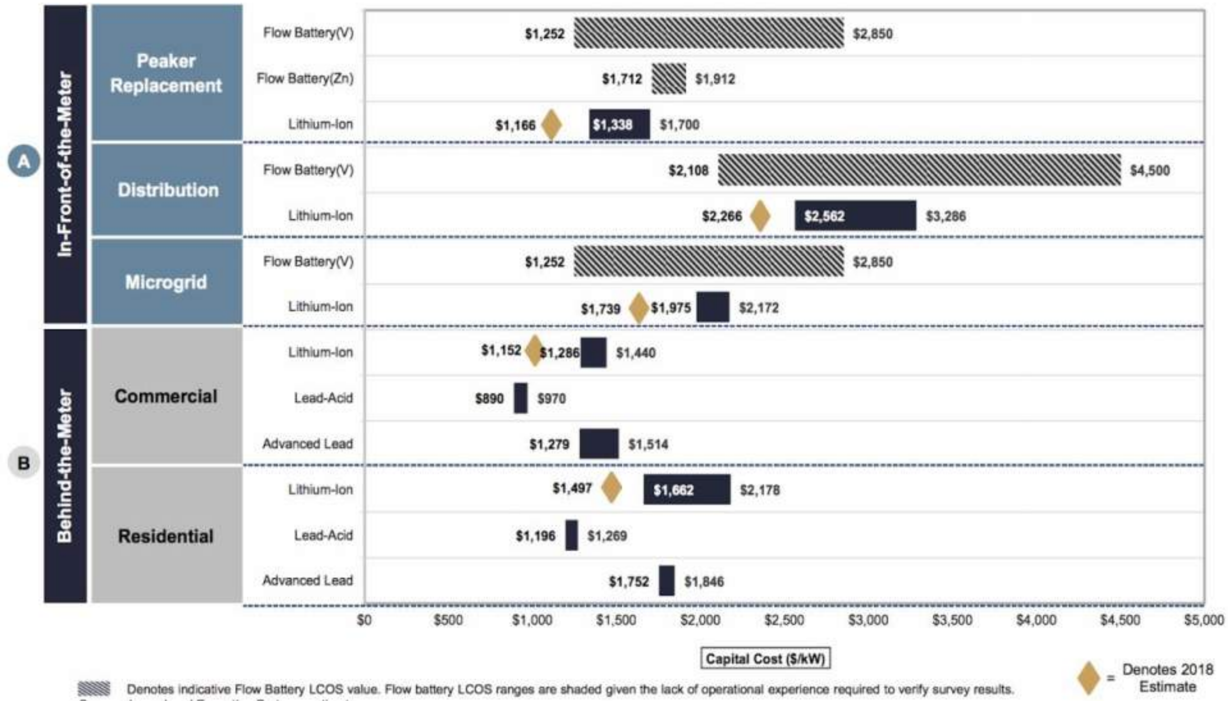
[25] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[26] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[27] Ravi Manghani (March 2018). "Will Energy Storage Replace Peaker Plants?" GTM Research. [https://d3v6gwebjc7bm7.cloudfront.net/event/15/88/96/3/rt/1/documents/resourceList1519927946005/willenergystoragereplacepeakerplantswebinarslides1519927951937.pdf]

Figure 9. Unsubsidized Energy Storage Capital Costs ($/kW)



Source: Lazard Associates 2017[28]

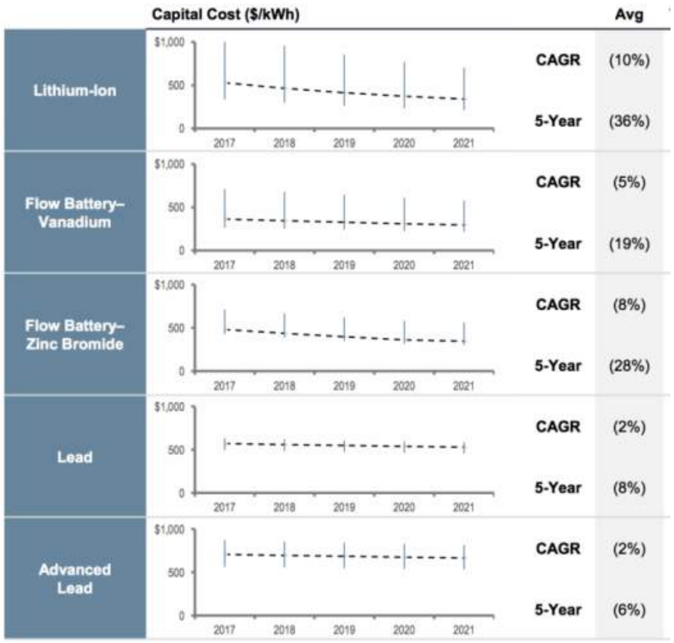
Forward Projections

Energy storage projects, especially battery storage resources, are expected to rapidly decline in cost, with a trajectory similar to that of renewable energy technology costs. Additionally, new energy storage projects can also qualify for the ITC (discussed in detail in the "Renewable Energy" section above), provided that those projects are added to new or existing wind or solar energy projects. Currently, stand-alone energy storage projects do not qualify for the federal ITC.[29]

[28] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]

[29] Heather Cooper (November 15, 2017). "Add batteries to your wind farm and get more (ITC) juice," McDermott Will & Emery. [https://www.mwe.com/en/thought-leadership/publications/2017/11/add-batteries-to-wind-farm-get-more-juice]

Figure 10. Storage Cost Projections



Source: Lazard Associates 2017[30]

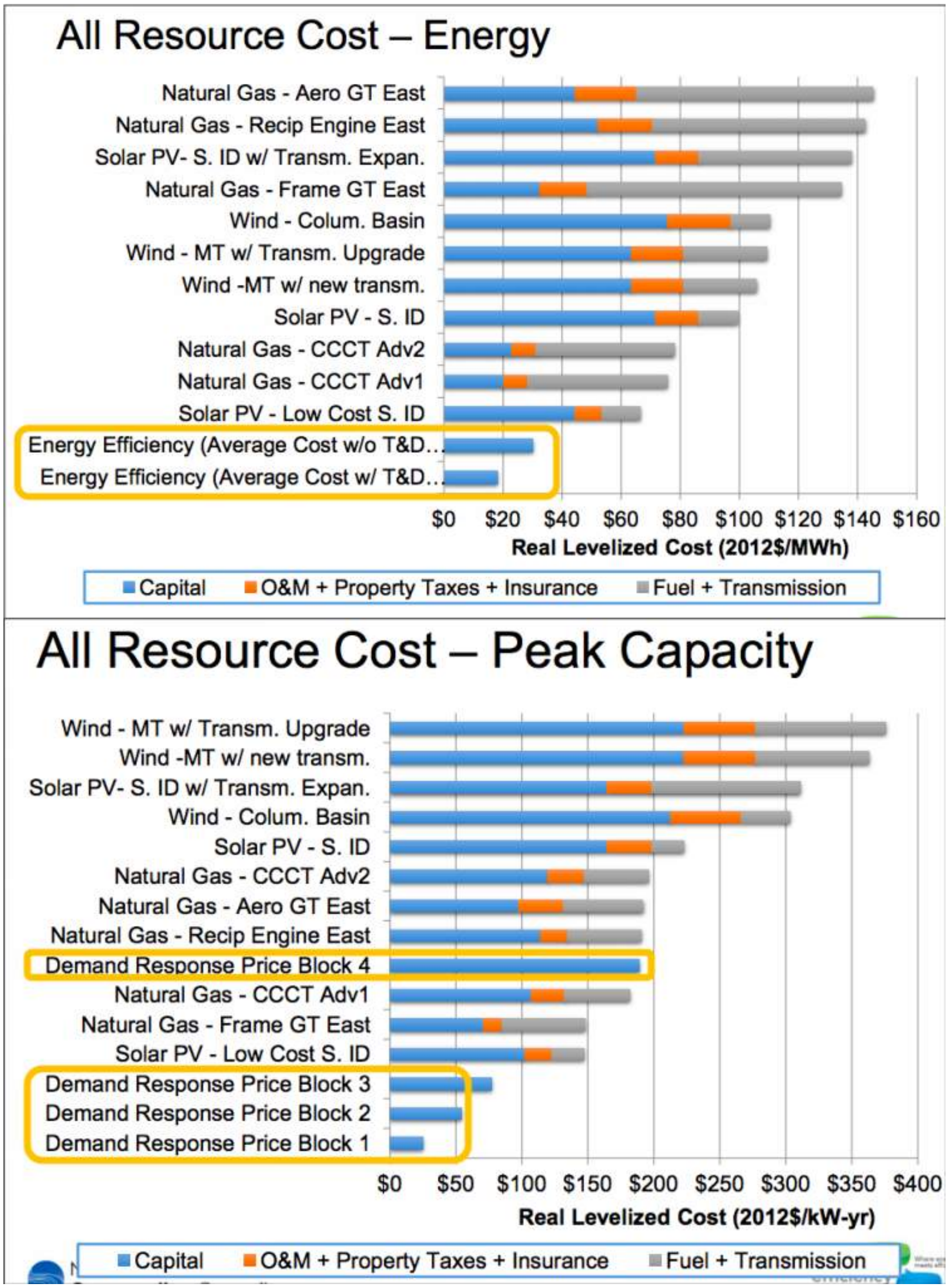
Storage provides benefits that are not captured in the traditional resource planning modeling, where the most granular resource evaluation occurs at the hourly basis. TVA's modeling for the 2015 IRP used a "representative hours" approach. Storage, besides pumped hydro, is a newer resource and power resource planning models were not designed with it in mind. Various industry players have developed "sub-hourly" modeling to evaluate the specific benefits, costs, and operations of different storage technologies, specifically for integration into resource planning. In order to meet current best practices, TVA should include sub-hourly modeling in its 2019 IRP.

Energy Efficiency Costs

Energy efficiency represents another area where TVA should look to its peer in the northwest: BPA. As discussed previously, BPA's resource plans are developed by the Northwest Power and Conservation Council (NPCC). The NPCC includes cost curves for both energy efficiency as an energy resource and demand response (DR) as a peak capacity resource. A snapshot comparing these levelized cost assumptions to those of generation resources is shown in the charts below.

[30] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]

Figure 11. Levelized Energy and Capacity Costs by Resource in Seventh Northwest Power Plan



Source: NPCC 2016[31]

The NPCC methodology breaks energy efficiency into a number of measure bundles across several sectors - each with its own assumptions on cost curves, potential, and load shape. These provide exponentially more detail than the "block" approach used by TVA used to model energy efficiency in its 2015 IRP, which lumps together all measures by sector.

[31] NPCC (April 2016). *Energy Efficiency in the Seventh Northwest Power Plan*, a presentation at the Efficiency Exchange conference. [https://www.nwcouncil.org/media/7150202/efficiency7thplan.pdf]

Figure 12. Energy Efficiency Measures Modeled in the Seventh Northwest Power Plan

Residential	
End-use	**Measure Bundle(s)**
Dryer	Heat pump clothes dryer
Electronics	Monitor
	Desktop
	Laptop
	Advanced power strips
HVAC	Controls, Commissioning, &
	Duct Sealing
	Ductless heat pump
	DHP with ducted system
	Ground-source heat pump
	Heat recovery ventilation
	Weatherization (Insulation +
	Air-source heat pump conversion
	ASHP upgrades
	Variable-capacity heat pump
	WiFi enabled thermostats
Lighting	LED lighting
	LED lighting – pre-2020
	Linear fluorescent lighting
Refrigeration	Refrigerator
	Freezer
Water Heating	Aerator
	Clothes washer
	Dishwasher
	Wastewater heat recovery
	Heat pump water heater
	Showerheads
	Solar water heater
Whole Bldg/ Meter Level	Behavior/Controls
	Electric vehicle supply
Food Preparation	Microwave
	Electric oven

Industrial	
End-use	**Measure Bundle(s)**
Air Compressor	Demand Reduction
	Air Compressor Equipment
	Air Compressor Management
Lighting	HighBay Lighting
	Lighting Controls
Motors	Efficient Rewind VSD Controls
	Motor Management Program
Fans	Fan Efficient Centrifugal
	Food: Fans and Blowers
	Other: Fans and Blowers
	Fan ASD Control
Pumps	Premium Pump
	Pump ASD Control
Food	Cooling and Storage
	Refrigeration Storage O&M
Metal	New Arc Furnace
Paper	Medium Consistency Pump
	Mech Pulp: Refiner Replacement
	Mech Pulp: Premium Process
	Mech Pulp: Refiner Plate Improvement
	Kraft Pulp: Effluent Treatment
	Kraft Pulp: Efficient Agitator
	Efficient Pulp Screen
	Premium Fan
	Material Handling
Wood	Replace Pneumatic Conveyor
	Hydraulic Press
Cold Storage	Retrofit
	Tuneup
	Fruit Storage Refer Retrofit
	Fruit Storage Tuneup
CS Retrofit	CO2 Scrub
	Membrane
Grocery	Dist Retrofit & Tuneup

Commercial	
End-use	**Measure Bundle(s)**
Compressed	Compressed Air
Electronics	Data Centers
	Desktop
	Laptop
	Monitor
	Smart Plug Power Strips
Food Preparation	Cooking Equipment
	Pre-rense Spray Valve
HVAC	Advanced Rooftop Controller
	Commercial Enery Management
	DCV Parking Garage
	DCV Restaurant Hood
	DCV Buildings
	Ductless Het Pumps
	Economizer
	Premium Fume Hood
	Secondary Glazing Systems
	Variable Speed Chiller
	Variable Refrigerant Flow
	Web-Enabled Programmable Thermostats
Lighting	Bi-Level Stairwell Lighting
	Exterior Building Lighting
	LEC Exit Sign
	Lighting Controls Interior
	Low Power LF Lamps
	Lighting Power Density
	Parking Garage Lighting
	Street and Roadway Lighting
Motors/Drives	ECM-Variable Air Volume
	Motors Rewind
Process Loads	Municipal Sewage Treatment
	Municipal Water Supply
Refrigeration	Grocery Refrigeration Bundle
	Water Cooler Controls
Water Heating	Water Heater Tanks
	Showerheads
	Clothes Washer

Agriculture	
End-use	**Measure Bundle(s)**
Lighting	Dairy lighting
	Outdoor barn lighting
Dairy	Vacuum pump
	Plate milk pre-cooler
	Heat recovery ventilation
Irrigation Water	Scientific Irrigation Scheduling
	Low-energy spray application
Irrigation hardware	Green motor rewind
	Replace/rebuild nozzles/gaskets/pipes
	Convert high/med pressure to low pressure

Distribution
Measure Bundle(s)
CVR
Reconductoring
VAR management
Phase load balancing
Feeder load balancing
Voltage regulators
EOL and LDC voltage control

Source: NPCC 2016[32]

In its 2015 IRP, TVA assumed energy efficiency costs would increase with increased penetration, despite the lack of adequate evidence of such a trend. An example contrary to TVA's assumption is the reduction in costs of LED lighting as the technology has become increasingly mainstream in recent years. TVA's 2019 IRP risks being inaccurate if it does not include some level of technological and cost improvements in its forecast for EE costs.

Planning Capacity Value

Stand-alone solar and wind resources are intermittent, but storage technologies currently being deployed are smoothing the dips and peaks in the output of these resources while not changing their overall capacity factor. Despite the intermittent nature of solar and wind resources, it is crucial that the ability of solar and wind to provide power during peak hours is properly quantified in the 2019 IRP. In a planning process, system planners (utilities and ISOs) account for the benefits solar and wind provide during peak hours by "derating" these resources based on a percentage of their "nameplate" capacity value – known as the planning capacity value. This derating varies regionally and depends on regional climate and system specifications. The on-peak availability of wind and solar is continuing to increase as operators gain experience with these technologies.[33] TVA should recalculate the capacity values for solar and wind used in the 2015 IRP in order to ensure they reflect the latest operational experience and technological advances. The capacity value for each generation technology should represent its availability during peak hours.

Cost Forecasts

One of the most important input metrics of any IRP are resource cost forecasts. TVA's 2019 IRP must include the latest price forecasts for coal, nuclear, hydro and natural gas, as well as for wind, solar and other renewable resources. The latest data on the cost of energy efficiency as a resource also should be used in the process. In the past, U.S. Energy Information Administration data have been unreliable as sole cost estimates. Better resources for renewable project costs in particular are discussed in a previous section.

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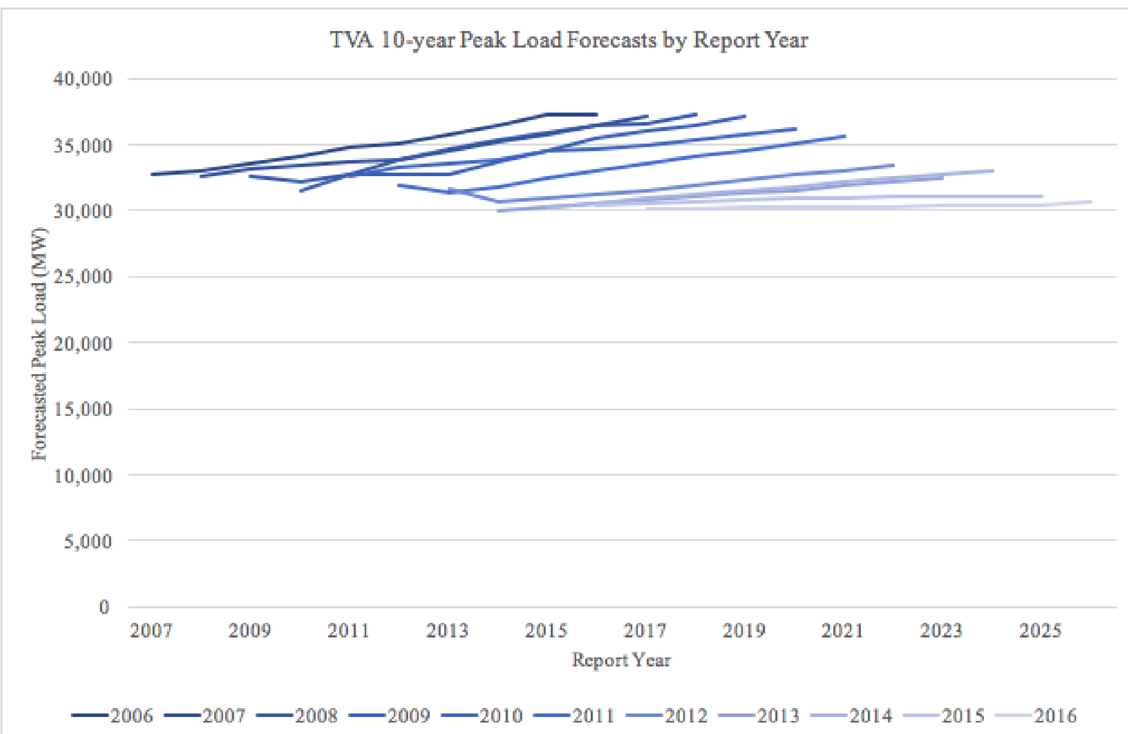
[32] NPCC (April 2016). *Energy Efficiency in the Seventh Northwest Power Plan*, a presentation at the Efficiency Exchange conference. [https://www.nwcouncil.org/media/7150202/efficiency7thplan.pdf]

[33] NERC (March 1, 2018) Long-term Reliability Assessment. [https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_12132017_Final.pdf]

Load Forecasts

Load growth trends have shifted dramatically compared to where they were 20 years ago. 2017 saw the largest drop in electricity sales since the Recession.[34] It is no longer common practice across the electricity industry to assume electricity use grows at a flat rate each year or that growth is tied directly to GDP and/or population growth. For example, PJM's 2013 Load Forecast Report included an annual growth rate of 1.3% whereas its 2017 Load Forecast Report included an annual growth rate of 0.2%, with many transmission owners reporting flat or negative load growth.[35] Factors influencing load growth include pushing load in both directions. For example, customers are reducing their load through distributed energy resources (DERs) like energy efficiency and distributed generation while also increasing their load by adopting electrification technologies like electric vehicles (EVs) (discussed further in a later section). Electric vehicle adoption is increasing and will have an impact on future load and load shapes in the region.

Figure 13. Historical TVA Load Forecast Growth Rates



Source: TVA 10-year Load Forecasts by Report Year

[34] EIA (April 3, 2018). "In 2017, U.S. electricity sales fell by the greatest amount since the recession" Today in Energy. [https://www.eia.gov/todayinenergy/detail.php?id=35612]
[35] PJM (August 3, 2017). *2017 RTEP Process Scope and Input Assumptions White Paper*. [https://www.energy.gov/sites/prod/files/2017/09/f36/2017%20RTEP%20Input%20Assumptions%20%26%20Scope%20Whitepaper_1.pdf]

Economic development activities not only influence load growth projections, but the generation resource profile, as well. And conversely, the resource profile can influence economic development activity and, hence, load growth. As further elaborated on page 6, a growing number of entities, from large corporations and manufacturers to retailers and government facilities, have stated renewable energy goals and/or have joined networks to push for renewable energy options. Access to renewable energy is a consideration for where these organizations establish or expand operations, and increase electrical load.

The NPCC holds the efficiency of appliances steady in its load forecasting in order to include energy efficiency and conservation as a resource in its resource planning model. In the latest resource plan, the Seventh Power Plan, the Council forecasts an average annual growth rate of 0.5-1.0% over the 2015-2035 timeframe *before* any energy efficiency and conservation.[36] NPCC has been a model of how to incorporate energy efficiency effectively into a resource planning framework. TVA should explore the methodologies used by the NWPP for both load forecasting and energy efficiency modeling and adapt them to the TVA framework.[37]

Coal Retirements

Coal-fired power plants are quickly becoming an antiquated means of generating electricity. They are expensive, dirty, and old. TVA has retired several coal units in recent years, following an international trend of movement away from coal as a generating fuel. Economics remains the main driver of coal retirements, though the economics are made worse for coal plants when regulations force plant owners to pay to clean up some of the damage their resources have caused for human health and the environment.

TVA still has seven active coal plants in its fleet. All analysis in the 2019 IRP should include an assumption that TVA retires at least half of its coal capacity by the end of the study period. Additional coal retirements should be included as an option in the greenhouse gas target and utility of the future strategies, discussed further below.

Nuclear

TVA's resource planning must include the latest real-world examples of nuclear project risk, including both cost overruns and delays as well as the likelihood of projects actually coming online. In addition, the 2019 IRP should consider the cost-effectiveness of continued investments in Small

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[36] Northwest Power and Conservation Council (April 4, 2016). *Seventh Power Plan, Appendix E: Load Forecast*. [https://www.nwcouncil.org/media/7149913/7thplanfinal_appdixe_dforecast.pdf]
[37] Details of the Plan and methodology are on the NPCC's website: https://www.nwcouncil.org/energy/powerplan/, and their resource planning model can be run on the website: https://www.nwcouncil.org/energy/rpm/rpmonline.

Modular Reactors (SMRs). TVA's resource plan should evaluate the benefits to customers and Valley residents of halting SMR investments and using those funds for energy efficiency, renewable energy, and storage resources in the region.

Scenarios and Strategies

TVA's previous IRPs have used scenarios and strategies to inform resource planning decisions. Generally, scenarios describe potential external forces that could impact the TVA system and strategies refer to actions TVA could take to capture opportunities or address challenges within those scenarios.

SACE is proposing that TVA include at least the following 3 scenarios and 4 strategies in its 2019 IRP.

Figure 14. SACE Proposed Scenarios and Strategies

Scenarios	Strategies
Renewable Energy	Renewable Energy
Carbon Policy	Energy Efficiency
Electrification	Greenhouse Gas Targets
	Utility of the Future

Scenarios

An IRP is only valuable if it looks at a variety of likely futures and bases its most likely future in reality. TVA's base scenario should look to the future and be driven by current industry trends, not by history. Just because electricity consumption grew from 1900 to the mid-2000's does not mean that trend will continue in the same direction or order of magnitude. It is of the utmost importance that TVA's base case represent a realistic story based in current reality and not the future that utility executives would like to have.

Utility resource plans tend to look out at least ten years. Ten years ago, distributed solar payback periods were 30 years, no one had heard of LEDs, natural gas prices were over $6/MMBtu (nominal) and predicted to rise, and the economy was in free-fall. It is always difficult to predict the future of this industry, and no one ever gets it exactly right. That is why variety is an important risk-mitigating tool in resource planning. What will change in the next 10 years that we are not even considering?

Bonneville Power Administration (BPA) is the closest TVA has to a peer. BPA tried to build 3 nuclear power plants in the 1970s based on faulty load growth forecasting, none were built but BPA customers are still paying off the debt for that major blunder. In response, in 1980 Congress put in place legislation to form the Northwest Power and Conservation Council (NPCC). One of the primary responsibilities of the NPCC is develop a long-term resource plan for the region every 5 years. In its most recent plan, the Seventh Power Plan, the Council looked at over two dozen scenarios, including:

- Existing Policy
- Social Cost of Carbon
- Retire Coal
- Retire Coal and Inefficient Gas
- Retire Coal & Impose Social Cost of Carbon
- Retire Coal & Impose Social Cost of Carbon & No New Gas
- Regional RPS @ 35%
- No Demand Response
- Increase Market Reliance
- Lower Conservation

One important takeaway from the NPCC's resource planning scenarios is the large number (over 24). Another is that they combined several scenarios to explore a variety of potential futures. For instance, they not only looked at a coal retirements scenario and a carbon cost scenario separately, but also evaluated what would happen if these two futures occurred together. This layering is important for understanding future risks in an industry as interconnected as the energy sector.

TVA Scenarios Should Focus on Generation

In its 2015 IRP, TVA evaluated five scenarios.

Figure 15. Scenarios from TVA 2015 IRP

Scenarios	Key Characteristics
1 - Current Outlook	The outlook for the future which TVA is currently using for resource planning studies
2 – Stagnant Economy	Stagnant economy results in flat to negative growth, delaying the need for new generation
3 – Growth Economy	Rapid economic growth translates into higher than forecasted energy sales and resource expansion
4 – De-Carbonized Future	Increasing climate-driven effects create strong federal push to curb greenhouse gas emissions; new legislation caps and penalizes CO_2 emissions from the utility industry and incentivizes non-emitting technologies
5 – Distributed Marketplace	Customers' awareness of growing competitive energy markets and the rapid advance in energy technologies produce unexpected high penetration rates in distributed generation and energy efficiency. TVA assumes responsibility to serve the net customer load (no backup for any customer-owned resources)

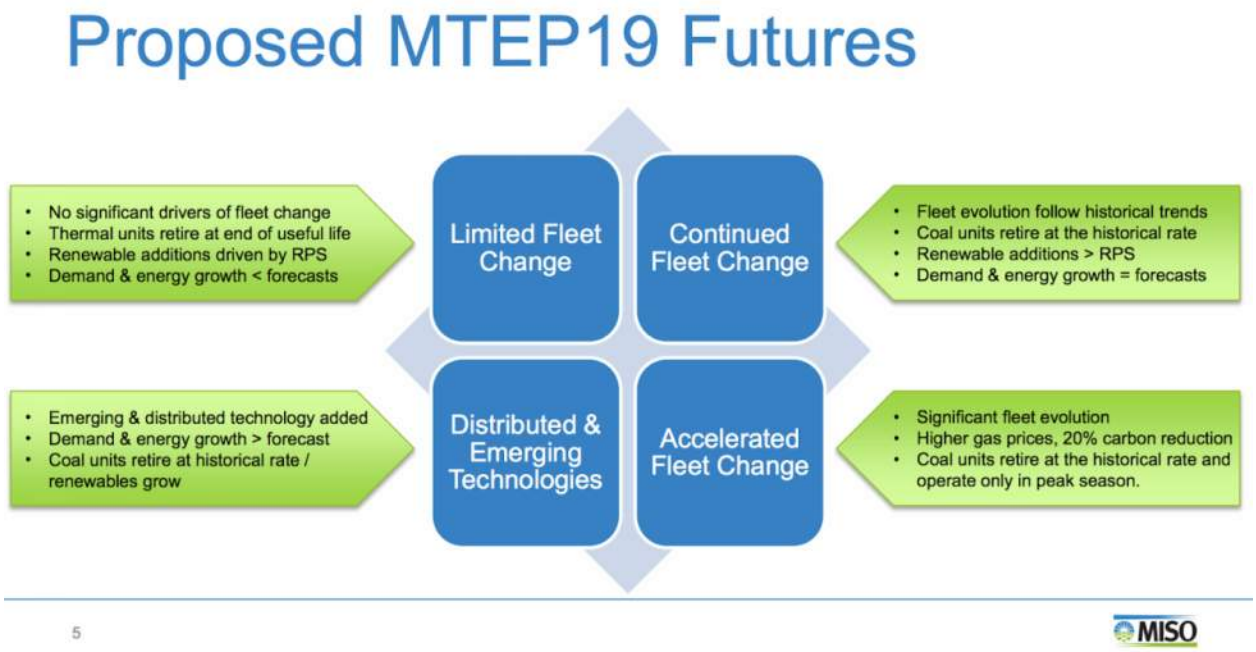
Figure 6-2: Scenario Key Characteristics

Source: TVA 2015 IRP

Generally, three scenarios evaluated were load-focused ("Current, Stagnant Economy" and "Growth Economy"), while two scenarios were generation-focused ("Decarbonized Future" and "Distributed Marketplace"). However, TVA has notified stakeholders that it anticipates relatively flat to declining load growth over the time frame covered by the 2019 IRP. Given that projections for load are anticipated to be flat to declining, evaluating multiple scenarios based on large changes in load scenarios is unrealistic and not useful. Instead, TVA should evaluate potential different load forecasts in the sensitivity analysis piece of the 2019 IRP.

MISO has abandoned evaluating futures based predominantly on load projections and instead focuses more heavily on generation projections. For example, MISO evaluates four futures in their 2019 MISO Transmission Expansion Plan (MTEP19) including scenarios for Limited Fleet Change, Continued Fleet Change, Distributed & Emerging Technologies and Accelerated Fleet Change.

Figure 16. Proposed Scenarios in MISO's 2019 MTEP



Source: MISO 2018[38]

Similarly, PJM has abandoned focusing heavily on load scenarios for its planning purposes. PJM states that,

> "During the first ten years since its inception in 1997, PJM's RTEP process generally found that the magnitude of uncertainty regarding future system conditions driving transmission need was limited to fewer major variables than today. Transmission expansion plans were mainly driven by load growth and generating resource interconnection requests. RTEP process tests could reasonably determine the expected date of future reliability violations with minimal risk of fluctuation. Now, however, a single set of RTEP baseline and market assumptions is simply not sufficiently flexible to consider all possible impacts of system enhancement drivers...Today, such external factors as public policy, regulatory action, fuel economics and operational performance are examined as part of PJM scenario studies (and in a number of cases, interregional studies). They provide valuable long-term expansion planning insights beyond those obtained from conventional baseline and market efficiency analyses."[39]

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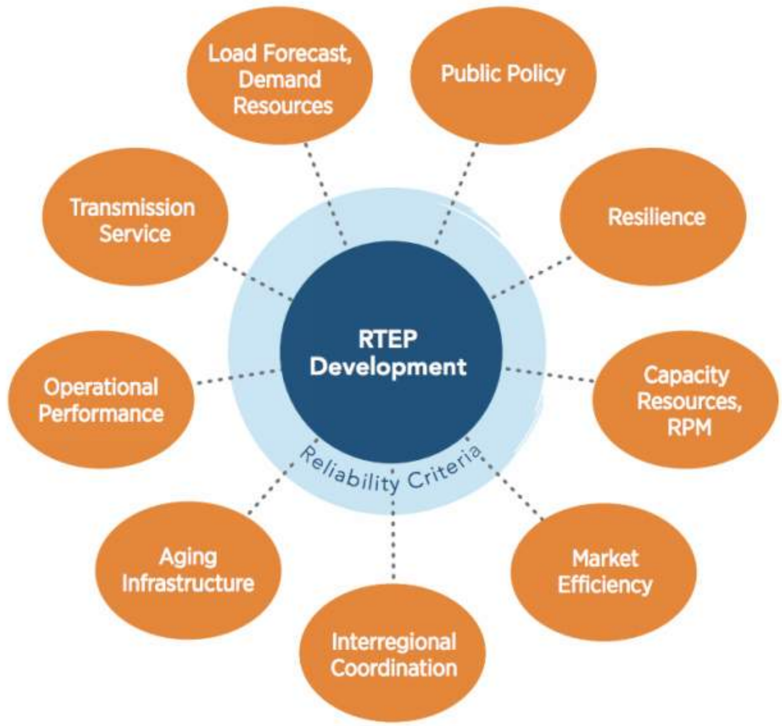
[38] Midcontinent Independent System Operator (March 20, 2018). MTEP19 Futures Development Workshop. [https://cdn.misoenergy.org/20180320%20MTEP19%20Futures%20Workshop%20Presentation150635.pdf]
[39] PJM (February 28, 2018). 2017 PJM Regional Transmission Expansion Plan. [pjm.com/-/media/library/reports-notices/2017-rtep/2017-rtep-book-2.ashx?la=en]

Figure 17. PJM RTEP Drivers

Figure 8.1: System Expansion Drivers



Source: PJM 2018[40]

Because both MISO and PJM planning exercises focus heavily on factors beyond a utility's load, TVA should develop scenarios that capture broader factors that will affect its operations in the years to come. For example, TVA should develop scenarios that evaluate:

- Earlier and later retirements for existing thermal generation;
- Baseline renewable energy and energy storage cost reductions (such as provided by the NREL ATB) and more aggressive cost reductions;
- Generic cost increases for existing fleet operations, which may be represented as additional environmental regulation or increased fuel costs;
- Anticipated DER deployment and a more aggressive outlook, including energy efficiency, small scale solar, commercial and industrial solar, electric vehicles and small scale battery storage; and
- Increased LPC control over generation procurement, up to 20% of TVA's total load.

Renewable Energy Scenario

IRP modeling should examine expanded renewable energy penetration at all scales: residential, commercial/industrial, community, and utility-scale.

[40] PJM (February 28, 2018). 2017 PJM Regional Transmission Expansion Plan. [pjm.com/-/media/library/reports-notices/2017-rtep/2017-rtep-book-2.ashx?la=en]

Distributed Solar

Just as with EVs, distributed solar occurs outside of TVA's immediate control and can serve as a strategy to take advantage of opportunities or address particular challenges. Forecasting future levels of distributed solar presents challenges similar to those experienced with EV forecasting. The ability to accurately forecast distributed solar resources depends on technological and economic factors that are expected to change continually for the foreseeable future as well as on customer behaviors. For its 2019 IRP, TVA should evaluate a variety of distributed solar penetration scenarios *prior* to including any distributed solar in its strategies. As with EVs, TVA could leverage outside expertise to develop a region-specific forecast or it could look to the many expert-driven forecasts being developed on a regular basis.

GTM Research, now a part of the specialized consulting firm Wood Mackenzie, and the Solar Energy Industries Association (SEIA) put out quarterly reports on both the current state and future forecast for solar energy by segment and state.[41] Navigant Research puts out regular reports on distributed solar[42] and distributed solar-plus-storage.[43] The National Renewable Energy Laboratory (NREL) has developed a Distributed Generation Market Demand Model (dGen) - "a geospatially rich, bottom-up, market-penetration model" that simulates DER adoption in the continental US through 2050. TVA could work with NREL to apply its assumptions to the dGen model and develop a set of region-specific DER penetration forecasts for use in 2019 IRP scenarios.

Corporate and Military Renewable Procurement

A growing number of entities, from large corporations and manufacturers to retailers and government facilities, have explicit renewable energy goals and/or have joined networks to push for renewable energy options in a coordinated way. The Business Renewables Center, an initiative of the Rocky Mountain Institute, currently has 230 members, while the Ceres BICEP network has 41 members. In total, 131 companies have pledged to go 100% renewable through the RE100. Due to the current, and likely future, increase of corporate and military renewable goals, it is imperative that TVA include scenarios with different levels of achievement for existing goals as well as scenarios where additional companies and entities develop renewable goals. These metrics are separate from the distributed solar example, described above, as renewable resources used by these companies are likely

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[41] GTM Research and SEIA (2017). *U.S. Solar Market Insight*. [https://www.greentechmedia.com/research/subscription/u-s-solar-market-insight]
[42] Navigant Research (May 2017). *The Annual Installed Capacity of Global Distributed Solar PV is Expected to Exceed 429 GW by 2026*. [https://www.navigantresearch.com/newsroom/the-annual-installed-capacity-of-global-distributed-solar-pv-is-expected-to-exceed-429-gw-by-2026]
[43] Navigant Research (April 2018). *Distributed Solar PV Plus Storage Energy Systems, Q1 2017*. [https://www.navigantresearch.com/research/distributed-solar-pv-plus-energy-storage-systems]

to include medium and large-scale solar, portions of utility-scale wind and solar projects and imported solar and wind.

Figure 18. Snapshot of Corporate Renewable Energy Goals from TVA

Source: TVPPA Rates & Contracts meeting, March 21, 2017

According to the Renewable Energy Buyers Alliance (REBA), the "C&I market is now around five GW of contracted wind and solar power, with commercial customers intending to procure an additional 60 GW by 2025."[44] TVA's 2019 IRP modeling should examine expanded renewable energy penetration at all scales: residential, commercial/industrial, community and utility-scale.

Carbon Policy Scenario

Enforceable federal regulation of greenhouse gas emissions from electric generating units has been eminent twice in the last decade – once, in 2010, when cap-and-trade legislation narrowly missed passage in the Senate and again, in 2015, when the Environmental Protection Agency promulgated a regulation under the Clean Air Act known as the Clean Power Plan (CPP). The number of states that regulate carbon emissions continues to grow. It is more likely than not that greenhouse gas emissions from TVA's power plants will be regulated within the next 20 years, if not sooner.

The most common way to include the impact of a carbon policy in future utility planning is by including a cost on carbon emissions when modeling the system. Utilities across the country

[44] Retail Industry Leaders Association, RILA (January 2017). *Corporate Clean Energy Procurement Index*.

consistently include a carbon price when evaluating future planning decisions, either as the base case or as a scenario. Additionally, companies beyond the power sector are including a cost on carbon emissions in their own future planning processes. TVA risks being unprepared for the likely regulation of carbon emissions from the power sector, should it fail to develop a Carbon Policy scenario that uses transparent policy assumptions in its 2019 IRP. The projected impacts of a carbon regulated future can be based on the Paris Agreement, or other regional plans such as the California and Regional Greenhouse Gas Initiative programs.

Although the CPP represents another data set from which TVA could borrow carbon policy impact assumptions, SACE does not recommend TVA use the CPP for its 2019 IRP. The state carbon emission reduction targets outlined in the CPP too low – with market forces already driving states to meet or exceed CPP targets – and do not meet the United States' pledge under the Paris Agreement. A future carbon policy is likely to be much stricter than the CPP. The Social Cost of Carbon (SCC) is similarly inappropriate for use in the 2019 IRP. The SCC is designed to measure the magnitude of the economic externality of the economic impacts of climate change for one ton of carbon dioxide. The cost to reduce emissions is a different calculation.

Electrification Scenario

Electric vehicles adoption rates are already increasing - but what if this trend increases further and expands beyond transportation? Electric heating is already common in some parts of TVA's service territory. Electric vehicle ownership is growing in particular areas as well. Most of the push for adoption of these technologies should come from LPCs, many of which have already launched programs to encourage efficient technologies. To reflect a future with increased electrification across various sectors, TVA should explore a scenario in its 2019 IRP where LPCs quickly ramp up support for all kinds of electrification, combined with potential electrification at TVA's industrial direct-serve customers. TVA should use a recent inform the assumptions on transportation electrification, see the resources listed in the Electric Vehicles Strategy section below. For additional resources on electrification rates and impacts, TVA should use a report recently published by LBNL.[45] The report includes technical and economic potential calculations.

[45] LBNL (March 2018). *Electrification of buildings and industry in the United States: Drivers, barriers, prospects, and policy approaches*. [http://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf]

Strategies

Any IRP is not complete unless all realistic future options are considered. This is where TVA's strategies come in. It is vital that TVA's strategies include a full mix of resource options and must incorporate the true and complete costs of the resources involved.

Renewable Energy Strategy

The "Renewable Energy Strategy" in TVA's 2015 IRP was based on an insignificant renewable energy target giving it included existing large hydropower. Since the last IRP, TVA has fallen farther and farther behind other Southeastern utilities when it comes development of renewable energy. Using significant renewable targets for any 2019 IRP renewable energy strategy represents best practices. TVA should not allow these targets to be met with existing hydro (as is standard practice when implementing renewable targets across the country).

In its 2015 IRP, TVA identified a number of paths for incorporating significant quantities of both wind energy and solar power. To date, TVA has made little effort in implementing its 2015 IRP with regards to renewable energy. Specifically, TVA stated its plan would:

- Wind: "Add between 500 and 1,750 MW by 2033, depending on pricing, performance, and integration costs. Given the variability of wind selections in the scenarios, evaluate accelerating wind deliveries into the first 10 years of the plan if operational characteristics and pricing result in lower-cost options."

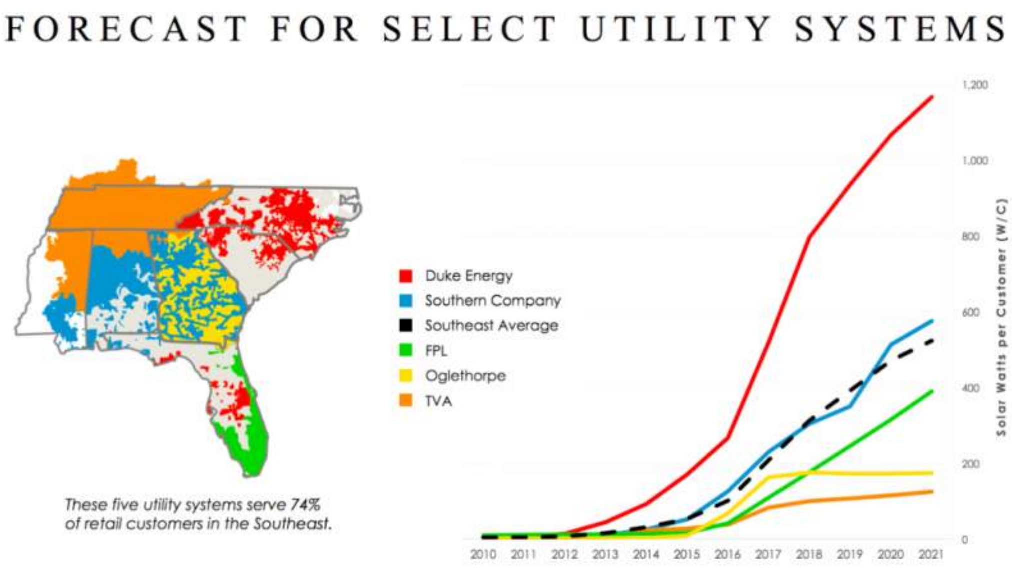
- Solar: "Add between 150 and 800 MW of large-scale solar by 2023, and between 3,150 and 3,800 MW of largescale solar by 2033. The trajectory and timing of solar additions will be highly dependent on pricing, performance and integration costs."[46]

From 2015-2017, TVA added approximately 200 MW of utility-scale solar, plus 50 MW of distributed energy solar. During that period TVA's wind portfolio actually shrank from approximately 1,540 MW to 1,240 MW (including approximately 30 MW of in-state, Tennessee, wind) when a 300 MW wind energy contract expired.

When compared on a watts per customer (W/C) basis, TVA significantly lags other utilities. The following graph compares that solar ratio for the five largest utility systems in the Southeast.

[46] Tennessee Valley Authority (March 2015). Integrated Resource Plan. [https://www.tva.com/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf]

Figure 19. Solar Watts per Customer for Select Southeast Utilities



Source: SACE Solar Report, December 2017

Quantity wise, TVA has more wind in its portfolio than any other utility in the Southeast: 1,240 MW (approximately 6% of TVA's capacity). As with solar, however, when compared on a watts-per-customer basis, TVA is not a Southeastern leader in wind energy. TVA's wind ratio computes as 264 W/C. In contrast, Gulf Power has more than double that ratio (600 W/C) thanks to wind contracts for 272 MW of wind (or 10% of Gulf's capacity).

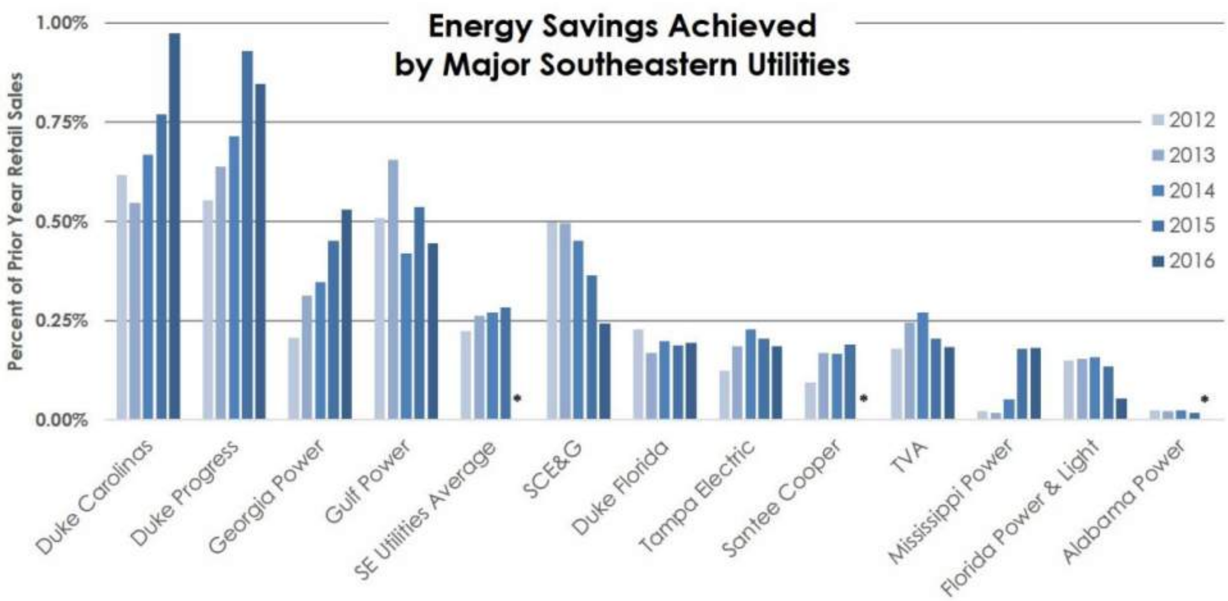
Energy Efficiency and Demand Response Strategy

Almost a decade ago, TVA's 2011 IRP promised to make the utility "a regional leader in energy efficiency." In its 2015 IRP, however, TVA drastically cut its energy efficiency targets. In its 2015 IRP, TVA purported to model energy efficiency as a resource in its resource planning methodology. While this is technically true, in reality, TVA effectively blocked energy efficiency improvements by using unrealistic assumptions for energy efficiency costs and potential by forcing in unsubstantiated constraints within the model.

In the 2019 IRP, TVA should explore a strategy to focus heavily on energy efficiency and demand response, sometimes collectively known as demand-side management (DSM). In this strategy, TVA will be able to evaluate a future where TVA and LPCs focus on maximizing energy efficiency savings across customer classes. Energy efficiency programs could be ramped up quickly by using strategies from other utilities across the Southeast and beyond.

Energy efficiency is not a new resource. Utilities in the region and across the world are meeting significant portions of load with energy efficiency. Annual savings can fall between 1-2%. TVA has some of the lowest levels of energy efficiency savings compared to other Southeastern utilities and is one of the rare utilities with a *downward* trend in annual energy savings achieved.[47] We encourage TVA to continue to model energy efficiency and demand response as resources, with the following methodology changes to reflect reality and not pick winners before modeling the system. 1277

Figure 20. Energy Savings Achieved 2012-2016 for Select Southeast Utilities



Source: SACE, 2017[48]

Low Greenhouse Gas Strategy

There are a myriad of reasons for TVA to include a low greenhouse gas (GHG) strategy in its 2019 IRP. TVA's mission under the TVA Act is three-pronged: provide electricity, provide economic development, and protect the environment. Environmental protection in the modern era includes reducing GHG emissions. As discussed in the Carbon Policy Scenario section above, a federal carbon policy is more likely than not over the 20-year planning period TVA is looking at in their 2019 IRP. A low greenhouse gas strategy would help TVA better prepare to meet future realities, and would have the added benefit of helping to establish TVA as a leader or benefactor when that policy goes into place.

The 2015 United Nations Climate Change Conference in Paris resulted in an agreement to hold the increase in average global temperatures to "well below 2° C" and to "pursue efforts" to limit that increase to 1.5° C.[49] The latest report by the Intergovernmental Panel on Climate Change (IPCC),

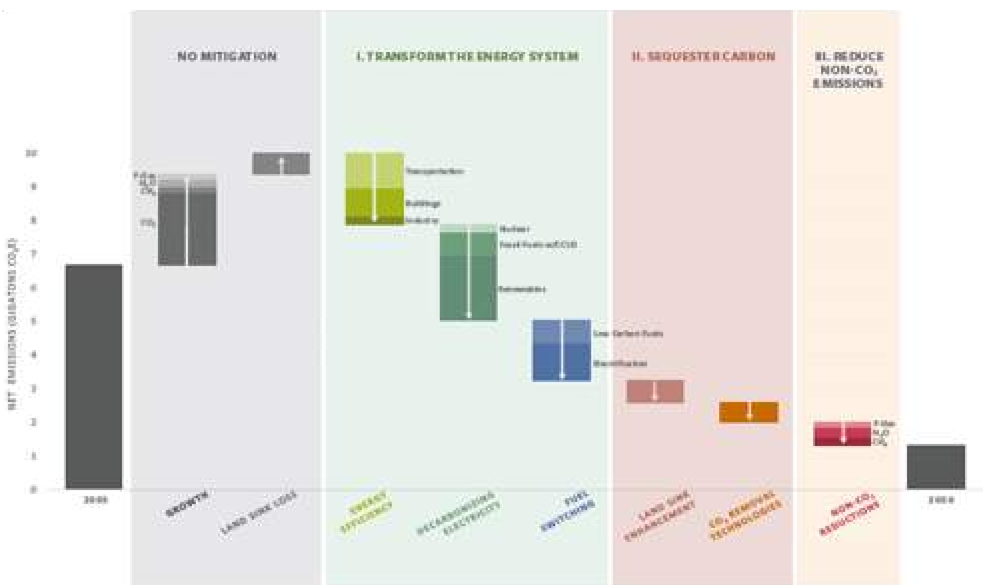
[47] SACE (October 2017). *Energy efficiency is trending up and down in the Southeast*. [http://blog.cleanenergy.org/2017/10/13/southeast-utilities-energy-efficiency-2017/]
[48] SACE (October 2017). *Energy efficiency is trending up and down in the Southeast*. [http://blog.cleanenergy.org/2017/10/13/southeast-utilities-energy-efficiency-2017/]
[49] UNFCCC (2016). *The Paris Agreement*. [https://unfccc.int/process/the-paris-agreement/what-is-the-paris-agreement]

released in 2014, stated that to limit warming to 2° C require reducing emissions to at least 90% below 2010 levels between 2040 and 2070.[50]

TVA's 2019 IRP must include a strategy where emissions are limited starting in 2020 and ramping down at a rate such that emissions in 2050 would be 90% below 2010 levels. This strategy is separate and distinct from a scenario in which a federal carbon policy is implemented. This strategy would show how a TVA-implemented carbon reduction strategy could help take advantage of future opportunities and address future challenges presented in the variety of scenarios evaluated. Conversely, the Carbon Policy Scenario is used to test the various strategies TVA would fare in a future where carbon is regulated or priced across the region.

The following graph is from the United States Mid-Century Strategy for Deep Decarbonization and illustrates a combination of interventions that can deliver 80% reduction in net GHG emissions (compared to a 2005 base year).[51] The majority of those necessary reductions are anticipated from Transforming the Energy System.

Figure 21. Measures to Achieve Deep Decarbonization



Source: United States Mid-Century Strategy for Deep Decarbonization

[50] IPCC (2014). *Fifth Assessment Report*. [https://www.ipcc.ch/report/ar5/]
[51] White House (November 2016). *United States Mid-Century Strategy for Deep Carbonization* [https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf]

TVA should note that some of its comparably-sized utility neighbors are pursuing strategies that are aligned with this basic framework:

- American Electric Power (AEP) had announced in February a clean energy strategy "that will lead to reductions in carbon dioxide emissions from its power plants of 60 percent from 2000 levels by 2030 and 80 percent from 2000 levels by 2050."[52]
- In early April, Southern Company CEO Tom Fanning announced that the generation fleet owned by Southern Co. will be "low to no-carbon" by 2050.[53]

TVA has achieved approximately 34% reduction in CO_2 emissions between 2005-2016. Sustained annual reductions of almost 6% per year will be necessary for emission in 2050 to be 90% below the 2010 baseline. Examining this type of resource portfolio will be very instructive in the 2019 IRP.

Electric Vehicles Strategy

There are a number of forecasts for EV deployment that provide a wide range of estimates. For example, the EIA Annual Energy Outlook 2017 estimates that nearly 15 million plug-in vehicles will be on the road by 2030; however, EIA has historically been a rather poor predictor of new technology adoption.[54] According to Bloomberg New Energy Finance, "While EV sales to 2025 will remain relatively low, we expect an inflection point in adoption between 2025 and 2030, as EVs become economical on an unsubsidized total cost of ownership basis across mass-market vehicle classes....Electric vehicles become price competitive on an unsubsidized basis beginning in 2025. Some segments will take longer, but by 2029 most will have reached parity with comparable internal combustion engine (ICE) vehicles."[55] By 2030, BNEF projects nearly one-third of all new car sales will be fully electric. Meanwhile, the American Automobile Association (AAA) recently reported that more than 30 million Americans are likely to purchase an electric vehicle as their next vehicle.[56]

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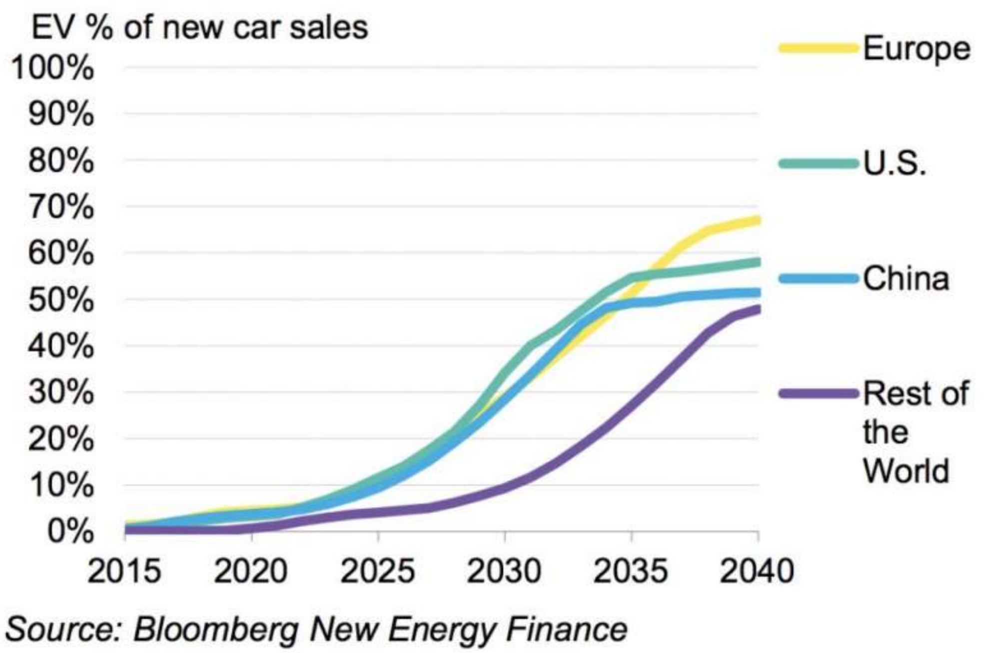
[52] AEP (February 6, 2018). "AEP's Clean Energy Strategy Will Achieve Significant Future Carbon Dioxide Reductions." [https://www.aep.com/newsroom/newsreleases/?id=2021]
[53] UtilityDive (April 9, 2018). "Southern Co. to be 'low to no carbon' by 2050, CEO says." [https://www.utilitydive.com/news/southern-co-to-be-low-to-no-carbon-by-2050-ceo-says/520907/]
[54] Michael Coren (October 19, 2017). "The US government keeps spectacularly underestimating solar energy installation," Quartz. [https://qz.com/1103874/the-us-government-underestimated-solar-energy-installation-in-the-us-by-4813-along-with-renewable-wind-and-solar-generation/]
[55] Bloomberg New Energy Finance (2017). Electric Vehicle Outlook 2017. [https://about.bnef.com/electric-vehicle-outlook/]
[56] AAA (April 18, 2017). "Consumer Appetite for Electric Vehicles Rivals Pickups." [https://newsroom.aaa.com/2017/04/consumer-appetite-electric-vehicles-rivals-pickups/]

Figure 22. Electric Vehicles as % of New Car Sales



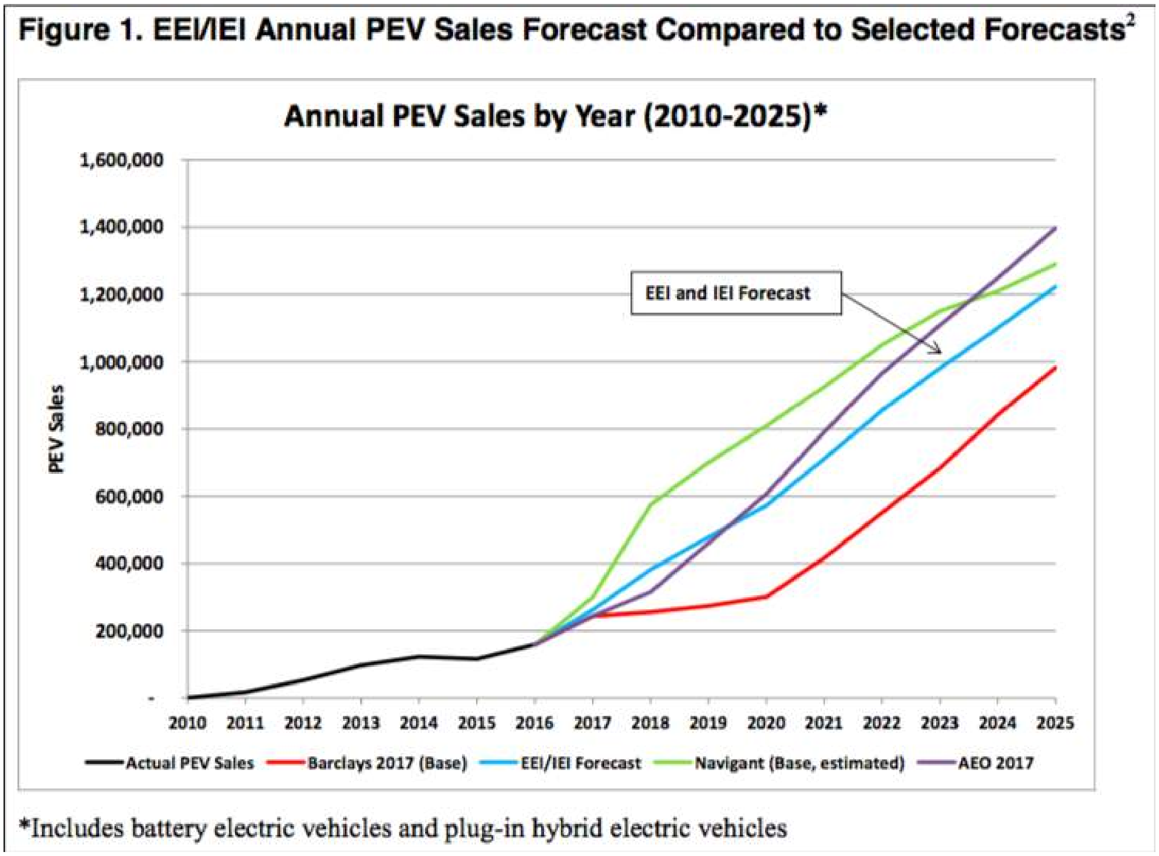
Source: BNEF 2017[57]

Electric vehicles can be both a strategy, discussed in more detail later, and also part of the variety of load scenarios TVA explores in its 2019 IRP. Forecasts of electric vehicle adoption must consider a number of drivers and barriers and the resulting forecasts can vary widely. In 2017, the IEI and EEI developed an EV forecast for the country based on three separate forecasts: one from the U.S. Energy Information Administration (EIA); one from a Barclays Equity Research Note; and one from the annual forecast from Navigant Research (see chart below).[58] Other forecasts are developed by Bloomberg New Energy Finance (BNEF),[59] the International Energy Agency (IEA)[60] and Energy Innovation.[61] TVA should include multiple EV penetration levels in their load forecast scenarios. To do so, TVA could bring in expert consultants to develop a set of forecasts specific to the region, or they could look to a variety of recent forecasts to develop a set of reasonable penetration levels (similar to what IEI and EEI did in their report). Ultimately, the TVA EV Strategy should be

[57] Bloomberg New Energy Finance (2017). Electric Vehicle Outlook 2017. [https://about.bnef.com/electric-vehicle-outlook/]
[58] IEI & EEI (June 2017). *Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required*. [http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf]
[59] BNEF (2017). *Electric Vehicle Outlook 2017*. [https://about.bnef.com/electric-vehicle-outlook/]
[60] IEA (2017). *Global EV Outlook 2017*. [https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf]
[61] Energy Innovation (September 2017). *The Future of Electric Vehicles in the US*. [http://energyinnovation.org/wp-content/uploads/2017/10/2017-09-13-Future-of-EVs-Research-Note_FINAL.pdf]

aggressive – similar to the Low Greenhouse Gas Strategy – in that it seeks to go well beyond what might happen in the absence of any TVA policy leadership.

Figure 23. Comparison of Plug-in Electric Vehicle Sales Forecasts



Source: IEI & EEI 2017[62]

<u>Utility of the Future Strategy</u>

Not only should TVA look at each of the strategies suggested above separately, it should also include a strategy that looks at these strategies in combination. This type of analysis is not duplicative, but rather serves multiple important purposes. Evaluating strategies separately is important to learn the likely outcomes of each individual strategy. Looking at these strategies in combination will allows TVA to identify additional benefits and challenges from a combination of strategies and develop appropriate planning responses. By evaluating these strategies both individually and cumulatively, the results of the 2019 IRP will better reflect reality, For example, it is extremely unrealistic to think that TVA will focus only on one strategy, renewable energy for instance, and completely halt all

[62] IEI & EEI (June 2017). *Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required*. [http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf]

investments in other strategies, like energy efficiency, measurement of greenhouse gases and/or implementation of electric vehicles.

Additional Considerations

Flexibility

TVA measured the flexibility of each strategy in the 2015 IRP by calculating the annual system regulating capability as a percentage of peak load. This is an extremely one-dimensional way to look at flexibility in the power sector. TVA should expand its definition of flexibility in the 2019 IRP to include additional measures that keep the grid resilient, such as fuel security and how a resource responds in an emergency, as well as measures for how quickly a resource can respond, both up and down. Solar and wind are intermittent resources in the short-term, but have substantially more secure fuel sources over the long-term compared to fossil fuels - and even hydropower in the event of a drought. Renewable resources combined with storage to create microgrids can be very effective in emergencies. For example, the state of New York is exploring ways to increase the use of these distributed technologies and microgrids in response to Hurricane Sandy.

Distributed storage, such as EVs and residential or commercial storage systems, can have levels of utility-control and be used for ramping as well as islanding in the case of emergencies. In January 2018, the Federal Energy Regulatory Commission (FERC) opened a docket to discuss reliability and resilience in the power system. In this docket. FERC defined resilience as the "ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[63] TVA should use this ongoing discussion between FERC and system operators across the country to inform its 2019 IRP.

At the least, if TVA continues to use its elementary definition of system flexibility, it should be sure to include the abilities of new technologies to provide regulation services. Natural gas plants and hydropower dams provide these services, but so do storage technologies, utility-scale renewables with controls and demand response. TVA should also be careful about how much of this kind of flexibility is needed. TVA is a well-connected utility without significant load pocket issues. With a well-thought-out combination of distributed and large-scale renewables across the grid and adequate upgrades to transmission as these resources are added to the grid, wind and solar resources can balance each other out with controls, over-paneling of solar systems, and energy storage. In TVA's 2015 IRP, all strategies, even the one with the highest level of renewable additions (Strategy E) showed system

[63] FERC Order issued January 8, 2018 under Docket RM18-1-000. [https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf]

flexibility improving over the 20-year planning period. New technology capabilities will drive this trend to be even greater in the 2019 IRP.

Another measure of flexibility that is important to consider when planning for an uncertain future is the ability of each strategy to adapt to different policy futures. For instance, a low GHG strategy would provide the flexibility for TVA to better adapt to a future with a federal or international climate policy that limits GHG emissions when compared to a business-as-usual strategy.

Energy and Environmental Justice

Environmental Justice (EJ) is the idea that all people and communities are entitled to equal protection under environmental law.[64] This includes energy policies, since they have a major impact on the environment. Ensuring EJ issues are considered as part of the broader environmental impact analysis helps develop healthy, sustainable, equitable communities that include healthier children and a more productive workforce. Inclusive and transparent policies that build community buy-in through a collaborative process are imperative in the EJ framework. TVA must weave EJ analysis throughout its 2019 IRP, not just because it is the right thing to do, but because it is mandated under the TVA Act. TVA should include the following approaches in its 2019 IRP process:

1. Identify populations currently or potentially vulnerable;
2. Provide meaningful engagement opportunities for those populations;
3. Assess community impacts of all scenario-strategy combinations using EJ-specific metrics; and
4. Mainstream EJ in all planning and decision-making.

For more information about how to include EJ in the planning process, TVA can refer to the Environmental Toolkit developed by the Metro Washington Council of Governments as a resource for decision makers like TVA.

Recently, TVA proposed a rate structure change, outlined in its 2018 Rate Change Environmental Assessment (EA), that favors industrial customers over residential and would disproportionally harm low-income residential customers. Already, a significant amount of TVA ratepayers are suffering under high energy burdens – a metric that looks at the percent of annual income any one household spends on energy costs over the course of a calendar year. is known as energy burden. TVA should be troubled by the fact that its largest customer, Memphis, TN, is home to communities with the highest energy burdens for low-income and minority communities in the entire country.[65] Overall, low-income households in TVA's service territory have an average energy burden

[64] MWCOG (July 2017). *Environmental Justice Toolkit*. [https://www.mwcog.org/documents/2017/07/27/environmental-justice-toolkit/]

[65] *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, American Council for an Energy Efficiency Economy (ACEEE), April 20, 2016.

of 12.6%, with energy burdens ranging from 7.1-28.7% by LPC.[66] Low-income households tend to use less energy than middle- and high-income households, yet TVA's Grid Access Charge included in its 2018 Rate Change EA proposal would increase the average energy burden of low-income households by as much as 2.8% of their household income. If TVA does not withdraw the proposal, as many stakeholders have recommended, it must further evaluate the socio-economic impacts of these rate changes under each 2019 IRP scenario-strategy combination.

Impacts of Climate Change

TVA has the formidable task of protecting water quality across a 41,000-square-mile watershed while also managing water resources for recreational, municipal and industrial uses. Water will be one of the natural resources most heavily impacted by climate change, particularly in the Southeast as water temperatures rise. Water resources are already in high demand, so it is crucial that TVA base its generation modeling and future planning on the best climate modeling and identify power plants or groups of power plants that may have a significant impact on water resources in the Valley.

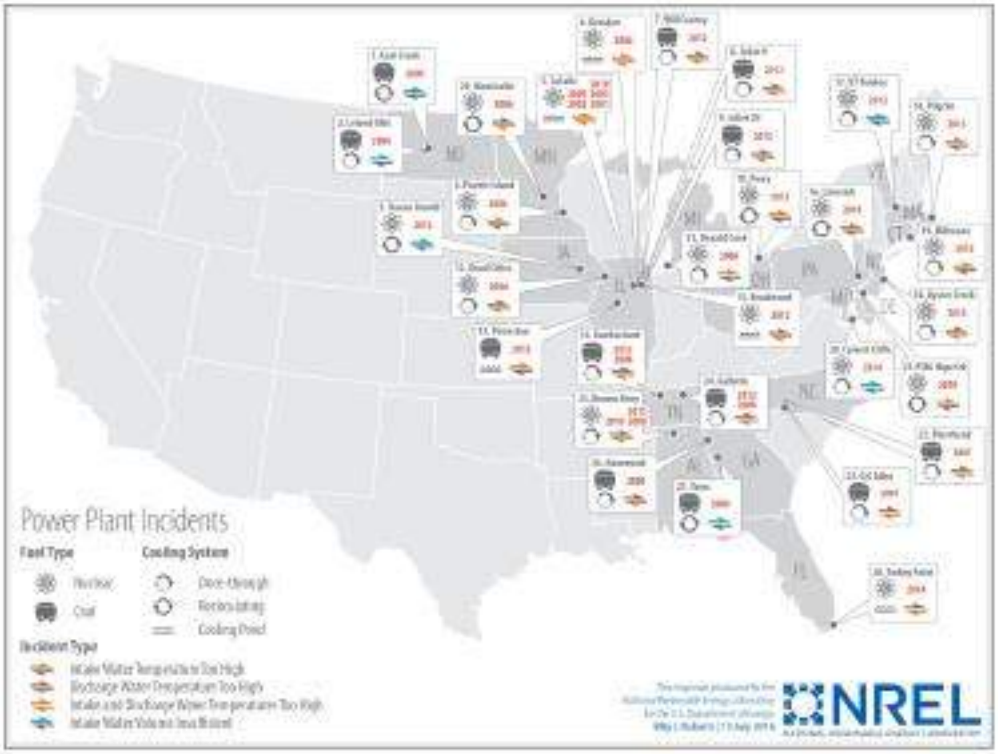
TVA's 2019 IRP and accompanying EIS must consider both the environmental impacts and operational considerations related to current and future water resource constraints, by river basin and sub-basin, in direct relation to specific generation resources. TVA's current generation fleet is very water-intensive, including both hydroelectric dams and thermal generation plants that depend on water for cooling. The significant warming our region will experience will contribute to higher water temperatures. The 2014 National Climate Assessment warns that the Southeast will experience "decreased water availability, exacerbated by population growth and land-use change, [that] will continue to increase competition for water and affect the region's economy and unique ecosystems." [67] This will increase stress on large, inflexible generators heavily reliant on adequate water supplies at appropriate temperatures and reduce necessary flows for TVA's hydropower generators.

NREL reports that "Over the past decade, there have been more than three dozen incidents where thermal power plants have been forced to curtail generation or shut down due to water-related temperature and availability issues." This includes seven such incidents at TVA plants: four incidents at coal-fired power plants (Cumberland and Gallatin, 2 incidents each in both 2008 and 2012) as well as three water-related issues at the Browns Ferry nuclear plant (occurring in 2008, 2010, and 2011).

---

[66] SACE (April 2018). "Is TVA ignoring how a proposed new fee could put vulnerable customers at risk?" [http://blog.cleanenergy.org/2018/04/12/is-tva-ignoring-how-a-proposed-new-fee-could-put-vulnerable-customers-at-risk/]
[67] 2014 National Climate Assessment available at https://nca2014.globalchange.gov/

Figure 24. Thermal Power Plant Curtailment Incidents



Source: NREL December 2016[68]

At the least, TVA's 2019 IRP must also consider both the changes in water temperatures and changes in precipitation as part of its regional climate change impacts analysis when modeling generation resources. TVA nominally included water resource impacts in its 2015 IRP in the water component of its environmental scoring metric. Nevertheless, TVA's analysis of the relationship between thermal generation assets and resource planning were lacking and need to be improved in several key ways. TVA should augment the system-level environmental stewardship metric, along with a closer look at how specific water resources (generally, specific river basins and sub-basins) would be affected by TVA's potential strategies.

Conclusion

In order for TVA to create a sufficiently useful and informative 2019 IRP and EIS, TVA should include the various analyses approaches, strategies and scenarios outlined in the above comments. Although we recognize that TVA's IRPs are, unfortunately, unenforceable and not proscriptive, these long-range planning processes should be taken seriously and include best practices and updated cost and performance assumptions for a wide-range of electric generation resources.

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[68] NREL (December 2016). *Water and Climate Impacts on Power System Operations: The Importance of Cooling Systems and Demand Response Measures*. [https://www.nrel.gov/docs/fy17osti/66714.pdf]

Respectfully submitted by,

Angela Garrone
Energy Research Attorney

On behalf of the Southern Alliance for Clean Energy
P.O. Box 1842
Knoxville, TN 37901
865-637-6055

From: Jack Gaw
29 W Paris St
Cookeville TN
38501

2019 Integrated Resource Plan

14 Ideas to Save TVA money

1. Use natural gas from the less expensive Marcellus gas field

2. Upgrade gas peaker plants to combined cycle reducing operating costs

3. Retire the Gallatin + Kingston TN Coal Plants by 2019
   Coal plants require too many employees
4. Retire the other TN coal plants by 2020

5. Retire the Kentucky coal plants by 2022
   Coal plants require too many employess
6. Put on a big push for more solar + wind energy

7. Rates for industrial + commercial customers should be gradually be raised to equal residential rates

8. Rates for larger residential users should not be decreased at the expense of smaller customers

9. There should be no charge if not using electricity

10. Increase efficiency efforts. Increase help for home Owners installing insulation + windows + solar panels

11. Put up for bidding 500 megawatts of solar per year

12. Help get the clean line approved. We need cheaper wind energy from Oklahoma and other providers until we can get more in TVA country

13. Don't waste ratepayers money on lawyers, clean up the coal ash. It will have to be done anyway.
14. Forget new nuclear - its too expensive

By 2023 I would like for Nuclear to be at 33⅓%
" " " " renewables " " " 33⅓%
" " " " Gas " " " 33⅓%
" " " " C[illegible] " " " 0%

From: Tim Gilbert
To: Integrated Resource Plan
Subject: Fwd: IRP
Date: Thursday, February 15, 2018 5:49:08 PM

TVA External Message. Please use caution when opening.

PS: Stop planning what to do and start doing what you plan!!!

Sent from my iPhone

Begin forwarded message:

> **From:** Tim Gilbert <timcgilbert@charter.net>
> **Date:** February 15, 2018 at 4:15:20 PM CST
> **To:** IRP@tva.gov
> **Subject: IRP**
>
> TVA continues to spend needless dollars on planning.
> A new IRP and only 3 years since the last one? A supposedly 20 year plan!
> Customers and distributors are bewildered by this repetitive waste of time and ratepayers money.
> Word on the street is that TVA's power assets are headed for privatization!
> There would be support for that, provided all the hydro assets were retained to fund TVA's neglected Resource Management obligations.
> Stop wasting money on these useless plans!!! Use that money to take better care of our reservoirs and public lands!!!
> Sent from my iPhone

From: Tim Good
To: Integrated Resource Plan
Subject: TVA Letter for NA Coal
Date: Sunday, April 15, 2018 6:07:18 PM
Attachments: TVA Document04152018.pdf

TVA External Message. Please use caution when opening.

Dear Ms. Pilakowski,

Please find attached my letter from Maxam Tire NA to promote the interest in general welfare of the people of the TVA service territory.

Any questions, please let me know.

Tim Good
Radial OTR Sales Manager
MAXAM TIRE NORTH AMERICA INC

300 Rosewood Drive, Suite 102, Danvers, MA 01923
Tel: 1-844-MAXAM-NA EXT 201
Mob: +1 330-283-2366
Fax: +1 978 560 0624
tim.good@maxamtirena.com
www.maxamtire.com

April 15, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, Maxam Tire North America is a tire manufacturer for the mining and construction industry. Maxam Tire NA supplies tires and rims to NA Coal for their equipment. Maxam Tire supports NA Coal's tire requirements for their large haul trucks and Ash trailers. They are a very important account for Maxam Tire NA.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Tim Good
Sales Manager Radial OTR Tires
Maxam Tire NA

300 Rosewood Drive, Suite 102, Danvers, MA 01923
+1-844-629-2662
+1-844-MAXAM NA

Graham, Cierra

From: Chuck Goodson <cgoodson@indlube.com>
Sent: Friday, April 13, 2018 2:58 PM
To: Integrated Resource Plan
Subject: ATTN: Ashley Pilakowski - NEPA Project Manager

TVA External Message. Please use caution when opening.

April 13, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, Industrial Lubricant Company is a 3rd generation family owned business that employees 85 people at 4 locations across the United. Industrial Lubricant Company provides Red Hills with specialty lubrication products, lubrication hardware, and technical services to maximize the operational uptime of plant equipment.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Chuck Goodson, P.E.
Branch Manager
Industrial Lubricant Company
11033 Hwy 271 Tyler, TX 75708
(903) 597-4800 tel | (902) 597-4862 fax | (903) 530-8592 cell
http://www.industriallubricant.com/

From:	Louise Gorenflo
To:	Integrated Resource Plan
Cc:	Alldredge, Jennifer; Betty Krogman; Courtney Shea; Dan Joranko; Denise Yeargin; Jennifer Alldredge; Pam Hindle; Paul Laudeman; Rev. Donna Butler; Rev. Paul Slentz; Sandy Kurtz; Stewart Clifton; Ted Jackson; Tim McDonald
Subject:	TVA 2019 IRP Comments
Date:	Friday, March 23, 2018 1:36:30 PM
Attachments:	TVA IRP Comments.pdf

TVA External Message. Please use caution when opening.

Ms. Pilakowski,
NEPA Project Manager
TVA

Please find attached the 2019 IRP Comments of TN Interfaith Power & Light.
If you have questions or comments, please contact me.

Louise Gorenflo
TN Interfaith Power & Light
865-441-7752

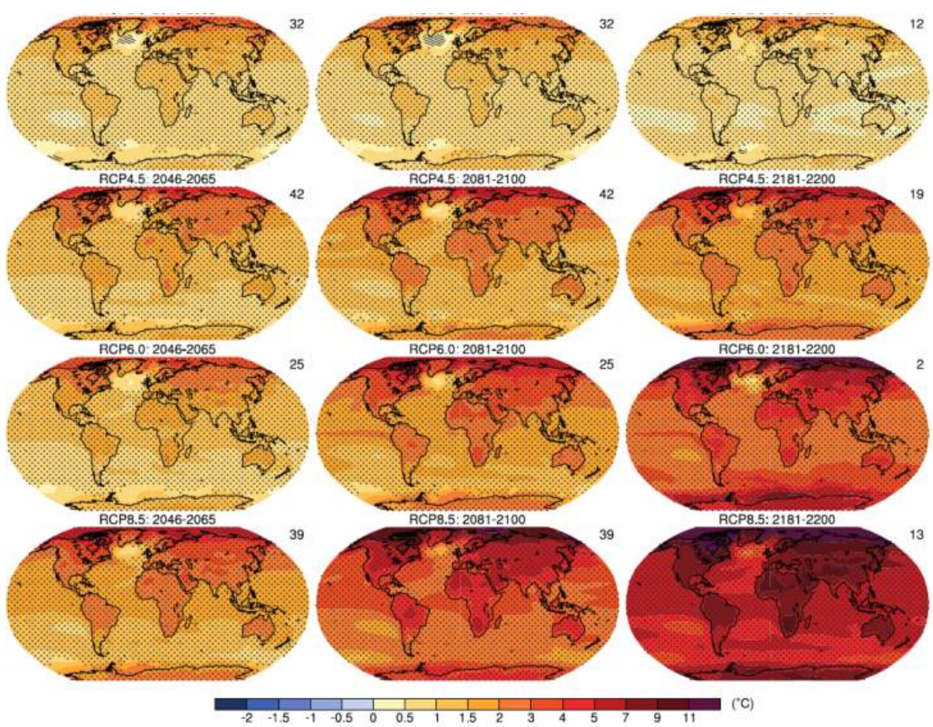
Tennessee Interfaith Power & Light
A Spiritual Response to Climate Change
www.tennipl.org tennesseeipl@gmail.com
PO Box 26313 Knoxville TN 37912

2019 IRP Comments
TN Interfaith Power & Light
Prepared by Louise Gorenflo
lgorenflo@gmail.com
March 28, 2018

The Paris Climate Agreement Scenario

The Paris Climate Agreement is founded on the goal of achieving the lower emission scenario of limiting global warming to 1.5° C, which depends upon limiting atmospheric carbon dioxide to 490 ppm (currently at 408.35 ppm.)

Among the four scenarios presented by the International Panel on Climate Change to the Paris Climate Agreement negotiation process, the lower emission scenario is the only one which offers the opportunity for civil society, civilization, and perhaps human survival to persist.

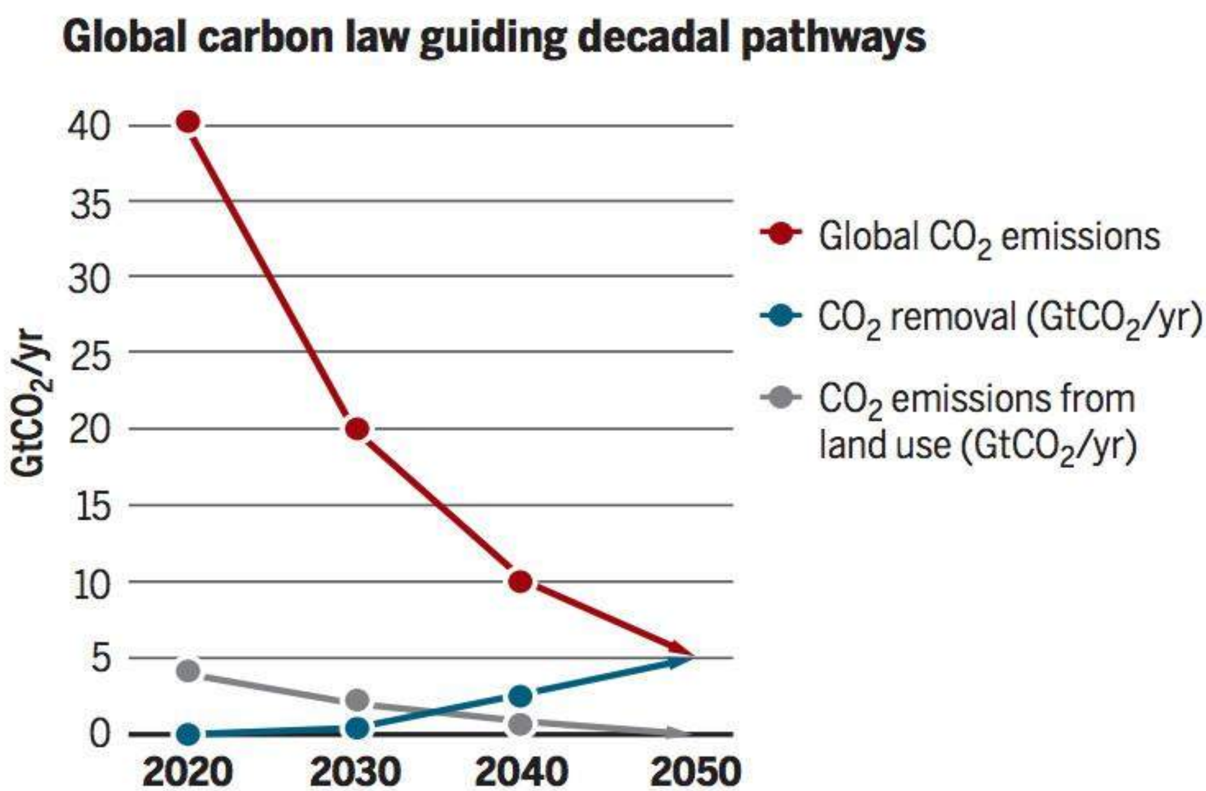


Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility.

The chart above depicts the four different scenarios: the lower emission scenario is the top row and the higher emission scenario is the bottom row. The color key represents the annual atmospheric degree temperature difference of projected from historic averages. Please note, that in every scenario other than the lower emission scenario, it is projected that the atmosphere is still warming by 2200.

These comments assume that TVA comprehends the profound wisdom of achieving the lower emission scenario and moves toward its achievement. The lower emission scenario requires the decarbonization of the global economy by 2050.

For TVA to be compliant with the Paris Climate agreement, TVA will need to adopt the goal of reducing its carbon emissions by half every decade: by 2030 TVA will have reduced by half its carbon emissions relative to its 2005 baseline. This carbon reduction requirement applies both its TVA power generating assets and the corporate carbon emissions as a whole.



TVA is well on its way to achieving the 2030 reduction goal for its generating assets. The Paris Climate Agreement uses 2005 as the baseline year. In that year, TVA plants emitted 105,590,306 T of carbon emissions. In 2016, those emissions were reduced to 69,256,411 tons. TVA's 2030 goal for its generating assets is 52,795,153 T. By closing more fossil-fueled generating units, TVA can easily reach that goal.

However, within the IRP, TVA will also need to plan to reducing its emissions by half again by 2040 and by half again by 2050. This will result in stranded assets, yet TVA in the previous IRP's chose centralized production over energy efficiency and renewable energy. It was the wrong path for TVA to have stubbornly taken, as its remaining fossil-fueled units will need to be shut down by 2050.

Beyond the emissions of its fossil-fuel generating assets, TVA needs to account for its operational emissions: asset maintenance, buildings, transportation, supplies, security, communications, services, and more. Only TVA can determine that value. Yet those emissions are also subject to the necessity to reduce them by half every decade. The Greenhouse Gas Protocol, in partnership with World Resources Institute, has established a comprehensive global standardized framework to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. This accounting should appear within this IRP.

Another condition to which TVA will become subject is a carbon tax. The shadow price that TVA uses in its modeling will need to include a variety of ranges. An ever increasing carbon tax will further depress TVA electric sales. There is a growing consensus that in the 2020's, carbon pricing across the world must expand to cover all GHG emissions, starting at $50/MT at least and exceeding $400/MT by mid-century.

A sufficiently robust carbon tax that will drive down carbon emissions to achieve the lower emission scenario will increase the cost of electricity. This higher cost will further depress electricity sales as consumers find ways to reduce their exposure to carbon-intensive products. These alternatives will include more renewable generation.

It would be wise for TVA to get as far ahead of this curve as fast as it can.

Finally, we urge TVA to assess its plans through an equity lens. The following questions need to be answered in such an investment:

- What are the IRP's intended equitable outcomes within the TVA service and what indicators will be used to measure the results?
- What are the intended equitable outcomes expected within TVA through the IRP and what performance measures will monitor the success of your proposal?
- What are the racial and income disparities demographics of those living within the TVA service area and who will be impacted by the adopted IRP scenario?
- What performance/service level data does TVA have available for the development of the scenarios?
- If there are data gaps, what additional data would be helpful in analyzing the scenarios and how can you obtain it?
- What actions has TVA taken in the past that disproportionately harmed communities of color and lower income households?

- Will any historical disparities /impacts be a determining factor in the ability to benefit from this IRP process? What are such examples?
- How will the IRP recommended scenario increase or decrease equity among communities of color and income? Identify any identified tradeoffs.
- How will equity impacts and performance be documented, evaluated, and reported? What methodologies will TVA use?
- What are our messages and communications strategies that will help advance equity?
- How will you continue to partner and deepen relationships with communities of color and lower income to make sure the TVA planning scenario if working and sustainable over time?

May TVA benefit all.

Name: Elroy Griffin

Comments: The system capacity could be expanded more quickly if TVA would provide greater incentive to residential power consumers to install solar power systems on their homes. Currently the rate that TVA buys back surplus power produced by solar is not equal to the billing rate they charge for the same kwh. Please make the buy back rate equal to the billing rate.

close window

From: Hall2052 .
To: Integrated Resource Plan
Subject: solar power with TVA
Date: Wednesday, March 7, 2018 11:47:25 PM

TVA External Message. Please use caution when opening.

TVA has a tremendous history throughout its 7 state service area and was one of the original groundbreakers in rural electrification bring power not just to industrial users, but to homeowners throughout the region, including my own grandparents. I was proud that TVA pioneered in nuclear power generation in the late 60s and 70s.

I was pleased to know TVA participated in the programs to promote independent power generation by homeowners who installed PV systems for their own homes. It pleases me, even more, to know this venerable utility is moving toward adding solar PV generation capacity on a utility scale. We know the PV cells are reliable since they have powered our space program since its inception.

People tend to think we don't have enough sun exposure here in the Tennessee Valley; however, if northern European countries such as Germany can generate enough power to replace their nuclear reactors, there is no valid reason why we here in the southeastern United States could not do the same. After all, Solar PV cells were an American invention.

Follow the money. How many homes could be powered with the capacity that could be put in place for the cost of just one nuclear reactor? This doesn't even begin to factor in the cost of disposal of the spent fuel. There should be no reason we could not build reactors that would "burn" that spent fuel if we changed the approach to nuclear generation for that matter; those reactors could also be made fail-safe if they were re-designed. However, changing the existing designs would cost many millions of dollars, while the cost of solar cells is now well under $2 per watt!

True, there is the problem of storage for night time and cloudy periods; however, with battery technology improving, and with Elon Musk working on utility-scale batteries, this problem is being resolved. There are other ways of storing the heat energy for later generation use as well.

I encourage the leadership of this great organization to lead the charge into the green energy future for American utilities!

Blessings & Peace,
Greg

From: Higdon, Matthew Stephen
To: Pilakowski, Ashley Anne
Subject: FW: IRP PLAN
Date: Wednesday, April 4, 2018 10:12:00 AM

IRP scoping comment?

-----Original Message-----
From: Annekhardin [mailto:annekhardin@yahoo.com]
Sent: Wednesday, April 04, 2018 7:06 AM
To: Higdon, Matthew Stephen
Subject: Fwd: IRP PLAN

TVA External Message. Please use caution when opening.

Begin forwarded message:

From: Annekhardin <annekhardin@yahoo.com>
Date: April 3, 2018 at 7:02:20 PM CDT
To: IRP@tva.gov
Subject: IRP PLAN

Dear TVA,

PLEASE Move quickly to shut down greenhouse gas emitting coal plants and replace them with clean, renewable energy sources such as solar and wind power. Give financial incentives to individuals, houses or worship, and businesses to install solar panels.

Life on earth as we know it depends on these important decisions. 99.5% of scientists cannot be wrong about the extreme threat of global warming. Do the right thing for our children's sake.

Thank you,
Anne K Hardin
St Augustines Episcopal community
Tennessee Interfaith Power and Light

From: Clyde Harrell
To: Integrated Resource Plan
Subject: Energy comments
Date: Tuesday, February 20, 2018 4:28:10 PM

TVA External Message. Please use caution when opening.

What I would like to see is investments in new environmentally friendly energy, maybe try to do solar and wind if possible. But stop using coal since it is a very dirty and nasty resource. Use more natural gas. At the same time try do more nuclear power. But at least stop using coal.

From: jay ecc
To: Integrated Resource Plan
Subject: TVA 2019 IRP
Date: Monday, March 26, 2018 9:54:53 AM

TVA External Message. Please use caution when opening.

Good morning!

PLEASE: MORE solar & wind power, MORE renewable energy, change fees & rate structures & policies to ENCOURAGE as much use of renewable energy as possible.

Thank you!

Peace & blessings,

Rev. Jay R. Hartley & the good people of Eastwood Christian Church (Disciples of Christ)
****
Rev. Jay R. Hartley
Eastwood Christian Church (Disciples of Christ)
1601 Eastland Avenue; Nashville, TN 37206
Phone: (615) 227-2285
Fax: (615) 228-4901
Email: jay_ecc@bellsouth.net (note the underscore)
Web: www.eastwoodchristianchurch.org

From: Brian Hartline
To: Integrated Resource Plan
Subject: TVA Letter
Date: Thursday, April 12, 2018 10:39:27 AM
Attachments: Letter for TVA.docx
Importance: High

TVA External Message. Please use caution when opening.

Hi,

I am Brian Hartline, from Hartline Supply, Inc. Please see the attached letter in regards to Red Hills Mine.

Thank you,

Brian C. Hartline
Hartline Supply, Inc.
(863) 425-6000

www.hartlinesupply.com

HARTLINE SUPPLY, INC.

ALABAMA SHOP PHYSICAL ADDRESS
2903 3RD AVENUE
JASPER, ALABAMA 35501
PHONE: 205-387-1343
FAX: 205-387-1343

CORPORATE ADDRESS
P.O. BOX 6836
LAKELAND, FLORIDA 33807
PHONE: 863-425-6000
FAX: 863-425-6020
EMAIL: curt@hartlinesupply.com
EMAIL: brian@hartlinesupply.com

WEBSITE: www.hartlinesupply.com

April 12, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, Hartline Supply, Inc. is a small business located in Jasper, Alabama. We have 2 employees at that location that service Red Hills Coal Mine. We are the only local business that services all their electrical cable repair and new sales needs. Red Hills Coal Mine is the main source of business for our Jasper, Alabama location.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

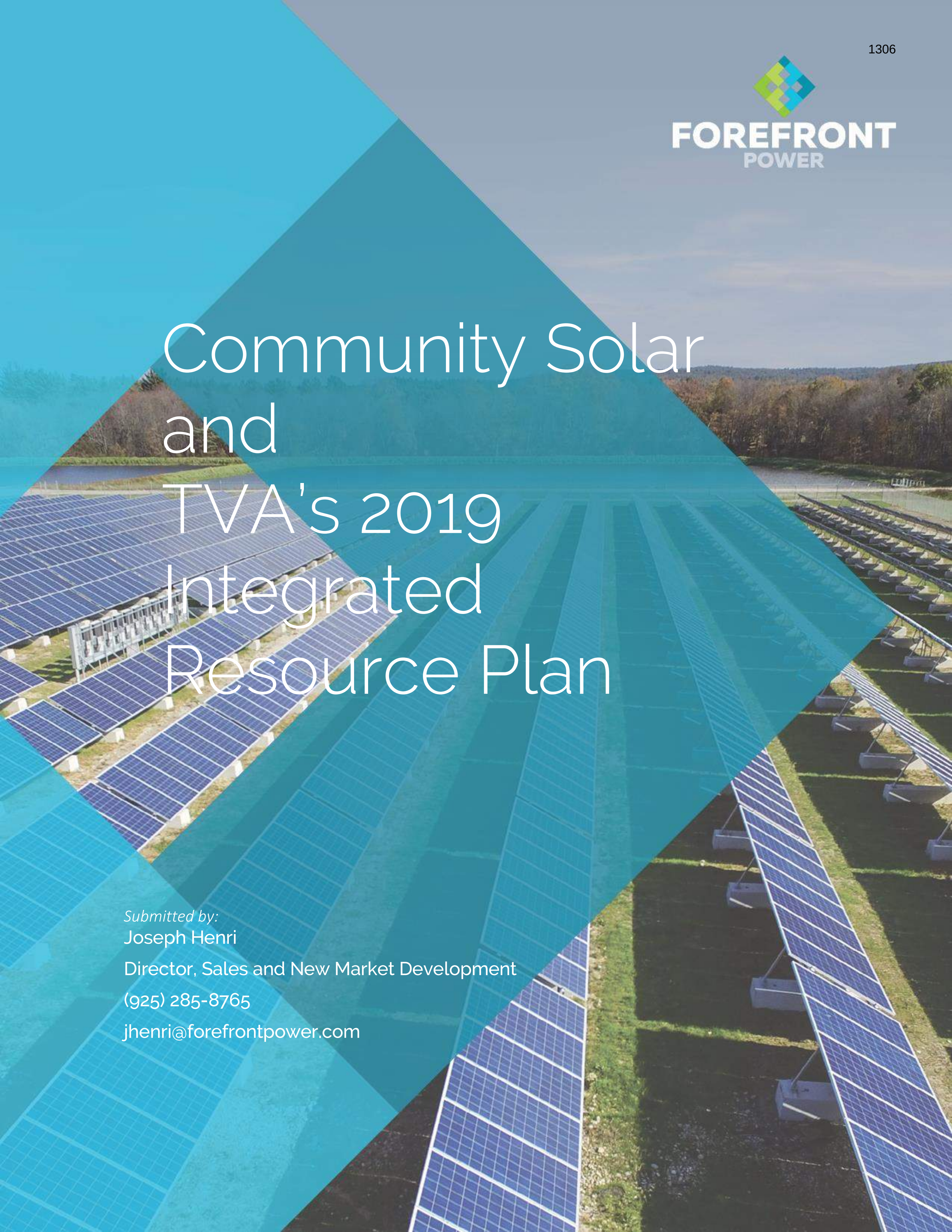
We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this region as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Brian C. Hartline
Hartline Supply, Inc.
President

CC: Curt Hartline / CEO



FOREFRONT POWER

Community Solar and TVA's 2019 Integrated Resource Plan

Submitted by:
Joseph Henri
Director, Sales and New Market Development
(925) 285-8765
jhenri@forefrontpower.com

ForeFront Power appreciates the opportunity to provide these brief comments on TVA's 2019 Integrated Resource Plan (IRP) and respectfully suggests that TVA take the opportunity to develop a robust Community Solar program that will spur economic development while providing low cost, clean energy to TVA customers.

Introduction to ForeFront Power

With over 800 MW of experience across more than 1,000 installations, ForeFront Power is an experienced solar developer. We possess more than a decade of renewable industry experience in executing behind-the-meter and Community Solar solutions for our utility, public sector, and commercial and industrial partners. Our team has been deeply involved in the development of nearly every solar market in the United States and ForeFront is currently developing Community Solar and other projects across the country.

As a wholly owned subsidiary of Mitsui & Co., Ltd., ForeFront takes a disciplined, pragmatic and customer-centric approach to solar development. ForeFront's strong financial relationships lead to power purchase and leasing arrangements that bring low-cost private capital to projects, allowing customers to gain the benefits of clean, low-cost energy without up-front investment.

ForeFront is a member of the Coalition for Community Solar Access[1] (CCSA) a national Coalition of businesses and non-profits working to expand energy independence, customer choice and access to solar for all American households and businesses through community solar. ForeFront and CCSA work with customers, utilities, local stakeholders, and policymakers to develop and implement policies and best practices that ensure community solar programs provide energy security, innovation and independence. CCSA member companies developed a Community Solar Policy Decision Matrix[2] that provides a thorough exploration of Community Solar program design issues.

What is Community Solar?

Community, or Shared, Solar is a voluntary program where a single solar electric system provides power and/or financial benefit to multiple community members. Community Solar has emerged in the past few years as an important complement to on-site and utility-scale solar projects because it allows participation and creates benefits for a wide cross-section of electric customers, particularly low- and moderate-income customers.

Community Solar provides economies of scale and optimal project siting in a location near the people and businesses it serves. In addition to the direct economic benefits of energy savings, community solar can provide economic development benefits by reinforcing local grids and attracting modern businesses with strong sustainability goals. Local, clean power generation creates energy security while demonstrating innovation and supporting a region's energy independence.

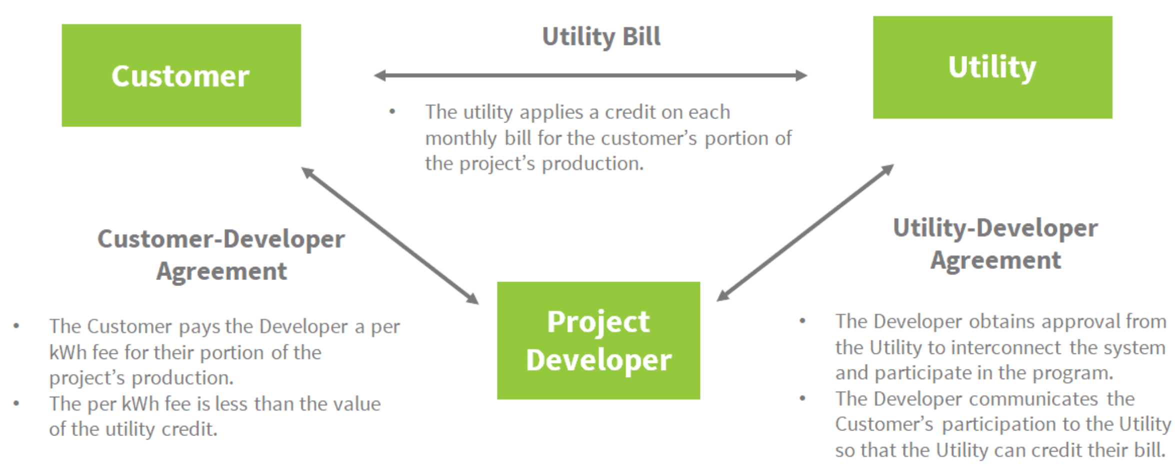
[1] http://www.communitysolaraccess.org/
[2] http://www.communitysolaraccess.org/wp-content/uploads/2017/12/Community-Solar-Policy-Decision-Matrix-2017.pdf

Ownership Models and Design Elements

Community Solar projects can be owned by utilities or third-party developers and can be located on public buildings, private land, brownfields, and other suitable areas. Capital costs of utility-owned projects are ratebased while third-party project developers provide their own financing and utilize the 30% Federal Investment Tax Credit (ITC). Costs of the two alternatives can be quite different but in either case they are recovered through customer rates.

There are many Community Solar program designs that vary by type of bill credit (usually kilowatt-hours or dollars), contract length, cost of participation and financing options, eligibility, number of participants allowed, and products offered (e.g., panels or generation). Typically, program participants who move within the same utility service territory or county retain their Community Solar share, but options for selling or donating program subscriptions can be designed into the program. Community Solar projects and programs can be designed with set-asides for low-income customers to ensure that all customers can receive program benefits.

Figure 1. How Community Solar Works Outside TVA—Third Party Developer Model



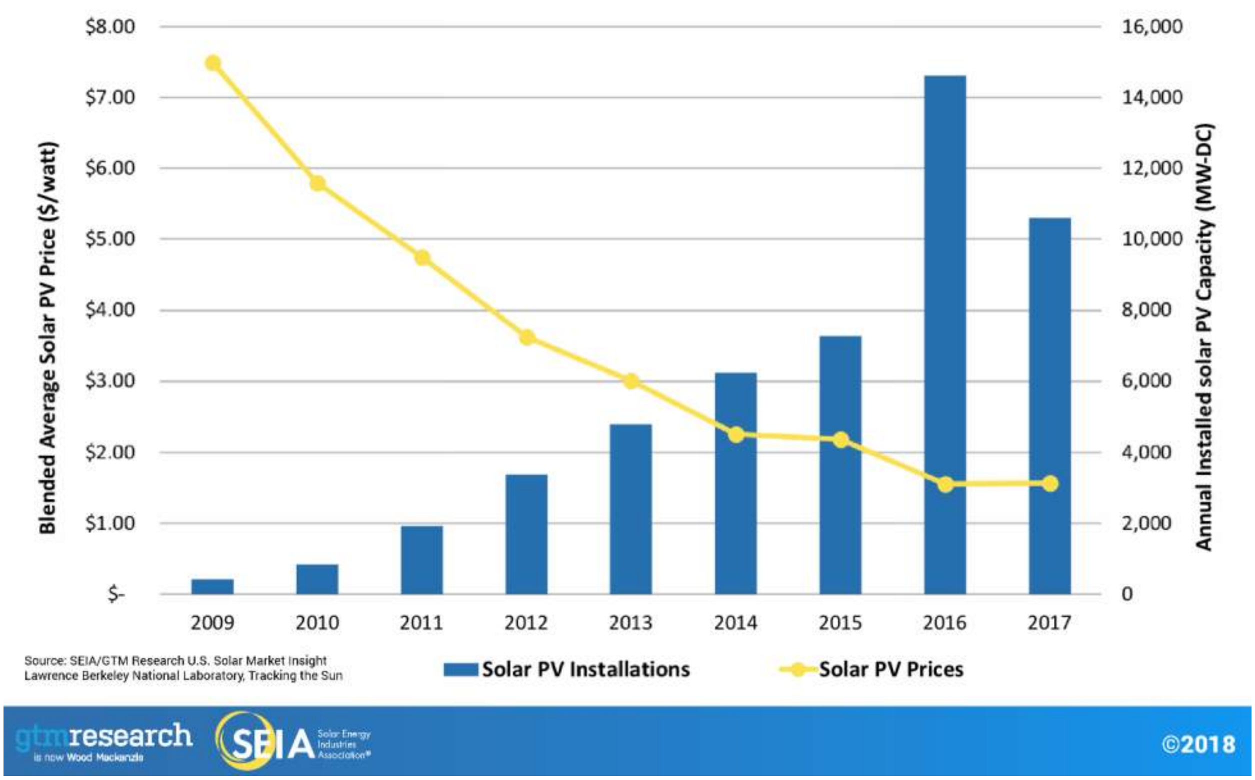
A key consideration in designing a community solar program is whether it will be a 'premium' product, like TVA's existing Green Power Switch, or a program that provides customer savings. Solar installation costs have declined over the past decade, particularly for large solar projects. Premiums were necessary in the past but modern solar projects now deliver peak power at prices competitive with, or cheaper than, natural gas peaking plants. Especially when the value of locational benefits, tradeable environmental attributes and economic development are factored into the value calculation, Community Solar energy can be delivered to program subscribers at a discount to their current electricity rate, rather than at a premium.

Community Solar Works

Photovoltaic (PV) solar has proved itself to be a clean, safe and reliable form of energy generation. The U.S. installed 10.6 gigawatts (GW) of solar PV capacity in 2017 to reach 53.3 gigawatts (GW) of total installed capacity, enough to power 10.1 million American homes. Total installed U.S. PV capacity is expected to more than double over the next five years, and by 2023, over 15 GW of PV capacity will be installed annually.[3] PV installation drives job growth, and there are nearly 250,000 Americans working in solar at more than 9,000 companies in every state across the U.S.

The tremendous growth in PV installations has led to dramatic cost declines—which have, in turn, spurred additional growth in installations. Since 2010, the cost to install solar has dropped by more than 70%.

Figure 2. PV Installations and Prices, 2009 - 2017[4]



Each year, utilities and businesses that once thought solar uncompetitive are finding it affordable and the savings compared to conventional generation or tariffed service very compelling.

Community Solar has evolved quickly, with programs springing up in municipal utilities, cooperatives and investor-owned utilities across the U.S. Sixteen states and Washington, D.C. have enacted key policies to enable community solar arrangements between community solar

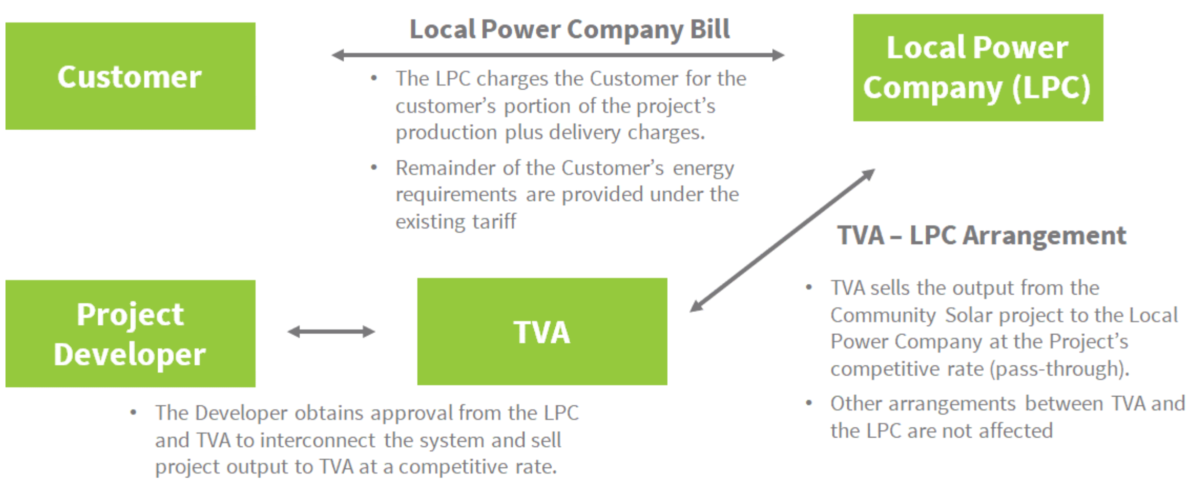
[3] https://www.seia.org/us-solar-market-insight; Updated March 15, 2018. Accessed April 4, 2018.
[4] https://www.seia.org/solar-industry-research-data. Accessed April 4, 2018

subscribing organizations and participating subscribers. Utilities across the country are implementing their own community solar programs[5]

One of the hallmarks of Community Solar is the fact that no two programs are identical. Different program models are required to meet the requirements of each new market. The TVA service territory covers 7 states and TVA serves 9 million people through 154 local power companies (LPCs). The region has distinct, rich history. Since 1933, TVA has had a proud tradition of embracing innovative generation technologies while delivering on its mission to foster economic development in the TVA services territory. A successful Community Solar program will be an innovation that must recognize and accommodate existing business arrangements as well as legal and regulatory requirements.

TVA's power supply contracts with its 154 LPCs require they purchase 100% of their energy from TVA. In addition, those contracts also require LPCs to restrict their retail customers from purchasing energy from third parties. These restrictions render the conventional Community Solar arrangements shown in Figure 1 unworkable. Fortunately, Community Solar is a concept that works best in cooperation with utilities and it can easily accommodate itself to the peculiarities of the TVA market.

Figure 3. A Model for Community Solar in TVA's Service Area



TVA is uniquely situated to provide critical oversight of Community Solar projects, such as assessment of project viability, interconnection, and a single, credit-worthy contracting party. In addition, TVA can provide important customer safeguards. Figure 3 illustrates the relationships between the Project Developer, TVA, the LPC and the Customer. This framework provides the

[5] http://www.communitysolaraccess.org/wp-content/uploads/2017/12/Community-Solar-Policy-Decision-Matrix-2017.pdf; accessed April 4, 2018. States with programs include California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New York, Oregon, Rhode Island, Vermont and Washington.

opportunity for the Project Developer to deploy third-party financing to build competitive solar generation, sell it under long-term contract to TVA, for an LPC's customers to receive the benefits of Community Solar and for the LPC to recover its costs associated with delivering the energy.

The distinguishing feature of this framework is the concept that TVA and the LPC pass through the Community Solar energy at the low, competitive rate offered by the solar Project Developer. LPCs would still maintain their direct customer relationships and recover their distribution costs just as they would on conventional generation provided by TVA. The value to customers would be reflected in the difference between the low cost of the solar generation and the higher cost of conventional TVA supplied power.

Economic Development Benefits of Community Solar

In addition to customer savings, a robust Community Solar program will deliver significant benefits regionally and locally. A well-designed and targeted program can reduce TVA's capital investment requirements, attract large commercial or industrial customers, and provide good local jobs.

Thoughtfully-sited solar generation can support local grids and reduce or defer transmission system investments. In regulatory proceedings across the United States, from New York, to Oregon, regulators are working to quantify the locational value of distributed energy resources such as solar. The question in those proceeding is not whether there's value, rather it's how much value should be attributed to the Community Solar and other distributed energy resource projects. Utilities such as Southern California Edison and ConEd, in Brooklyn, New York, have successfully turned to solar and energy storage for grid support[6].

Many communities in TVA's service territory are developing special economic development zones to attract new industries and jobs. TVA has played an important role in this process by offering special rates to large customers to encourage economic development. Firms are carefully evaluating incentives and many other factors before they make the decision on where to site their business. Amazon's "HQ-2" process is a well-publicized example of the vetting a firm does in evaluating future sites. While Amazon's specific evaluation criteria aren't public knowledge, it is public knowledge that Amazon is the second largest corporate renewable purchaser in the U.S., behind Google and just ahead of Microsoft.[7]

It's not just data centers and software companies who are purchasing renewable energy. The U.S. Department of Defense, Wal-Mart Stores, Dow Chemical, Kaiser Permanente, Proctor and Gamble, General Motors and Toyota are all examples of major U.S. organizations from every sector of the

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[6] *See SCE's Locational Capacity Requirements (LCR) Program* https://www.sce.com/wps/portal/home/procurement/solicitations/lcr/!ut/p/b1/hc_LDoIwEAXQb3HBUnq1KOCuBsXi-xWxGwMGKwlSgyjx70XDxsTH7GZy7mSGCOITkQa3WAZ5rNIgefaivfO4wxqu0eRYexSMwjGc9RjDvlGCbQnwpRj-5TdE_CRmqwINy2UDvgSHObLBu7NFz17Z1DJpBWwXvYE3BXdXcwpO55gsWbkI7Qr8ONIjQiYqfD28ZWlILUlEFh2iLMr0a1aOj3l-vnQ0aCiKQpdKySTS9-qk4VPkqC458d8lOZ98xLwuwntRewAMcBF7/dl4/d5/L2dBISEvZ0FBIS9nQSEh/
See ConEd's Non-wires solutions https://www.coned.com/en/about-con-edison/media/news/20170628/con-edison-eying-more-neighborhoods-energy-savings-grid-support
[7] https://www.blog.google/topics/environment/meeting-our-match-buying-100-percent-renewable-energy/ Accessed April 5, 2018

economy who have made significant purchases of renewable energy. Not only are these companies purchasing renewable energy for their own use, they are requiring their supply chains to also utilize renewable energy. The auto industry, in particular, has adopted aggressive renewable energy and carbon goals as they continue to develop an electric fleet.

One of the important criteria these desireable companies use in evaluating their renewable energy investment is the concept of "additionality"—the ability to demonstrate that through their efforts renewable generation has been added to the grid, displacing conventional fossil-fired generation. While TVA can be justifiably proud that its generation fleet has a relatively low carbon footprint, TVA's low-carbon generation was built many decades ago when TVA installed its vast network of hydroelectric and flood-control dams early in the 20th Century. Likewise, TVA's fleet of nuclear power plants emits no carbon but companies using TVA power aren't displacing any fossil generation and can't claim additionality.

Community Solar provides an option for large commercial or industrial firms to be an anchor-tenant in a community-based solar facility, providing firms with the means to meet their sustainability targets within the existing TVA-LPC contractual framework and bring economic development benefits to the region.

In addition to attracting new businesses, Community Solar projects encourage economic development through job training, employment opportunities and support for local businesses during construction. While a one-off project may provide benefits for limited time, a multi-year program ensures a pipeline of projects, continued employment, and the development of local infrastructure that in turn reduces project costs and leads to more development. Similar to the housing industry, no single project lasts very long but the pipeline of projects provides good jobs and ancillary benefits for local businesses who provide direct or indirect services.

Benefits for Low- and Moderate-Income (LMI) Customers

TVA's Extreme Energy Makeover is an excellent example of a program designed to provide long-term benefits for customers in the lowest income brackets. Unfortunately, programs like these tend to reach a limited number of households and they have a limited life—TVA's Extreme Energy Makeover program, for instance, ended in September 2017 after reaching 3,420 homes[8].

One important factor behind the rapid growth in Community Solar is the ability to reserve portions of this low-cost solar capacity for groups who can't typically participate in solar. LMI electric customers who rent or live in multi-family units don't have access to clean solar power. Accordingly, every state that encourages community solar also provides incentives or set-asides for the benefit of LMI customers, so they can benefit from the long-term access to reduced electricity costs and the quality of life improvements that come with being able to use heat in the winter and cooling during the summer. Community Solar can empower communities by targeting benefits directly to those customers who most need the help.

[8] https://www.publicpower.org/periodical/article/real-choices-real-savings-keeping-lights-low-income-customers; accessed April 4, 2018

Conclusion

TVA's 2019 IRP is an important opportunity to reflect on what has worked well during TVA's long history and to anticipate necessary changes. Community Solar has emerged as a tested and reliable model that makes business sense and encourages economic development. Community Solar is flexible enough to accommodate TVA's legal, regulatory and contractual requirements while delivering benefits directly to low- and moderate-income customers. ForeFront Power encourages TVA to incorporate a significant Community Solar program into its planning process and deliver the benefits of clean, community-based electric generation that fosters innovation and energy security while meeting customer desires for energy independence.

For questions, comments or additional information please contact:

Joseph Henri
Director, Sales and New Market Development
ForeFront Power, LLC
100 Montgomery Street, Suite 725
San Francisco, CA 94104
(925) 285-8765
jhenri@forefrontpower.com

Name: Chase Hively

Comments: TVA operates numerous coal-fired power plants and will likely continue to do so for the foreseeable future. Fly Ash produced as a by-product of burning coal is a critically important resource for the ready mix concrete industry, as well as related concrete production industries. As recent events in Tennessee and elsewhere have demonstrated the fly ash produced by the production of electricity through the burning of coal places significant liability on the operators of such power plants, and can become a significant financial liability to the operators and by extension to the rate-payers who use this electricity. The historical methods of landfilling coal combustion byproducts have proven to create significant and ongoing environmental concerns for both the power plants and surrounding communities.

TVA should move quickly to embrace existing technology that allows landfilled (either dry or wet) fly ash to be beneficiated and sold to industry. While not all landfilled fly ash can be beneficiated and sold as a commercial product, a significant portion of such landfilled fly ash can be recovered and sold to industry. This permanently reduces the need to landfill and manage fly ash while improving the quality of the construction in which such fly ash is utilized. In addition, some beneficiation process can be used to treat both landfilled fly ash as well as the fly ash resulting from current electricity production. In these cases, the cost of landfilling fly ash is avoided on the front end and revenue can be realized to offset any additional cost related to the specific beneficiation process.

The concrete industry is currently facing persistent and recurring shortages of commercial grade fly ash even in areas such as Tennessee where much of our electricity is produced from burning coal. This is due primarily to the variability in the fly ash that results from current operational practices utilities employ as they produce electricity. This type of variability can be addressed by various beneficiation processes that are already commercially available in the marketplace.

A key factor here is that commercial grade fly ash has a definitive market-value and a well-established market demand throughout the Southeast. The ongoing need for such fly ash is real and well recognized within the concrete industry where fly ash has become a critical component in the production of everyday commercial concrete as well as high-performance concrete for tall buildings, bridges and other structures that utilize concrete. TVA should recognize and embrace their responsibility to better manage fly ash produced at it's power plants by making this product available to industry as a first priority rather than using landfilling as the first option.

Landfilled fly ash represents an ongoing liability for utilities that is quite likely to grow over time and one that will never completely disappear. Employing technology to beneficiate fly ash and make it available to industry represents a permanent and responsible solution that creates an additional revenue stream for the utility and eliminates the creation of a lingering and potentially immense liability from landfilling fly ash.

TVA's future Integrated Resource Plan should recognize and immediately begin to implement the existing technology described above. This clearly meets the objectives outlined in the request for comments on the 2019 IRP as shown below:

The 2019 IRP will consider many views of the future to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Valley over the next 20 years. As part of the IRP decision-making process, and in alignment with the National Environmental Policy Act (NEPA), TVA will analyze potential environmental implications associated with an updated IRP by issuing an environmental impact statement (EIS).

Implementing a long-term strategy to beneficiate currently produced fly ash and to recover (where feasible) landfilled fly ash meets every criteria listed above:

1. Beneficiated fly ash is commercially viable product with a demand that extends at least 20 years into the future and can help reduce the cost of electricity produced by TVA.

2. Diverting fly ash to beneficial industrial use that safely incorporates the fly ash into the

product (like concrete) is a far preferable method for TVA to demonstrate environmental stewardship.

3. A steady, consistent source of fly will allow concrete producers to provide higher-quality, lower cost concrete for construction that will aid in economic development for the communities served by TVA.

4. Employing technology to reduce existing stocks of landfilled fly ash while potentially eliminating the need for future landfilling with fly ash is a crystal-clear environmental benefit as compared to the current practices, and will lower TVA's environmental

close window

Graham, Cierra

From: Michael Brannon Huddleston <forester.michaelh@gmail.com>
Sent: Sunday, April 15, 2018 10:57 PM
To: Integrated Resource Plan
Subject: irp comments

TVA External Message. Please use caution when opening.

TVA-you are NOT doing your job. your job is to produce CHEAP electricity. but you are not cheap.

your job is hydro-electric production and flood control. but you are NOT producing electricity at every dam and you are NOT building or improving dams and have NOT prevented floods in recent decades.

coal has been dirt cheap and the technology to produce clean cheap steam from coal, gas, wood chips, waste, etc exists but you are NOT doing that either and you are NOT reducing costs or charges to electric users as a result. modernize your coal and steam production and quit messing around with FAKE green energy like wind and solar.

europe has already tried that failed experiment along with biogas for 20 years and trapped itself messing up farming, the environment, the landscape, the economy, the geo politics of dependency on russian resources which is at the heart of the REAL anti-russian misdirected animus.

you need to help micro hydro and steam or gas producers design, locate, for self sufficiency and surplus production.

you have been one of the biggest land thieves in america. return the private lands to their rightful owners and where you have remaining lines pay those landowners annual leases for going over their land. CO LOCATE lines with other utilities and rights of ways and STOP carving up the landscape, causing visual damage, environmental damage, land use damage, magnetic field hazards, etc.

you also have to figure out how to run the nuclear plants with ZERO danger to anyone and total safe renewal or neutralization of nuclear waste. you also need to be turning coal - fire wastes into fertilizer.

your executive and all employee compensation need to be slashed.

ask in the strongest possible channels to the CONGRESS that created you to open the largest low sulphur coal field in america-2nd largest in the world to mining that was closed by clinton as a favor to whacko fake environmental groups and as a favor to the communist chinese for subsequent personal gain.

your job is cheap clean steam and water electricity. mbh

Michael B. Huddleston

3312 HWY 48

Cunningham, TN 37052

Forester.michaelh@gmail.com 931-387-2655

B.S. and M.S. Forestry, University of Tennessee

Retired Forester State of Tennessee, 30+ years service

Other National, International, Family Wood Supply Business, 9 years experience

Consultant, 4 years

Name: Kenneth Hyche

Comments: Please do not destroy renewable energy production. Make it easy for people to transition to renewable energy and do not put extra cost on consumers who chose to invest in renewable.
Thanks
Ken Hyche

close window

From:	rene.hypes@dcr.virginia.gov on behalf of nhreview, rr
To:	Integrated Resource Plan
Cc:	eir@deq.virginia.gov
Subject:	Tennessee Valley Authority Environmental Impact Statement for 2019 Update to the Integrated Resource Plan
Date:	Monday, April 16, 2018 6:40:43 PM
Attachments:	75416, EIS for 2019 Update to the TVA Integrated Resource Plan.pdf

TVA External Message. Please use caution when opening.

Ms. Pilakowski,

Please find attached the DCR-DNH comments for the above referenced project. The comments are in PDF format and can be printed for your records. Also species rank information is available at http://www.dcr.virginia.gov/natural-heritage/help.shtml for your reference.

Thank you for the opportunity to comment on this project.

S. Rene' Hypes
Project Review Coordinator
Department of Conservation and Recreation
Division of Natural Heritage
600 East Main Street, 24th Floor
Richmond, Virginia 23219
804-371-2708 (phone)
804-371-2674 (fax)
rene.hypes@dcr.virginia.gov

Conserving VA's Biodiversity through Inventory, Protection and Stewardship
http://www.dcr.virginia.gov/natural-heritage/

Matthew J. Strickler
Secretary of Natural Resources

Clyde E. Cristman
Director

COMMONWEALTH of VIRGINIA
DEPARTMENT OF CONSERVATION AND RECREATION

Rochelle Altholz
Deputy Director of Administration and Finance

Russell W. Baxter
Deputy Director of Dam Safety & Floodplain Management and Soil & Water Conservation

Thomas L. Smith
Deputy Director of Operations

April 16, 2018

Ashley Pilakowski, NEPA
Compliance Specialist, 400 West
Summit Hill Dr., WT 11D, Knoxville,
TN 37902–1499

Re: Tennessee Valley Authority Environmental Impact Statement for 2019 Update to the Integrated Resource Plan

Dear Ms. Pilakowski:

The Department of Conservation and Recreation's Division of Natural Heritage's (DCR) mission is conserving Virginia's biodiversity through inventory, protection, and stewardship. Natural heritage resources are defined as the habitat of rare, threatened, or endangered plant and animal species, unique or exemplary natural communities, and significant geologic formations.

According to the information currently in our files, natural heritage resources and State Natural Area Preserves are documented in the Tennessee Valley Authority Service area outlined on the scoping notice map. As resource management recommendations and specific projects are developed, DCR recommends coordination with this office for updated natural heritage information and determination of potential impacts to natural heritage resources.

Under a Memorandum of Agreement established between the Virginia Department of Agriculture and Consumer Services (VDACS) and the DCR, DCR represents VDACS in comments regarding potential impacts on state-listed threatened and endangered plant and insect species.

New and updated information is continually added to Biotics. Please re-submit a completed order form and project map for an update on this natural heritage information if the scope of the project changes and/or six months has passed before it is utilized.

The Virginia Department of Game and Inland Fisheries (VDGIF) maintains a database of wildlife locations, including threatened and endangered species, trout streams, and anadromous fish waters that may contain information not documented in this letter. Their database may be accessed from http://vafwis.org/fwis/ or contact Ernie Aschenbach at 804-367-2733 or Ernie.Aschenbach@dgif.virginia.gov.

Should you have any questions or concerns, feel free to contact me at (804) 692-0984. Thank you for the opportunity to comment on this project.

Sincerely,

S. René Hypes
Project Review Coordinator

CC: DEQ Office of Environmental Impact Review, DEQ-EIR

From: joanne irvin
To: Integrated Resource Plan
Subject: Solar panels, wind turbines
Date: Tuesday, March 13, 2018 9:48:08 AM

TVA External Message. Please use caution when opening.

I strongly encourage TVA to support and sponsor the sustainable energies of wind and solar. I am delighted with my solar panels and plan to add more to accommodate an electric vehicle. These sustainable, reusable energies are vital to us reducing our carbon footprint and protecting the environment. I was so impressed with your earlier sponsorship of solar panel additions and energy reduction/conservation. I have been disappointed by the seeming reversal of policy in the last year. Change is stressful, but change is coming. The emphasis on solar and wind energy is growing. I strongly recommend that you support it and change your business plan to embrace it.
Sent from my iPhone

From: J D
To: Integrated Resource Plan
Subject: 2019 integrated resource plan
Date: Sunday, March 25, 2018 2:29:28 PM

TVA External Message. Please use caution when opening.

I would like for tva to replace the Tennessee coal plants in the next 4 or 5 years with wind and solar energy. Thank you

Name: James Jerkins

Comments: In the next 20 years the population of the Tennessee Valley will continue the recent trends of both economic and population growth. This will result in increases in residential and commercial power consumption. Similar increases in both population and energy demand are happening globally. As a result, non-renewable sources are rapidly becoming scarcer and more expensive to acquire. In addition, energy generation from non-renewable sources such as fossil fuels are causing significant damage to the earth witnessed in the TVA region by increasingly variable weather patterns and severe weather events. Therefore, TVA should accelerate the adoption of non-renewable energy sources and the strategic planning required to generate, purchase, and distribute renewable energy from sources such as solar, wind, and hydro. Concurrently, TVA should implement, internally and externally through partnerships, research programs into energy distribution technology. It is well known that the nation's electrical infrastructure is not well suited for the demands of 21st century. Cyberphysical threats, an increasingly expensive to maintain distribution system, and antiquated practices for managing demand are all barriers to supporting economic prosperity in the Tennessee Valley. Additionally, the widespread adoption of energy efficient goods will continue to place pressure on the cost structure of generating and distributing power. TVA must become a leader in research into distribution and management of power systems by harnessing the latest technological achievements in battery chemistry, material science, and renewable energy policy. Finally, economic and social opportunity are closely aligned with costs for essential services and goods. When the cost of living outpaces the earning power of citizens, the resulting struggle to make ends meet impairs social mobility, economic opportunity, and the general well-being of a region's population. TVA should actively seek ways to lower the cost of generating and distributing power by sponsoring research and innovation within the TVA ecosystem and through public-private partnerships. By proactively investing in the development of future technologies for renewable power generation and distribution, TVA will empower the Tennessee Valley's economic growth and serve its residents with abundant, low cost power for residential and commercial use.

close window

Name: Lyndon Johnson

Comments: I'd like to see more encouragement of solar energy for TVA's service area, to include residential power production and localized solar generation that serves whole neighborhoods or cities. Also, I would like to see TVA do more to encourage installation of efficient lighting, building materials, and appliances. TVA has displayed a disappointing attitude toward this kind of environmentally responsible power policies in recent years, and if it fails to bring itself into the 21st Century on these matters, I'm prepared to vote for candidates who will seek to eliminate TVA's defacto monopoly on electricity sales in my state.

close window

Name: Robert Johnson

Comments: The current TVA Green Power Providers program seems counter-intuitive to moving toward providing reasonable cost electricity in an environmentally responsible manner. TVA is asking people to accept payment for solar generated electricity at a value below retail rate and lock that rate in for twenty years. Everyone knows that electricity rate will increase but the amount TVA purchases power from these solar owners stay constant. This is just unreasonable. It is time TVA joined the majority of America and most of the developed world and offer a netmetering program, using a bi-directional meter, exchange 1 kWh for 1 KWh where the customer receives credits against future usage.

close window

From: Jack Keeling
To: Integrated Resource Plan
Subject: 2019 Integrated Resource Plan
Date: Thursday, February 15, 2018 10:26:32 AM

TVA External Message. Please use caution when opening.

It is useless at this point, with the administration planning to sell the TVA, to prepare this document. Money would be better spent developing a plan for selling TVA resources, or incorporating the power generation and transmission assets of TVA into a private corporation secured by selling stock in the corporation.

Jack R. Keeling

From: Cathy Koczaja
To: Integrated Resource Plan
Subject: IRP
Date: Wednesday, March 7, 2018 3:21:04 PM

TVA External Message. Please use caution when opening.

I am writing to express my support for greener solutions to energy production, most particularly solar generation and encouraging energy efficiency.

I appreciate the option for public comment and I truly hope that TVA hears what its consumers are asking for. Overall I am discouraged by the lack of oversight of the organization and don't know that you'll hear me, but I'll try...

We need more solar. Period.

I am troubled by TVA's distinct lack of support (and, more appropriately but sadly, discouraging tactics toward) the solar industry and independent solar generators. As a consumer I want my energy supplier to be fair and balanced and the current TVA policies are anything but. I am also troubled by the proposed changes to the rate structures that dramatically limit the value-added benefits of energy efficiency improvements through increased meter rates and decreased per KWh billing. This not only discourages energy efficient measures that can dramatically decrease greenhouse gases but also hurts the poorer consumers who would otherwise be able to decrease their bills by not using as much energy.

In short I hope that TVA shows more solar support, has lower meter rates as opposed to low KWh rates, and generally supports citizen choice and flexibility in energy generation and consumption.

Please allow us the options that help the environment and support our values by encouraging and allowing for solar and other energy-efficient measures to have a place in TVA's structure. It really DOES matter.

Thank you,

Catherine

Name: Bill Kornrich

Comments: I understand that TVA will not enter into the world of solar and wind powered electricity generation. I find this difficult to believe.
Although the moral and planetary imperative (not polluting our world more than needs be with fossil fuels) should be enough, investing in wind and/or solar power has significant economic advantages in terms of creating jobs in a future-based economy.
The reduction in fossil fuel emissions from fossil fuel production and burning will improve peoples' health, especially in communities located close to source of emissions.

Look, why prop up a dying industry? Invest in a brighter more sustainable future. China is doing it. Europe is doing it. Australia is doing it. Very smart of them. Very stupid of TVA.

close window

From: Fritz Kruger
To: Integrated Resource Plan
Cc: Sara King
Subject: Comments related to Red Hills Coal Mine
Date: Monday, April 16, 2018 3:36:08 PM
Attachments: Letter to TVA in Support of Red Hills Coal Mine.pdf
Importance: High

TVA External Message. Please use caution when opening.

Please find attached our comments related to the Red Hills Coal Mine.

Fritz Kruger
FlowTech Fueling
Senior Sales Representative
92 Robinson Road
Moorcroft, WY 82721
cell: 307-696-9754
fax: 307-756-9873

April 16, 2018

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, FlowTech Fueling, LLC is a small business located near Moorcroft, Wyoming in northeast Wyoming. We are a company that supplies fueling equipment for heavy mining equipment used at the Red Hills Coal Mine. Our business employs 7 people. As you can see by our physical location, the Red Hills Coal Mine not only has an impact on their local economy with the employment of local people, local purchase of service and goods, and providing a large tax base, but also has a far-reaching business impact across the United States.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid.

We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Fritz Kruger

FlowTech Fueling, LLC
Senior Sales Representative
92 Robinson Road
Moorcroft, Wyoming 82721

April 13, 2018

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

Thompson Machinery is a full service Caterpillar Dealer that services northern Mississippi and western and middle Tennessee. We have over 600 employees company wide. Our store in Columbus is the store with primary responsibility for supporting the Red Hills Mine. We employ over 50 people here and the Red Hills Mine accounts for over half of our parts and service sales. In addition, we also use our Memphis, Greenwood, Tupelo and Lavergne to support them. They have been our company's single largest parts and service customer for a number of years. So you can see that their economic impact spreads throughout the TVA footprint. They are a pleasure to work for.
We would like for you to consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further than the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. Maximum utilization of the Red Hills Power plant means more socio-economic and economic benefit to many businesses, people, and organizations .
They offer you a low-risk, environmentally responsible, reliable, fuel source that can be counted on as the backbone to a successful power grid. We hope you will consider it as such. The TVA has built a reputation for its low-cost, environmentally responsible, reliable, domestic energy. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. Thank you for receiving these comments.

Respectfully submitted,

Steve Lawrence
Thompson Machinery, MS Region Product Support Manager
901-569-3121

From: Madison Coburn
To: Integrated Resource Plan
Cc: John Brunini; McGrew, Rebecca; Trouart, Joel
Subject: MLMC 2019 IRP Comment Submission
Date: Monday, April 16, 2018 7:05:27 PM
Attachments: MLMC Comment 4.16.18.pdf
MLMC Cover Letter 4.16.18.pdf

TVA External Message. Please use caution when opening.

To whom it concerns:

Attached to this email, please find a Cover Letter and Official Comment submitted on behalf of the Mississippi Lignite Mining Company ("MLMC"). Thank you for your consideration of MLMC's Comment in this matter. MLMC looks forward to meaningful participation in the 2019 TVA IRP process.

Best personal regards,

Madison Coburn

Madison E. Coburn
Butler Snow LLP

D: (601) 985-4490 | F: (601) 985-4500
1020 Highland Colony Parkway, Suite 1400, Ridgeland, MS 39157
P.O. Box 6010, Ridgeland, MS 39158-6010
Madison.Coburn@butlersnow.com | vCard | Bio

Twitter | LinkedIn | Facebook | YouTube

MISSISSIPPI LIGNITE MINING COMPANY

April 16, 2018

Ms. Ashley Pilakowski
NEPA Proejct Manager
Tennessee Valley Authority
400 West Summit Dr., WT 11D
Knoxville, TN 37902

Dear Ms. Pliakowski,

The Mississippi Lignite Mining Company ("MLMC") submits the attached comment as its official comment in response to TVA's Notice of Intent to update and replace its 2015 Integrated Resource Plan ("IRP") and the associated Environmental Impact Statement ("EIS"). MLMC owns and operates a surface mine located in Ackerman, Choctaw County, Mississippi, known as the Red Hills Mine. The output of lignite from the Red Hills Mine is dedicated to the neighboring Red Hills Power Plant, which is a coal-fired generating plant owned by Southern Company. TVA purchases power from Red Hills under a Power Purchase Agreement, which extends through 2032.

MLMC requests that, as part of its EIS process, TVA consider dispatching the Red Hills Power Plant as a baseload facility in TVA's power system. MLMC's attached comment demonstrates that the Red Hills Power Plant and the Red Hills Mine, together referred to as the Red Hills Project, are uniquely capable of helping TVA fulfill its statutory purpose and its three-fold mission to provide clean, low-cost energy, maintain environmental sustainability, and support economic development.

In addition to providing TVA with a broad spectrum of information that it should consider in this EIS process, MLMC's comment also addresses certain questions on which TVA has invited comment for the 2019 IRP:

1. Should the diversity of the current power generation mix change?
2. How should energy efficiency and demand response be considered in planning for future energy needs, and how can TVA directly affect electricity usage by consumers?
3. How will the resource decisions affect reliability, dispatchabilty, and cost of electricity?

Section 2.0 of MLMC's comment focuses on future energy needs and energy portfolio strategies and demonstrates the benefits that utilizing the Red Hills Power Plant as a baseload facility would provide TVA's customers. MLMC's comment also addresses other important concepts that TVA should consider as part of this EIS process, including environmental stewardship and economic development.

Thank you for your consideration of MLMC's comment in this matter and we look forward to meaningful participation in this process. Should you have any questions regarding this or any other related matter, please do not hesitate to contact me.

Sincerely,

David P. Liffrig
President

Mississippi Lignite Mining Company

Mississippi Lignite Mining Company
2019 IRP Official Comment
April 16, 2018

Mississippi Lignite Mining Company

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NorthAmerican Coal Corporation
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1.0 INTRODUCTION

The Mississippi Lignite Mining Company ("MLMC"), a subsidiary of The North American Coal Corporation, submits this comment ("MLMC'S Comment") in response to the Tennessee Valley Authority's ("TVA") notice of intent to update and replace its 2015 Integrated Resource Plan ("IRP") and the associated Supplemental Environmental Impact Statement ("EIS"). MLMC is the owner and operator of a surface mine located in Ackerman, Choctaw County, Mississippi and known as the Red Hills Mine. The output of lignite from the Red Hills Mine is dedicated to the adjacent Red Hills Power Plant (hereinafter Red Hills Mine, together with Red Hills Power Plant, shall be referred to as the "Red Hills Project"), which is a coal-fired generating plant owned by Southern Company utilizing two circulating fluidized bed boilers with limestone injection, feeding a single steam turbine with a net output of 440 MW of electricity.[1] TVA purchases power from Red Hills under a Power Purchase Agreement extending through 2032.

The purpose of MLMC's Comment is to demonstrate that the Red Hills Project is uniquely aligned with the mission of TVA and the broad goals, objectives and policies that TVA has implemented for more than eight decades. This special alignment between the mission and goals of TVA and the Red Hills Project provides a solid foundation for TVA to justify an increase in the utilization of the Red Hills Power Plant by dispatching it as a baseload facility in TVA's power system.

1.1 Tennessee Valley Authority

The TVA was created by the Tennessee Valley Authority Act of 1933 "to improve navigability and to provide for the flood control of the Tennessee River; to provide for reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for agricultural and industrial development of said valley … and for other purposes."[2] TVA's mission is three-fold:

1. To provide clean, reliable, low cost **energy**;
2. To maintain **environmental sustainability** and provide good recreational opportunities for people in the Tennessee Valley; and
3. To diligently support **economic development** activities that draw new jobs and investment to the region, or help companies stay here and grow.[3]

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[1]This comment is submitted solely on behalf of MLMC. The information contained herein does not necessarily represent the position of Southern Company, the owner of the Red Hills Power Plant.
[2] 16 U.S.C. § 831 *et seq*.
[3] TVA.com, Mission in Motion, https://www.tva.com/Newsroom/News-Features/Our-Year-of-Achievement (last visited Mar. 14, 2018).

TVA's service footprint covers territory in seven (7) states, including 15,533 square miles in Mississippi.[4] TVA's revenues for Mississippi in 2017 totaled $1 billion—9.6% of total TVA operating revenue.[5] In addition to the provision of billions of kilowatt-hours to Mississippi customers, TVA manages numerous recreational sites and has invested millions of dollars in economic development in Mississippi.[6]

1.2 Utilizing Red Hills

In the development and implementation of the 2019 IRP and associated EIS, TVA should consider how the Red Hills Project satisfies the three key areas on which TVA's mission and purpose are focused: Energy, Environment, and Economic Development, as explained below.

1.2.1 Energy

With regard to energy, the Red Hills Project benefits TVA by providing a stable, low-cost and reliable source of power through a generating plant using locally-sourced lignite and by diversifying TVA's energy generation mix. TVA's own operating history evidences a need for flexibility and reliance upon stable, know-priced coal-fired generating capacity to offset unpredictable fluctuations in the cost of natural gas and other sources of power generation. Coal-fired generation plants, like Red Hills, provide TVA with a stable and reliably-priced source of power generation to diversify its portfolio to maintain low rates to customers in times of economic fluidity. Natural gas price forecasts are extremely volatile, subject to ever-changing market conditions. The Red Hills Project is the only mine-mouth coal plant in TVA's coal fleet, and its predictable energy prices under a power purchase agenda extending through 2032 serve to limit TVA's exposure to spikes in spot market coal and natural gas prices. In fact, purchasing power from Red Hills helps "TVA meet the demand for electricity in its service area and maintain reliable service to its customers." [7] Thus, maintaining capacity at coal-fired, mine-mouth generating plants like Red Hills best serves the public interest and satisfies TVA's energy mission by providing reliable, long-term fuel diversity and greater price stability. Section 2.0 of MLMC's Comment provides further detail on how the Red Hills Project achieves this critical component of TVA's mission.

1.2.2 Environment

Environmental sustainability and stewardship are important aspects of TVA's mission of service. The Red Hills Project provides remarkable – in fact, national award-winning – environmental benefits to its part of TVA's service area. Constructed and put into service in 1999, the Red Hills Power Plant utilizes state of the art circulating fluidized bed boilers and

[4] TVA IN MISSISSIPPI, FISCAL YEAR 2018 (OCTOBER 2016 – SEPTEMBER 2017), *available at* https://www.tva.com/About-TVA .
[5] *Id.*
[6] *Id.*
[7] TVA Red Hills Power Project, Record of Decision, 63 Fed. Reg. 44944, 44946 (Aug. 21, 1998).

NORTH AMERICAN COAL CORPORATION
Mississippi Lignite Mining Company

emission capture and control technology to reduce its impacts on air quality. A full environmental assessment of the Red Hills Project involves far more than evaluation of CO_2 emissions, water usage, and waste generation. In fact, and as set forth in subsequent sections of MLMC's Comment, the Red Hills Mine provides quantifiable and documented benefits in emission control, soils management, reforestation, and Native Grass re-establishment.

The Red Hills Mine is also committed to maintaining and improving water quality through diligent operational controls and stream reconstruction that has proven to leave the area's resources in a better condition than prior to mining. The Red Hills Mine is a leading environmental partner for TVA and the regional community, having reclaimed thousands of acres, over 10 miles of streams, and a 77-acre trophy bass lake resulting in improved agricultural, wildlife and recreational use in the local community. This is evidenced by the Red Hills Mine winning three (3) national awards for community outreach and reclamation efforts. Specifically, in 2006, the Red Hills Mine won the United States Department of Interior's Office of Surface Mining Excellence in Surface Coal Mining Reclamation Award[8] for its mining and accompanying reforestation reclamation efforts. In 2009, it won the U.S. Department of Interior Office of Surface Mining Reclamation and Enforcement ("OSMRE") Good Neighbor Award[9] and, in 2014, the Red Hills Mine again won the OSMRE Excellence in Surface Coal Mining Reclamation Award for its distinction in stream reclamation. Without question, the Red Hills Project fulfills the principles of environmental stewardship and sustainability announced in TVA's mission and the TVA Act. TVA should consider environmental metrics beyond CO_2 emissions, water usage, and waste generation, such as the Red Hills Project's environmental benefits, when developing scorecard metrics.

1.2.3 Economic Development

Finally, as initially set forth in the TVA's Record of Decision supporting the purchase of power from the Red Hills Power Plant, the local socioeconomic benefit as a result of the Red Hills Project has been and is overwhelming.[10] In a region of Mississippi with relatively small economic development opportunities, the Red Hills Project provides employment to 200 individuals.

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[8] "The Excellence in Surface Coal Mining Reclamation Awards are presented to coal mining companies that achieve the most exemplary coal mine reclamation in the nation. Past winners have demonstrated a commitment to sound mining practices and effective reclamation plans that enhanced beneficial post-mining use of the land. OSMRE has honored high quality coal mine land reclamation since 1986. All winning projects go beyond reclamation requirements to achieve superior results in returning a site to productive use after completion of mining." Excellence in Surface Coal Mining Reclamation Awards Winners, Active Mine Awards, https://www.osmre.gov/programs/awards/ActiveWinners.shtm (last visited Mar. 15, 2018).

[9] "Good Neighbor Awards are given to mine operators for successfully working with the surrounding land owners and the community while completing mining and reclamation. Nominations for this category should briefly describe the mining and reclamation operation (using both narrative and photos), and include testimonial letters and/or other documentation of a successful good neighbor policy." *Id.*

[10] 63 Fed. Reg. at 44946.

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As evidenced in this Introduction, the Red Hills Project is an important partner to TVA in accomplishing its mission in this service area: energy, environmental sustainability and economic development. As a coal-fired generating plant, the Red Hills Project provides TVA with a reliable and stable source of power that best serves its customers through the diversification of TVA's energy generation portfolio, which lowers costs. Red Hills has a proven track record of environmental sustainability through its provision of nationally acclaimed reclamation at the Red Hills Mine, which has fostered the development of pristine lands primed for agricultural, wildlife and recreational activities. Finally, the socio-economic impact of Red Hills to this region cannot be underestimated. As detailed in Section 4 of this Comment, the Red Hills Mine is an economic engine that generates over $2 million in annual state and local taxes, over $24 million in annual personal income, and provides a nearly $50 million annual contribution to Mississippi's annual gross domestic product.[11] The Red Hills Project is tangible evidence of the positive socioeconomic impact TVA can have when it fulfills its statutory purpose and its stated mission regarding economic development. For these reasons and those to follow, during the course of studying and subsequent implementation of the 2019 IRP and corresponding EIS, TVA should heavily consider utilizing the Red Hills Power Plant as a baseload power plant.

2.0 ENERGY

2.1 Resource Planning/Portfolio Development

The first aspect of TVA's three-fold mission is to provide clean, reliable energy at a low cost. As part of the TVA IRP EIS process, TVA considers future demand and how to meet such demand with its current portfolio of generating assets and potential new generating assets. Thus, resource planning and portfolio development are crucial to TVA's ability to satisfy its energy mission.

In past TVA IRP processes, TVA has evaluated portfolio and strategy metrics with a trade-off analysis that focuses on many factors, including cost, financial risks, environmental impacts and other risks and aspects of TVA's overall mission. A study of the TVA resource planning metrics shows that "ranking metrics" rates four key components including: Present Value Revenue Requirements ("PVRR") , Short-Term Rate Impact, PVRR Risk/Benefit, and PVRR Risk. Additionally, it indicates that "strategic metrics" rates Environmental Stewardship (CO_2 Footprint, Water, Waste) and Economic Impact (Total Employment, and Growth in Personal Income).[12] When evaluating the Red Hills Project against with the "Energy Supply" criteria, the Red Hills Project ranks high due to elimination of issues and risk associated with PVRR, Short-Term Rate Impact, PVRR Risk/Benefit, and PVRR Risk because it is purchased power and because of the long-term nature of the fuel supply contract between the Red Hills

[11] NSPARC, Mississippi State University, Red Hills Coal Mine: An Economic Engine for Choctaw County and the Surrounding Region (2018).
[12] Exploring Least-Regrets Resource Planning: A Forum on Modeling for Long-Range Power Supply Studies, April 16, 2014, TVA 2015 Integrated Resource Plan.

Mississippi Lignite Mining Company

Mine and the Red Hills Power Plant. In addition, the Environmental Stewardship evaluation of CO_2, Water, and Waste is extremely limited in scope because it does not take into consideration the environmental benefits of the coal mine reclamation components, as detailed below in the 3.0 Environmental section, and it does not take into account the full recognition of what is “Environmental Stewardship”.

Finally, the Strategic Metrics includes Economic Impact such as total employment and growth in personal income. A socioeconomic study of the Red Hills Mine, as discussed later in section 4.0 and as attached, indicates that employment in Choctaw County has increased since the opening of the mine, and that personal income growth has increased by 23% in Choctaw County versus 7.2% in the region, since the opening of the mine. ***The EIS should consider the benefits of purchased power as a low-risk option to TVA. In addition, the EIS should consider the environmental benefits of the coal mine reclamation and stewardship of the land that is stated in section 3.0 in this document. Further, the EIS should also consider the role that the Red Hills mine plays in the increased total employment and growth in personal income in the area***.

When fully considered, the Red Hills Project is extremely additive in this analysis, as it benefits TVA by providing a stable, low-cost and reliable source of power from a generating plant that uses locally-sourced lignite, while also diversifying TVA’s energy generation mix. Economic conditions in the local region surrounding the Red Hills Project epitomize the economy of the TVA service area, which has historically been more dependent on manufacturing than the U.S. as a whole. Initially, high energy demand manufacturing was drawn to the region because of the availability of natural resources and reliable, inexpensive electricity.[13] The Red Hills Project provides critical fuel diversity to support TVA’s dual-peaking system with high demand occurring in both the summer and winter months.

In efforts to support the dual-peaking system, TVA’s reserve capacity planned margin is 15% above peak load and is applied during both the summer and winter seasons.[14] Such generating supply comes from a diverse portfolio of coal, nuclear, hydroelectric, natural gas, and renewable resources as well as market purchases designed to provide reliable, low-cost power and minimize the risk of disproportionate reliance on any one type of resource.[15] TVA’s 2014 resource mix is shown below:[16]

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[13] *See* TVA, 2015 Integrated Resource Plan, p.26, https://www.tva.com/Environment/Environmental-Stewardship/Integrated-Resource-Plan/2015-Integrated-Resource-Plan (last visited Apr. 2, 2018).
[14] *Id*. at 33.
[15] *Id*. at 32.
[16] *See* TVA, 2015 Integrated Resource Plan, https://www.tva.com/Environment/Environmental-Stewardship/Integrated-Resource-Plan/2015-Integrated-Resource-Plan (last visited Apr. 2, 2018)(2014 data). *See Our Power System*, TVA, https://www.tva.gov/Energy/Our-Power-System (last visited Apr. 16, 2018)(2018 and 2027 data).

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TVA ENERGY RESOURCE MIX			
	2014 (%)	2018 (%)	2027 (%)
COAL	44	26	22
NATURAL GAS	9	20	19
NUCLEAR	38	40	43
HYDROELECTRIC	9	10	10
RENEWABLES	< 1	3	5
ENERGY EFFICIENCY	N/A	1	1
PURCHASED POWER	18,740 GWh	N/A	N/A

The average age of TVA's coal fleet is 52 years and most coal-fired plants will soon be reaching their useful life. No new coal plants are planned. The Red Hills Power Plant is 16 years old and can provide diversity to TVA's energy mix and dampen the effects of fluctuating energy prices of other sources for years to come. It is MLMC's understanding that the Red Hills Power Plant's life extends to 2045.

As a coal-fired generation plant with a dedicated, adjacent lignite mining operation, the Red Hills Project provides TVA with the most reliable and predictably-priced source of energy to meet demand during peak seasons and support its reserve capacity. ***Accordingly, TVA should dispatch the Red Hills Power Plant as a baseload facility because it supports the following critical elements of a portfolio planning strategy, which are discussed in more detail below:***

1. Diversity;
2. Reliability;
3. Environmental stewardship; and
4. Cost.

2.2 Key Components of a Portfolio and Dispatch Strategy

2.2.1 Diversity

TVA's 2011 and 2015 IRP both concluded that a diverse portfolio is still the best way to deliver low-cost, reliable electricity to those it serves.[17] Thus, TVA's decision to maintain, increase or eliminate fuel diversity has long-term ramifications on its ability to supply low-cost, reliable energy in peak seasons and during adverse weather events. The state of the current U.S. electrical grid coupled with recent weather events supports TVA's mission statement to provide diversity in its energy generation portfolio.

[17] *See supra*, n. 2.

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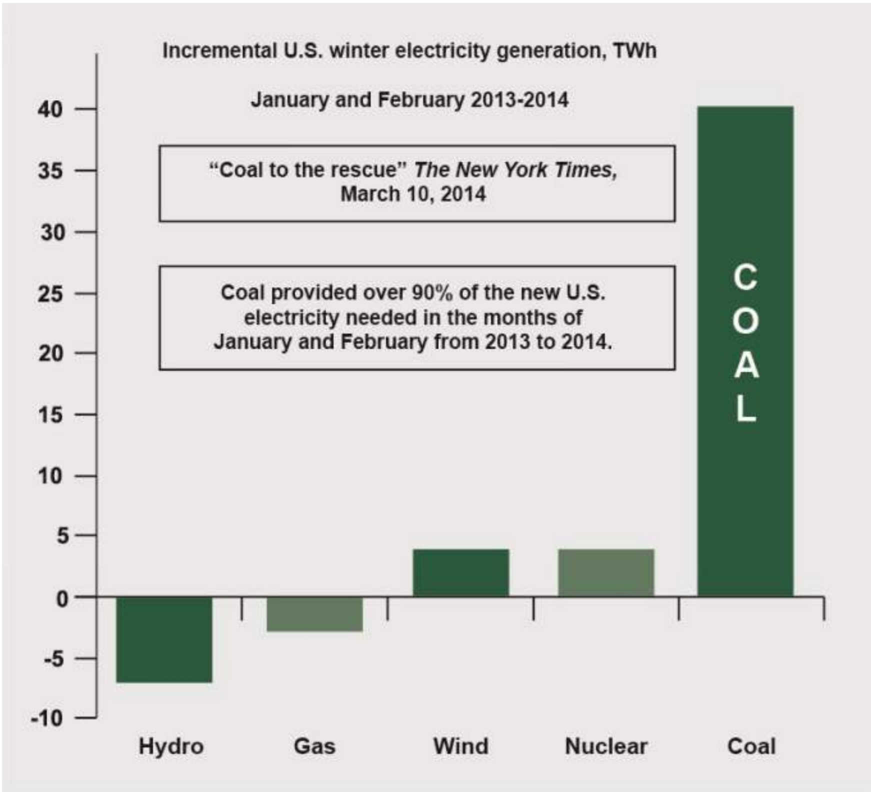
Concerns about the reliability and resiliency of the U.S. electric power system are being voiced more frequently with the continued retirement of coal-fired power plants and older gas-fired power plants, extreme polar vortex weather events, and the recent "bomb cyclone" in the Northeast.[18] "Electric grid operators reported that coal use soared during the cold snap in the Midwest and East Coast, showing the importance of fuel diversity."[19] Additionally, Assistant U.S. Energy Secretary Bruce Walker testified during a Senate Energy and Natural Resources Committee hearing: "What was apparent during this weather event [(the "bomb cyclone")] was the continued reliance on baseload generation and a diverse energy portfolio…."[20] The following chart[21] illustrates that during the Polar Vortex event of 2013, coal supplied 90% of the new electricity needed:

Incremental U.S. Winter Electricity Generation



[18] *See* Jude Clemente, Forbes, Coal Retirements Threaten U.S. Electric Grid Reliability and Resiliency (Mar. 18, 2018), https://www.forbes.com/sites/judeclemente/2018/03/18/coal-retirements-threaten-u-s-electric-grid-reliability-and-resiliency/#331f2285403e.
[19] *Id.*
[20] *Id.*
[21] *Id.* (citing U.S. Energy Information Administration, Electric Power Monthly, https://www.eia.gov/electricity/monthly/).

Baseload plants, including large coal-fired plants like the Red Hills Power Plant, have high-capacity factors and generate large amounts of energy for long periods of time. Thus, baseload generators are primarily used to meet continuous energy needs by operating constantly at full capacity. According to the North American Electric Reliability Corporation ("NERC"), conventional steam-driven generation resources have traditionally low forced hours and maintenance outage hours coupled with low exposure to fuel supply chain issues, which is one of the most fundamental necessities of an over-arching reliable bulk power system.[22] NERC's Key Findings in its Special Reliability Assessment, state that natural gas disruptions can have varying impacts on the ability of electric generating facilities operating on natural gas to produce needed power during summer or winter peak conditions, which would likely lead to some level of electric generation outages.[23]

For these reasons, TVA's 2019 EIS should evaluate the ability of TVA to supply fuel in critical weather events such as a heat wave during the peak of summer, polar vortex-type events, and adverse weather events in other regions of the U.S. that may pull resources, such as natural gas, away from the TVA service area and TVA energy suppliers. TVA's generation mix should include a prominent role for coal so that TVA can maintain fuel diversity. Dispatching power from the Red Hills Power Plant not only helps TVA maintain diversity in its generating mix, but – as explained in the following sections – it also meets other critical elements of a responsible portfolio and dispatch strategy, including reliability, environmental stewardship and cost.

2.2.2 Reliability

Not only does coal play a vital role in diversifying TVA's portfolio to accommodate peak seasons, it is an extremely reliable fuel source with little to no fuel delivery disruption that typically impacts other fuel sources. In a 2017 letter to the Federal Energy Regulatory Commission ("FERC"), Energy Secretary Perry confirmed the importance of traditional baseload generation with on-site fuel storage that can withstand major fuel disruptions caused by natural and man-made disasters.[24] For example, during the 2014 Polar Vortex that affected much of the eastern United States, there was record-high winter peak electric and natural gas demand for heating.[25] During the event, the regional electrical transmission organization that served 13 states and the District of Columbia faced a severe shortage of generation due to the high demand.[26] Such a loss of generation capacity could have proved devastating, except numerous coal plants that were scheduled for retirement were dispatched to meet the electricity demand.[27] Fortunately

[22] Department of Energy, Staff Report on Electricity Markets and Reliability (p. 5), *available at* https://www.scribd.com/document/357152575/Staff-Report-on-Electricity-Markets-and-Reliability (August 2017).
[23] NERC, Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System, *available at* http://www.nerc.com/pa/RAPA/ra/Reliability Assessments DL/NERC_SPOD_11142017_Final.pdf (November 2017).
[24] Letter from Rick Perry, U.S. Energy Secretary, to Neil Chatterjee, Chairman, FERC (Sept. 28, 2017).
[25] *Id.* at 3.
[26] *Id.*
[27] *Id.*

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although these coal fired plants were scheduled for retirement, they had not yet initiated the decommissioning process which would have rendered these plants unable to assist in this emergency shortage situation. Thus, thanks to the coal-fired generation plants and other traditional baseload generation sources like nuclear energy, the electric grid was able to remain resilient and provided the life-saving electrical capacity to meet the excessively high demand.[28]

In a more recent example, in late December of 2017 through early January of 2018, the northeastern United States experienced a "bomb cyclone" weather event that blanketed the area with extreme wintry weather. A recent report by the National Energy Technology Laboratory ("NETL"), a division of the U.S. Department of Energy, evaluated the impact of that weather event on the actual U.S. electricity market. NETL's report concluded:

> During the worst of the storm from January 5-6, 2018, actual U.S. electricity market experience demonstrated that without the resilience of coal- and fuel oil/dual-firing plants—its ability to add 24-hour baseload capacity—the eastern United States would have suffered severe electricity shortages, likely leading to widespread blackouts. Experience with such blackouts indicates the potentially enormous toll in both economic losses and human suffering associated with widespread lack of electricity…[29]

Yet, despite these recent experiences, Secretary Perry identified a troubling issue in his letter to FERC Chairman Chatterjee: from 2010 to 2015, over 50% of power plant retirements were coal-fired plants (over 37 GW) and between 2016 and 2020, an additional 17 GW are expected to be retired.[30] As a result, the shift to natural gas, solar and wind power as increased fuel sources to generate electricity increases the likelihood of exposing the U.S. electrical grid to generation shortages during future polar vortex-like events, or to extreme heat events such as the heat waves experienced in Tennessee in 2012 and 2015 which could prove disastrous without reliable coal-fired baseload capacity. While wind and solar resources produce renewable forms of energy, they have lower generation capacity in extreme weather conditions. In addition, natural gas has proven to be susceptible to supply shortages during adverse weather events as a result of the diversion of natural gas for home heating and away from electric generation.[31]

In contrast, coal remains one of the most stable, reliable and cost-effective sources of fuel for electricity generation. The Red Hills Project, for example, is a mine-mouth operation, where the coal mine is adjacent to the consuming power plant. The Red Hills Mine provides a readily available, physically-adjacent and extremely secure fuel supply for the Red Hills Power Plant. Proximity of the coal to the power plant obviates the need for expensive, long distance, disruption-susceptible third-party transportation, thereby eliminating the potential for supply (and resulting generation) disruption due to natural events like flooding of portions of lengthy

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[28] *Id.*

[29] Nat'l Energy Tech. Laboratory, Reliability, Resilience and the Oncoming Wave of Retiring Baseload Units, Volume 1: The Critical Role of Thermal Units During Extreme Weather Events 3 (Mar. 13, 2018).

[30] *Id.* at 2.

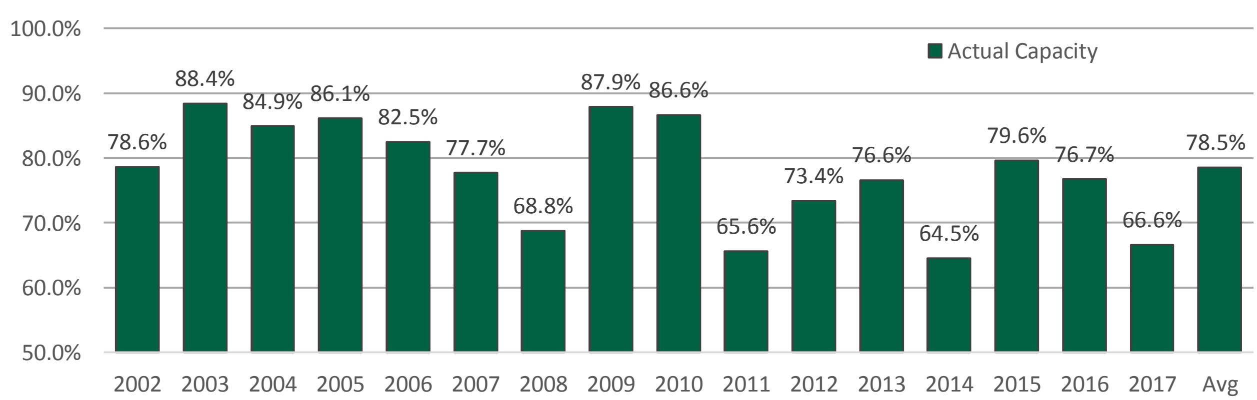
[31] *See supra* note 21 and accompanying text.

railways or actions of individuals, such as terrorism or vandalism, or geologic movements that impact natural gas pipelines.

In addition, the Red Hills Plant has a long-term Power Purchase Agreement with TVA (through 2032). Long-term power purchase agreements like these assure there will be no fuel delivery disruptions influenced by market upsets, alternative demands or short-term price spikes, such as the extreme natural gas price spikes experienced by the northeast during the recent "bomb cyclone." The long-term contract between the Red Hills Power Plant and TVA provides assurance against disruptions that would otherwise threaten TVA's ability to serve and sustain its customers. As such, the Red Hills Project offers TVA something unique and invaluable in its electricity generating portfolio - absolute fuel security. In addition, as previously discussed, the Red Hills Project ranks high in the Least-Regrets metrics due to elimination of issues and risk associated with PVRR, Short-Term Rate Impact, PVRR Risk/Benefit, and PVRR Risk because it is purchased power and because of the long-term nature of the fuel supply contract between the Red Hills Mine and the Red Hills Power Plant.

Another component of reliability is the actual, historical performance of a generating facility. Below is a table that shows historical capacity at the Red Hills Power Plant.

Red Hills Generating Station – Historical Capacity Trend



It is noteworthy that over the past few years, the Red Hills Power Plant has not met its anticipated annual capacity factor. In 2014, the Red Hills Power Plant planned a large outage in order to conduct maintenance and improvements designed to enhance plant reliability, increase efficiency, and address normal maintenance issues. After this outage was completed, plant capacity increased significantly. Then, for the first time, TVA began cycling the plant late in 2015. It has been documented that cycling coal-fired power plants introduces stresses that these plants are not designed to handle. In addition, cycling of coal fired units typically results in increased power generation costs due to increases in maintenance and overhaul capital expenditures and forced outage effects, including forced outage time, replacement energy, and capacity, as well as cost of increased unit heat rate.[32] As the challenges of low gas prices and subsidized, mandated, and/or reduced cost of intermittent renewables continue, coal units that were typically baseloaded, will experience repeated cycling. For instance, the policy-induced 6.6 GW solar growth in California between 2011 and 2017 has led to price collapses during daylight peak as well as induced cycling for California gas units and neighboring Desert Southwest coal units.[33]

The Red Hills Power Plant has met and exceeded its annual capacity factor in the past and with additional dispatch commitment from TVA, we believe that the facility will exceed its capacity in the future.

Due to the availability and stability of the fuel supply, it is clear that coal-fired generation plants provide TVA with a strong, reliable partner in meeting all types of electricity demands. ***Accordingly, in this EIS, TVA should strongly consider the Red Hills Project's on-site fuel supply of lignite coal and the benefits afforded by the long-term power purchase agreement between TVA and the Red Hills Power Plant. These features of the Red Hills Project are unique within TVA's portfolio. The Red Hills Project's absolute fuel security and reliability warrant a decision by TVA to dispatch the Red Hills Power Plant as a baseload facility***.

2.2.3 Environmental Stewardship

Without question, environmental stewardship and sustainably is an important component to TVA's portfolio planning strategy. The 2015 IRP process identified CO_2 emissions, water usage, and waste generation as the primary environmental metrics used to guide the EIS process. The Red Hills Project has demonstrated its commitment to the environment since its inception and continues to demonstrate regulatory compliance as well as compliance with the TVA Act. ***TVA should add a metric to account for how each project complies with TVA's congressionally mandated responsibilities including providing for reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for agricultural and industrial development of said valley, and for other purposes***. For a more detailed analysis on the environmental benefits and impacts of the Red Hills Project, please see Section 3.0.

2.2.4 Cost

Another factor for TVA to consider in its energy portfolio planning strategy is cost. ***In doing so, TVA must undertake the vital analysis of load forecasting, the accuracy of which is of great significance for the operation and managerial loading of TVA, which directly affects its consumers.*** Thus, key inputs to the load forecasts include: economic activity, customer

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[32] The Cost Associated with Cycling Coal Fired Powerplants, Coal Power Magazine, 206, p. 16-20. https://www.ipautah.com/assets/CyclingArticles.pdf (Last visited 4/4/18).

[33] *See Reliability, Resilience and the Oncoming Wave of Retiring Baseload Units*, NATIONAL ENERGY TECHNOLOGY LABORATORY, p. 26, https://www.netl.doe.gov/energy-analyses/temp/ReliabilityandtheOncomingWaveofRetiringBaseloadUnitsVolumeITheCriticalRoleofThermalUnits_031318.pdf (last visited Apr. 16, 2018).

retention, price of electricity, and price of substitute sources of energy, particularly natural gas and renewables, and the cost of subsidies associated with renewables which are ultimately borne by consumers in their taxes.

In the past, high natural gas prices, when compared to coal and nuclear fuel prices on a unit basis, have made natural gas-fired combined cycle plants a more expensive option for large continuous generation needs. Although current natural gas price predictions indicate gas prices will remain relatively low and stable, history typically is the best forecast tool and certainly should be considered when evaluating the future cost of natural gas. The table below shows the fluctuation in the cost of natural gas over the previous twenty years:

Henry Hub Natural Gas Spot Price (Dollars per Million Btu)[34]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	3.45	2.15	1.89	2.03	2.25	2.20	2.19	2.49	2.88	3.07	3.01	2.35
1998	2.09	2.23	2.24	2.43	2.14	2.17	2.17	1.85	2.02	1.91	2.12	1.72
1999	1.85	1.77	1.79	2.15	2.26	2.30	2.31	2.80	2.55	2.73	2.37	2.36
2000	2.42	2.66	2.79	3.04	3.59	4.29	3.99	4.43	5.06	5.02	5.52	8.90
2001	8.17	5.61	5.23	5.19	4.19	3.72	3.11	2.97	2.19	2.46	2.34	2.30
2002	2.32	2.32	3.03	3.43	3.50	3.26	2.99	3.09	3.55	4.13	4.04	4.74
2003	5.43	7.71	5.93	5.26	5.81	5.82	5.03	4.99	4.62	4.63	4.47	6.13
2004	6.14	5.37	5.39	5.71	6.33	6.27	5.93	5.41	5.15	6.35	6.17	6.58
2005	6.15	6.14	6.96	7.16	6.47	7.18	7.63	9.53	11.75	13.42	10.30	13.05
2006	8.69	7.54	6.89	7.16	6.25	6.21	6.17	7.14	4.90	5.85	7.41	6.73
2007	6.55	8.00	7.11	7.60	7.64	7.35	6.22	6.22	6.08	6.74	7.10	7.11
2008	7.99	8.54	9.41	10.18	11.27	12.69	11.09	8.26	7.67	6.74	6.68	5.82
2009	5.24	4.52	3.96	3.50	3.83	3.80	3.38	3.14	2.99	4.01	3.66	5.35
2010	5.83	5.32	4.29	4.03	4.14	4.80	4.63	4.32	3.89	3.43	3.71	4.25
2011	4.49	4.09	3.97	4.24	4.31	4.54	4.42	4.06	3.90	3.57	3.24	3.17
2012	2.67	2.51	2.17	1.95	2.43	2.46	2.95	2.84	2.85	3.32	3.54	3.34
2013	3.33	3.33	3.81	4.17	4.04	3.83	3.62	3.43	3.62	3.68	3.64	4.24
2014	4.71	6.00	4.90	4.66	4.58	4.59	4.05	3.91	3.92	3.78	4.12	3.48
2015	2.99	2.87	2.83	2.61	2.85	2.78	2.84	2.77	2.66	2.34	2.09	1.93
2016	2.28	1.99	1.73	1.92	1.92	2.59	2.82	2.82	2.99	2.98	2.55	3.59
2017	3.30	2.85	2.88	3.10	3.15	2.98	2.98	2.90	2.98	2.88	3.01	2.82
2018	3.87	2.67										

In addition, the development of LNG exports in the United States and the world, has introduced a new facet of price uncertainty in the natural gas market. In a 2017 Report, ICF

[34] U.S. ENERGY INFORMATION ADMINISTRATION, HENRY HUB NATURAL GAS SPOT PRICE, *available at* https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm (last visited Apr. 2, 2018).

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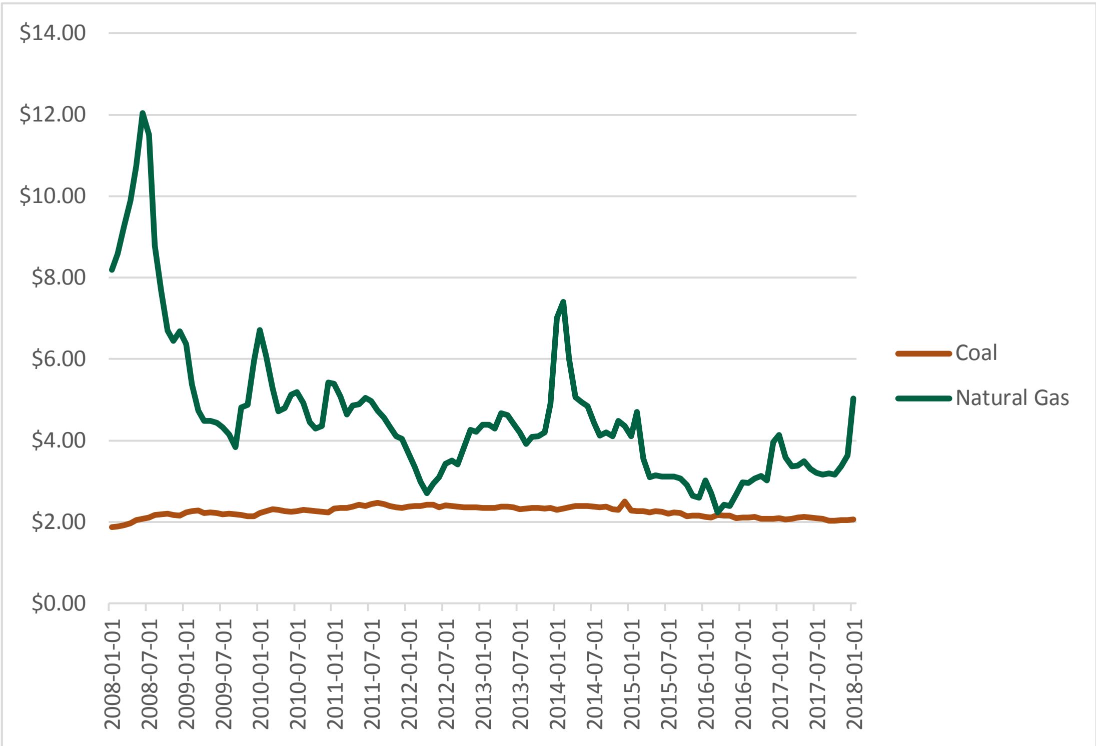
stated that "[u]ncertainty regarding world economic growth, government policies toward LNG imports and pricing, greenhouse gas (GHG) mitigation policies, subsidization policies for renewables, and development of the world's unconventional natural gas resources make LNG trade forecasting difficult."[35] EIA says, LNG "accounts for a growing share of world natural gas trade… World LNG trade more than doubles, from about 12 Tcf in 2012 to 29 Tcf in 2040. Most of the increase in liquefaction capacity occurs in Australia and North America."[36] The Energy Information Administration expects that U.S. LNG exports will exceed 3 billion cubic feet per day in 2018 and over 12 billion cubic feet per day by 2035.

In contrast, the price of coal has remained stable over that time frame, especially when compared to natural gas:

Summary of Coal Versus Natural Gas Prices[37]



As depicted above, natural gas prices have been volatile due to market activity and adverse weather events, while coal prices have remained steady over the same period of time.

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[35] ICF International, U.S. LNG Exports: Impacts on Energy Markets and the Economy, (2017) (citing ICF International, U.S. LNG Exports: Impacts on Energy Markets and the Economy, (2013), http://www.api.org/~/media/Files/Policy/LNG-Exports/API-LNG-Export-Report-by-ICF.pdf.)
[36] *Chapter 3: Natural Gas*, U.S. ENERGY INFORMATION ADMINISTRATION, p. 37, https://www.eia.gov/outlooks/ieo/pdf/nat_gas.pdf.
[37] *See generally supra*, n. 34.

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TVA places a high priority on providing low cost power to its customers. While low cost electricity is important to all of TVA's customers, it is especially important for low-income families. For example, one Texas study determined that low-income families spent over 16% of their after-tax income on energy-related expenditures.[38] Increasing the use of coal in TVA's generation mix provides stability and insurance against changing market conditions and fuels subject to such fluctuation, like natural gas. As discussed in Section 2.2.1, having a diversified portfolio with a prominent role for coal is critically important to TVA's ability to ensure that it can provide low cost electricity to its customers. In order to protect its customers from significant increases in the cost of power, especially its low-income family customers, TVA should expand its use of coal as a fuel source for its electrical generation needs.

Further, due to considerable subsidies for certain fuel sources like renewables, additional fuel price uncertainty exists because such subsidies could be decreased or altered. The following chart demonstrates that federal energy subsidies mask the true cost of many other energy sources:

Federal Energy Subsidies and Support FY 2013 ($mm)[39]

Energy Source	Direct Expenditures	Tax Expenditures	R&D Expenditures	Federal & RUS Electricity	Total
Coal	74	779	202	30	1,085
Oil & Gas*	3,178	2,250	34	-	5,462
Nuclear	37	1,109	406	109	1,661
Renewables	**8,365**	**5,454**	**1,050**	**176**	**15,045**
Biofuels	404	1,716	325	-	2,445
Geothermal	312	31	2	-	345
Hydropower	197	17	10	171	395
Solar	2,969	2,076	284	-	5,329
Wind	4,274	1,614	49	-	5,937
Other Renewables	209	-	380	5	594
End Use	**1,238**	**2,838**	**1,798**	**134**	**6,008**
Power Grid	8	211	831	134	1,184
Conservation	833	630	501	-	1,964
Other End Use	397	1,997	466	-	2,860
Total Federal Expense	**12,891**	**12,428**	**3,491**	**449**	**29,258**

Source: EIA, "Direct Federal Financial Interventions and Subsidies in Energy", March 2015
*Includes home heating subsidies for oil products under LIHEAP program

[38] *Energy Cost Impacts on Texas Families*, AMERICAN COALITION FOR CLEAN COAL ELECTRICITY (2016), http://www.americaspower.org/wp-content/uploads/2016/02/TEXAS-Trisko-one-pager-February-4-2016.pdf (citing Eugene M. Trisko, Energy Cost Impacts on Texas Families (Jan. 2016)).
[39] *See Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013*, U.S. ENERGY INFORMATION ADMINISTRATION (2015), https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

As reflected in the above chart, existing power markets are distorted by federal tax incentives and subsidies for renewables, which allow them to dispatch at artificially low prices (negative in some cases).

In order to ensure that it can continue providing reliable electricity at low costs, TVA must include coal as part of its generating mix because coal is less susceptible to price fluctuations that have historically occurred with natural gas and fluctuations that could occur with other energy sources if federal subsidies that artificially deflate their costs are decreased or removed. Depending on how TVA accounts for variable and fixed cost of generation sources, electricity generated at the Red Hills Power Plant may or may not currently be the least expensive electricity generated within TVA, and current cost is not the only consideration in portfolio planning. TVA should place a high priority on the price stability offered by electricity generated by the Red Hills Power Plant.

Currently, Red Hills' electricity is cost competitive and it provides TVA customers with insurance against market fluctuations that have historically affected other energy sources. TVA's long-term Power Purchase Agreement with the Red Hills Plant serves to reduce the uncertainty associated with an unknown price future to TVA's portfolio and its customer base. For these reasons, TVA should dispatch the Red Hills Power Plant as a baseload facility.

2.3 Conclusion

As set forth in the TVA Act, a major component of TVA's authority and purpose relates to improving the lives of residents of the TVA service area by providing low cost electricity. The Red Hills Project aligns with TVA's enabling legislation and its stated energy mission of providing reliable, affordable, sustainable energy to customers in its service area. As described above, the Red Hills Project addresses the critical elements of a portfolio planning strategy - diversity, reliability, environmental stewardship, and cost-effectiveness. By choosing to dispatch the Red Hills Power Plant as a baseload facility, TVA chooses to provide its customers with the most reliable source of electricity in extreme weather events and when demand is at its greatest. In addition, the Red Hills Project is protective of the environment, provides TVA with absolute fuel security, and protects its customer base from the risk of dramatic cost increases that are inherent in other fuel sources. No other asset in TVA's electricity generating portfolio provides this level of value to its customer base. ***Accordingly, in its IRP EIS, TVA should evaluate dispatching the Red Hills Power Plant as a baseload facility***.

3.0 ENVIRONMENTAL SUSTAINABILITY AND STEWARDSHIP

MLMC recognizes that the purpose of TVA's IRP EIS is to evaluate TVA's current energy portfolio and alternative future portfolios to ensure energy needs of the future are met, while accounting for TVA's three-fold mission. The comments provided in this section have been guided by the TVA's 2015 Supplemental EIS. The anticipated environmental impacts assessed by TVA in the 2015 EIS included air quality, water resources, land resources, and waste generation. MLMC requests the following items be considered as TVA drafts the 2019 EIS.

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3.1 Affected Environment and Environmental Impacts

3.1.1 Climate and Greenhouse Gasses

The 2015 Final Supplemental Environmental Impact Statement for TVA's Integrated Resource Plan included a discussion of greenhouse gas emissions and climate change (see Section 4.2, page 49, and Section 7.5.2, page 200). TVA determined that current climate models projected increases in temperatures across the South (see page 52). However, there is no discussion regarding the current and growing discrepancy between climate models used to make these projections, and real temperatures experienced over the past several years. For example, Figure 4-2 (graph showing regional average annual temperatures) must be updated with latest temperature data. It must also include a trend line with a much better correlation than the R^2 of 0.15 which the original graph had. We believe that a higher correlating trend line (possibly using a power or exponential equation) would indicate a slowing of temperature increases across the region over the past several years. ***The new EIS should include a discussion of flaws and shortcomings of these models, as well as how the most current temperature trend data does not indicate the increased rate of temperature increase that was projected just several years ago***.

TVA also projected that "there is a high degree of certainty that the heaviest precipitation events will increase everywhere and by large amounts" (see page 55). ***TVA should include a discussion of contrary valid modelling, as well as the lack of correlation between actual extreme precipitation events and climate models, in their new updated EIS. Failure to address the large uncertainty associated with future precipitation projections is a serious shortcoming because it could lead TVA to erroneously overestimate the value of hydropower assets in the future.***

TVA addressed projected reductions in CO_2 emissions from different scenarios described (see page 200). However, there was no discussion regarding the overall temperature impact that any reduction in CO_2 emissions from these scenarios would affect. ***TVA should also include an assessment of other greenhouse gasses emitted by their generation sources, namely methane. The assessment should include information about the relative global warming potential of methane and how emissions are projected to change due to an increasing reliance on natural gas fired generation***.

Finally, ***TVA should identify a range of temperature changes expected as a result of changes in greenhouse gas emissions under different scenarios. The expected temperature changes should be compared to errors in estimation.***

3.1.2 Water Resources

Chapter 4 of the 2015 EIS incorrectly states that mining is considered a non-point source of pollution and is not subject to government regulations. Instead, mining operations in the United States must apply for and receive National Pollutant Discharge Elimination System ("NPDES") permits prior to mining, in accordance with 40 CFR Part 434 of the Federal Regulations. In fact, all mine water discharges from the Red Hills Project are authorized by an

NPDES discharge permit. MLMC has never violated its NPDES discharge limitations and routine water quality sampling has shown a reduction in downstream sedimentation as a result of implementation of best management practices at the mine.

3.1.3 Land Resources

The 2015 EIS correctly states that natural gas and coal-fired generation sources have the smallest land use footprints per MWh. However, the EIS also states: "Despite the large land requirements of utility-scale solar facilities, which typically displace agricultural operations or other land use activities, the impacts of solar facilities on the land are low relative to other types of generating facilities. The construction of solar facilities typically does not require extensive excavation and solar facilities have little associated permanent or semi-permanent infrastructure that hinders restoration of the site after the facility is dismantled." In this context, TVA does not consider the "loss-of-use" of large tracts of land (27,000 – 62,200 acres) from solar generation as a long-term impact even though the contracts for these solar farms are typically long-term.

The 2015 EIS states that the Red Hills facility occupies about 320 acres and its fuel cycle disturbs about 275 acres/year which is equivalent to 0.09 acre/GWh energy generated. The number of annually disturbed acres estimated for fuel deliveries is incorrect. Normal mining operations disturb and subsequently reclaim approximately 100 acres/year which results in a net disturbance of zero acres. The only permanent disturbances at the Red Hills Mine are the constructed office facilities which will be reused once mining and reclamation activities are complete. The total number of disturbed acres is 1,560 and remains relatively constant from year to year which is equivalent to 0.02 acres/GWh. Once mining and reclamation activities are complete, there will be less than 20 disturbed acres associated with the building complex.

The 2015 EIS goes on to state that "[c]oal mining has the potential to adversely impact large areas, depending on the mining method."[40] TVA should recognize that surface mining impacts are temporal and can be mitigated via the reclamation process – just as those impacts to solar farms are mitigated once the project is completed. Since surface mining activities began at the Red Hills Mine in late 1998, MLMC has been implementing mining and reclamation techniques which have proven to be protective of the environment. These techniques and outcomes are described in Section 3.2 of this document.

3.1.4 Waste Generation

The 2015 EIS also states that "[c]oal plants produce large quantities of ash and, if equipped with FGD systems, calcium-based residues…Although some of these coal combustion residuals (CCRs) are recycled for a range of beneficial uses, large quantities are typically

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[40] TVA, 2015 Integrated Resource Plan, Final Supplemental Environmental Impact Statement, Volume I, p. 178, https://www.tva.com/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/TVA%20Final%20Integrated%20Resource%20Plan%20EIS%20Volume%201.pdf (last visited Apr. 16, 2018).

permanently stored in impoundments or landfills at or near coal plants."[41] In its EIS process, TVA should note that the Red Hills Mine beneficially re-uses 85-90% of the coal ash produced at the Red Hills Power Plant. Choctaw County is permitted to market the fly ash for sub-grade material for road construction and other land development and industrial projects. Red Hills' re-use of this ash is authorized by several Beneficial Use Permits on file with MDEQ. Finally, it should be noted that the Red Hills Generation facility relies on a permitted dry-ash storage system for any ash not beneficially used which is recognized as the least environmentally intrusive manner to store CCRs.

3.2 MLMC Specific Mitigation Measures

3.2.1 Soil Health

In Mississippi and throughout the Gulf states, most of the native soils associated with lignite deposits have inherent undesirable physical and/or chemical properties that limit plant growth and productivity, and which were exacerbated further by past abusive farming and timber management practices.

Sixty-six percent of the soils within the Red Hills Mine permit area are described as strongly acid sandy soils occurring on slopes ranging from 5% to 38%, which may have root penetration and water flow restrictions, and are described as having a severe erosion hazard.[42] These soils are highly weathered soils with high iron and aluminum oxide content and low nutrient content. Approximately 24% of the soils mapped in the permit area are moderately well drained soils with little clay or iron and aluminum and are classified as prime farmland soils by USDA.

Because of the abundance of soil with substandard chemical and physical traits, MLMC is approved to implement a topsoil replacement program at the Red Hills Mine except for soils which meet the Office of Surface Mining definition of prime farmland. On behalf of MLMC, Mississippi State University (MSU) conducted a three-year research study titled "Productivity of Native and Substitute Soils at Mississippi Lignite Mining Company's Red Hills Mine." The results indicate the oxidized overburden (the soil material immediately above the coal seam) will result in a plant growth medium equal to or better than the available predominant native soils, including the NRCS designated prime farmland soils, due to higher nutrient concentrations and overall better texture.

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[41] *Id.* at 180.

[42] *See Soil Survey of Choctaw County, Mississippi*, UNITED STATES DEPARTMENT OF AGRICULTURE (1986), https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/mississippi/MS019/0/choctaw.pdf (last visited Apr. 16, 2018).

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3.2.2 Reclamation Practices

European settlement began in Choctaw County in the early to mid-1800s. Timber was cleared, and years of unsustainable farming practices resulted in significant erosion and loss of topsoil. Prior to development of the Red Hills Mine, the predominant land use was transitioning to forestland due to the federal conservation programs designed to address marginal agriculture land.[43]

Mining and reclamation practices offer a unique opportunity to correct systemic soil health issues. The process of mining and reclamation can restore soils to a condition better than pre-mine conditions by carefully selecting materials with optimal characteristics (i.e. texture, oxidization state, etc.) for final reclamation. In addition to improvements to degraded pre-mine soils, Red Hills Mine salvages any soil OSM defines as prime farmland within the foot print of mining operations. These soils are returned to the post mine landscape and are subject to more restrictive post-mine production standards.

MLMC has been working with the NRCS to implement a multi-phase plan for mapping and correlation of an official soil series based on the characteristics of the reclaimed soils at the Red Hills Mine. Thus far, field and laboratory data have been collected at a level sufficient for taxonomic placement and definition of ranges of characteristics for the Red Hills Series, which is named for the mine.[44] The current status of the Red Hills Series is awaiting final correlation and inclusion in the database supporting NRCS Web Soil Survey. It is possible that the Red Hills Series could be classified as a "prime farmland soil" which, as defined by NRCS, has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. Should this designation be awarded, Red Hills Mine will be responsible for a net increase of prime farmland soil in the project area.

In short, as a result of the surface mining and reclamation activities at the Red Hills Mine, the reclaimed areas exhibit better soil characteristics than pre-mining conditions. The Red Hills Mine is committed to reclaiming mined areas so and leaving them in better condition than they were prior to mining. This commitment by the Red Hills Mine is consistent with TVA's congressionally mandated requirement for the proper use of marginal lands and to provide for agricultural and industrial development. ***TVA should consider the positive impacts of soil restoration and preservation of designated prime farmland soils as it considers environmental impacts during the EIS process***.

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[43] *See generally Conservation Reserve Program*, UNITED STATES DEPARTMENT OF AGRICULTURE, https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index (last visited Apr. 16, 2018).

[44] *See* RED HILLS SERIES, https://soilseries.sc.egov.usda.gov/OSD_Docs/R/REDHILLS.html (last visited March 18, 2018).

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3.2.3 Restoration Quality

Research indicates reclaimed soils have the potential to improve soil quality over time;[45] however much of the associated research was located in temperate and cold climates.[46] Research conducted by Adeli, et. al. (2013) indicates Red Hills Mine reclamation practices result in sustainable, healthy postmining ecosystems where aggregate stability, total carbon, organic carbon, and microbial biomass increase with increasing reclamation age. To date, Red Hills Mine has reclaimed 885 acres (56%) with pine trees, 125 acres (8%) with hardwood trees, and 575 acres (36%) with grasses.

Red Hills has been awarded three reclamation awards from the federal Office of Surface Mining (OSM). In 2006, the Red Hills Mine won the United States Department of Interior's Office of Surface Mining Excellence in Surface Coal Mining Reclamation Award for successfully identifying and implementing post-mine techniques capable of stabilizing the landscape in a high rainfall, sub-tropical environment. In 2009, Red Hills was awarded the Good Neighbor Award[47] for community involvement activities including teacher workshops, open tour policy, and willingness to work hand-in-hand with landowners to ensure the post-mine land use met landowner approval. Finally, in 2014, the Red Hills Mine again won the Excellence in Surface Coal Mining Reclamation Award for its distinction in stream reclamation. This award recognized Red Hills goes above and beyond the regulatory requirements for stream restoration when applying principles of geomorphic stream design to the post-mine landscape.

3.2.4 Native Warm-Season Grasses (NWSG)

While not common in the area, planting of native grasses is becoming more common throughout the United States due to increasing recognition of soil and ecosystem benefits. Native grasses can outperform introduced warm-season species (including bermudagrass) in forage production, wildlife habitat, and drought tolerance due to deeper rooting depths.[48]

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[45] *See* R. LAL ET AL., THE POTENTIAL OF US CROPLAND TO SEQUESTER CARBON AND MITIGATE THE GREENHOUSE EFFECT (1998); M.K. SHUKLA, SOIL QUALITY INDICATORS FOR RECLAIMED MINESOILS IN SOUTHEASTERN OHIO (2004).

[46] *See* A. ADELI ET AL., AGE CHRONOSEQUENCE EFFECTS ON RESTORATION QUALITY OF RECLAIMED COAL MINE SOILS IN MISSISSIPPI AGROECOSYSTEMS (2013).

[47] "Good Neighbor Awards are given to mine operators for successfully working with the surrounding land owners and the community while completing mining and reclamation. Nominations for this category should briefly describe the mining and reclamation operation (using both narrative and photos), and include testimonial letters and/or other documentation of a successful good neighbor policy." *Excellence in Surface Coal Mining Reclamation Awards*, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT, https://www.osmre.gov/programs/awards/ActiveMineAwards.shtm (last visited Apr. 16, 2018).

[48] *See* V.W. TEMU, GROWTH RESPONSE OF MIXED NATIVE GRASS STANDS TO STIMULATE GRAZING IN MISSISSIPPI (2011).

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Even though planting native grass is significantly more expensive[49] than alternative plantings, Red Hills Mine recognized the environmental benefits of incorporating a native grass planting program; however, several limitations had to be overcome.

Red Hills Mine's surface coal mine permit required reconstructed prime farmland soils to be capable of producing hay in accordance with production standards published by the Choctaw County soil survey and the approved surface coal mine permit. The soil survey did not have hay production rates for NWSG, so Red Hills Mine contracted MSU to determine if reconstructed prime farmland soils were capable of producing NWSG hay at a rate that would exceed bermudagrass hay production[50]. The results of the study were favorable. To date, MLMC has planted approximately 100 acres of reconstructed prime farmland soils with a native grass mix and plans to plant an additional 150 acres of native grasses as mining and reclamation continue.

3.2.5 Flood Control & Downstream Water Quality

Sedimentation control ponds are constructed within the mine boundary, prior to mining, to capture all surface water within the disturbed area. Once water in the sedimentation control ponds meets NPDES water quality standards, it is discharged back into an existing stream. At present, Red Hills operates four sediment control ponds to manage stormwater within the active mine area. These four ponds combined have a capacity to retain 2,892 acre-feet of water that would otherwise contribute to downstream flooding and turbidity during high-intensity rainfall events. In an emergency, the pit itself is capable of storing an additional 3,264 acre-feet of stormwater. While the storage capacity of the ponds and pit may be relatively low as compared to TVA reservoirs, it should be recognized the mining operations at Red Hills are located within a headwater system. Headwater systems are susceptible to flooding due to high intensity or prolonged rainfall events.

A statistical analysis was conducted by InControl Technologies to determine whether mining operations were negatively impacting water quality. Box-and-whisker plots were utilized to provide a summary of the distribution including the mean, the median, the 25th and 75th percentile. The data were also temporally analyzed to determine general trends, including seasonal effects and natural variation, within each of the sampling points between monitoring events. The results of the statistical analysis indicate mining operations conducted in Choctaw County, Mississippi have decreased downstream sedimentation.[51]

3.2.6 Stream Reconstruction

MLMC voluntarily adopted geomorphic stream reclamation techniques along with the use of naturally available materials for reconstructed stream bank stabilization. Reconstruction of

[49] *See* J. TURK ET AL., COST-BENEFIT ANALYSIS OF NATIVE WARM SEASON GRASSES FOR TRANSMISSION LINE RIGHT-OF-WAY REVEGETATION (2017).
[50] Surface Coal Mine Permit MS002, Renewal 3, Appendix 2715-9.
[51] See Appendix 2523-2, Surface Coal Mine Permit MS002, Renewal 3.

the relocated McIntire Branch Creek began with development of the post-mine topography. MLMC engineers allowed as much floodplain to be developed adjacent to the stream reach as possible while minimizing steep slopes within the surrounding, hilly reclaimed terrain. By reconnecting a stream to the floodplain, flash flooding of the stream can be reduced while retaining more nutrients within the system.[52]

Once the floodplain of the stream was reclaimed, a sinuous channel was developed, and woody debris was strategically placed. MLMC personnel adapted woody debris placement guides published by the Maryland Department of the Environment, Waterway Construction Guidelines[53] and Bioengineering for Streambank Erosion Control.[54] Large root-wads and logs salvaged from ahead of the mining operations were keyed into the banks to provide bank stability and aquatic habitat. Riffle runs and pools were created to provide a variable habitat to support an aquatic ecosystem. The banks were vegetated and a mixed-hardwood riparian corridor was planted. Based on the successful stream reconstruction and commitment of the Red Hills Mine to leave the mined area in a better condition than prior to mining, OSMRE, the federal agency responsible for regulatory oversight of mining and reclamation, awarded Red Hills a National Reclamation Award in 2014 for stream reconstruction activities.[55]

Most recently, MLMC has incorporated geomorphic principles into an individual Corp of Engineers 404 Permit. The mitigation plan associated with this permit involves the development of reconstructed streams on the reclaimed mine land, appropriately sized to the reclaimed watershed, which will subsequently become Waters of the United States (WOTUS) once all mining and reclamation activities are complete. MLMC's commitment to excellence means impacts to WOTUS will continue to be mitigated primarily within the watershed where impacts occurred[56] and will occur primarily on reclaimed mine land.

3.3 Cultural Resources

Prior to mining activities, the Red Hills Mine has conducted Phase I Archeological Surveys on more than 10,000 acres in the project area. The results have been submitted to Mississippi's State Historic Preservation Officer (SHPO) and the Tribal Historic Preservation Officers (THPO) associated with the Choctaw and Chickasaw Nations. The archeological

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[52] F.D. SHIELDS, JR. ET AL., REHABILITATION OF AN INCISED STREAM WITH PLANT MATERIALS: THE DOMINANCE OF GEOMORPHIC PROCESSES (2008).
[53] *See Maryland Waterway Construction Guidelines*, MARYLAND DEPARTMENT OF THE ENVIRONMENT, WATER MANAGEMENT ADMINISTRATION, http://mde.maryland.gov/programs/Water/WetlandsandWaterways/DocumentsandInformation/Documents/www.mde.state.md.us/assets/document/WetlandsWaterways/mgwc.pdf (last visited Apr. 16, 2018).
[54] *See* Hollis H. Allen & James Leech, *Bioengineering for Streambank Erosion Control, Report 1, Guidelines, Technical Report EL-97-8* (1997), https://emrrp.el.erdc.dren.mil/elpubs/pdf/trel97-8.pdf.
[55] *Office of Surface Mining Reclamation and Enforcement Honors Coal Mining Companies for Exemplary Reclamation at the 2014 Excellence in Surface Coal Mining Reclamation Awards*, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT, https://www.osmre.gov/resources/newsroom/News/2014/102714.pdf (last accessed March 18, 2018).
[56] *See* U.S. Army Corps of Engineers, Mobile District, Permit No. MVK-2017-257.

surveys identified 13 prehistoric sites, 48 historic sites, and 11 sites with both prehistoric and historic components. While most sites are not eligible for the National Register of Historic Places, the results provide an increased depth of understanding of the pre-historic and historic cultural activities in the area that otherwise would likely go unknown.

3.4 Conclusion

The TVA Act established that the purpose of TVA would include a focus on environmental stewardship. TVA has remained faithful to that Congressional charge by including in its mission statement the important concepts of environmental sustainability and stewardship. Since the inception of the Red Hills Project in the late 1990s, the Red Hills Mine and the Red Hills Power Plant have been committed to environmental stewardship and sustainability. This commitment manifests itself in tangible and quantifiable environmental benefits at the Red Hills Project. As described in detail above, award-winning reclamation at the Red Hills Mine has resulted in significantly improved soils and the successful reforestation of over 1000 acres with pine and hardwood trees. In addition, the Red Hills Mine sought and received approval from the Mississippi Department of Environmental Quality to reestablish native warm season grasses in its reclaim area. These grasses have provided documented improvements in forage production, wildlife habitat and drought tolerance. In addition, the Red Hills Project has a demonstrated commitment to maintaining water quality by maintaining compliance with regulatory requirements and achieving nationally recognized stream reconstruction work in the mine reclaim area. The Red Hills Project has been an excellent environmental partner to TVA since its inception and, like TVA, the Red Hills Project is dedicated to environmental sustainability and stewardship.

4.0 ECONOMIC DEVELOPMENT

According to the TVA Act of 1933, TVA was created, among other things, "to provide for agricultural and industrial development of said valley …." [57] The TVA Act expands on this purpose by stating that TVA shall seek to advance "the physical, social and economic development of the area in which it conducts its operations" and to improve "the economic and social well-being of the people living in said river basin."[58] From these statutory charges, TVA has developed a three-part mission, with one part focusing on economic development.

According to TVA's website, "[e]conomic development is a cornerstone of TVA's mission to make life better for Valley residents." [59] TVA has characterized its mission as requiring it "[t]o diligently support **economic development** activities that draw new jobs and investment to the region, or help companies stay here and grow."[60] Finally, TVA has stated that

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[57] 16 U.S.C. § 831.
[58] *Id*. at § 831n-4(h) and § 831v.
[59] TVA, TVA at a Glance, https://www.tva.gov/About-TVA/TVA-at-a-Glance (last visited Apr. 12, 2018).
[60] TVA, Mission in Motion, https://www.tva.gov/Newsroom/News-Features/Our-Year-of-Achievement (last visited Apr. 12, 2018).

"[g]etting businesses to locate to the Tennessee Valley may be our number one priority—at first. But TVA Economic Development also understands that success requires ongoing support of both businesses and communities." [61]

In 1998, TVA published its Record of Decision ("1998 ROD") to enter into a long-term power purchase agreement with the Red Hills Power Plant. In the 1998 ROD, TVA recognized the economic impact that the Red Hills Project would have on the local region. In fact, TVA based its decision to enter into a long term power purchase agreement with the Red Hills Power Plant, in part, on the fact that no alternatives to the Red Hills Project "would produce the local socioeconomic benefits that would result from the RHPP." [62]

In 1998, even before the Red Hills Project was constructed, TVA clearly believed that this project would have a dynamic impact on the economic and socioeconomic condition of Choctaw County, surrounding counties, and the State of Mississippi. TVA was correct. Twenty years later, it is indisputable that the Red Hills Project has delivered on the promise of a tremendous positive economic impact for the area.

In order to quantify the economic benefits of the Red Hills Mine, MLMC engaged NSPARC – the National Strategic Planning and Analysis Research Center – to conduct an economic impact analysis of the Red Hills Mine. NSPARC, a unit of Mississippi State University, specializes in using data science with a focus on data analytics, predictive analytics, machine learning, AI, system of systems, data governance, cyber security, cloud technology, and high-performance computing to develop innovations that further human progress.[63] Specifically, NSPARC has achieved national prominence with its use of data science in economic development, workforce development, education and delivery of human services at all levels of government.[64]

In preparing the economic impact analysis for the Red Hills Mine, NSPARC utilized the Regional Economic Modeling Inc.'s (REMI) PI+ model. The REMI PI+ model generates year-by-year estimates of the total regional effects of any specific policy initiative.[65] Thus, the model helps the user interpret the predicted economic and demographic effects on a wide range of policy variables.[66] The REMI PI+ model is used by consulting firms, nonprofit institutions, universities, public utilities and many federal and state governmental agencies, including TVA.[67] The model's equations and research findings have been published extensively in professional national journals, including the American Economic Review, The Review of Economic

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[61] TVA, Engage Businesses + Communities, https://tva.gov/Ecomonic-Development/Engage (last visited Apr. 12, 2018).
[62] TVA Issuance of Record of Decision on Red Hills Power Project, 63 Fed. Reg. 44944, 44946 (Aug. 21, 1998).
[63] NSPARC, What We Do, https://www.nsparc.msstate.edu/what-we-do/ (last visited Apr. 12, 2018).
[64] *Id.*
[65] REMI, PI+ Model, www.remi.com/model/pi/ (last visited Apr. 12, 2018).
[66] *Id.*
[67] *Id.* at http://www.remi.com/clients/ (last visited Apr. 12, 2018).

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Statistics, the Journal of Regional Science and the International Regional Science Review.[68] Therefore, the accuracy of the data generated by NSPARC using the REMI PI+ model is credible and reliable.

NSPARC's study of the economic impact analysis of the Red Hills Mine demonstrates the striking role the mine plays in Choctaw County, Mississippi and its surrounding region. While the complete study provides an excellent snapshot of the Red Hills Mine's economic impact on the area and is attached hereto as **Appendix A**, it is worth highlighting herein certain impacts identified by the study. [69] To start, the Red Hills Mine employs over 200 people who earn an average annual salary of $75,000.[70] The NSPARC study reveals that, for every job created at the mine, an additional estimated 1.2 jobs are created indirectly in other sectors in the county and surrounding six-county region.[71] This direct and indirect employment is associated with the generation of an estimated $3.0 million in state and local taxes, $28 million in total personal income and a contribution of $46 million to the state GDP annually.[72]

Without question, the Red Hills Mine is a main economic engine for the county and surrounding region, and is crucial to maintaining the economic health of Choctaw County.[73] Employment in the county has increased by over 11 percent since the opening of the mine, while statewide employment is down by 1 percent.[74] In addition, the unemployment rates for the county and region (4.8 and 5.3, respectively) are among the lowest in the state.[75] Since the Red Hills Mine began operations, average earnings, accounting for inflation, have increased by 23 percent in the county and seven percent in the region, easily outpacing the state.[76] This growth has helped buffer against dramatic increases in poverty that have impacted Mississippi over the past two decades.[77] While the poverty rate has increased by six percent in the county since 2000, it has increased almost 20 percent in Mississippi as a whole during the same time period.[78]

TVA's 1998 decision to support the Red Hills Project has provided for the type of industrial development in Choctaw County and the surrounding region that Congress hoped for when it established TVA through the TVA Act of 1933. As the results of the NSPARC economic impact study clearly demonstrate, TVA's support of the Red Hills Project has improved "the economic and social well-being of the people…" living in the surrounding

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[68] *Id.*
[69] NSPARC, MISSISSIPPI STATE UNIVERSITY, RED HILLS COAL MINE: AN ECONOMIC ENGINE FOR CHOCTAW COUNTY AND THE SURROUNDING REGION (2018).
[70] *Id.* at 1.
[71] *Id.*
[72] *Id.* at 10.
[73] *Id.* at 1.
[74] *Id.* at 4-6.
[75] *Id.*
[76] *Id.* at 7.
[77] *Id.* at 7-8.
[78] *Id.*

region.[79] TVA's support of the Red Hills Project helped create the largest private sector employer in Choctaw County and indirectly generates additional employment in a region in desperate need of quality employment and wages. TVA's support of the Red Hills Project has also resulted in the generation of millions in annual state and local taxes, personal income and to Mississippi's GDP.

Tax revenues have led to improved schools and infrastructure in Choctaw County, enabling its residents to succeed at a greater rate than they could before the Red Hills Project came into existence. The Red Hills Project has been a shining example of the good that TVA can do when it commits to economic development.

As mentioned earlier and as part of its economic development mission, TVA has stated that "[g]etting businesses to locate to the Tennessee Valley may be our number one priority—at first. But TVA Economic Development also understands that success requires ongoing support of both businesses and communities."[80] Now, in order to ensure the continued success of the Red Hills Project and the TVA customers who rely upon it, TVA should consider the Red Hills Project's very positive effect on the region and dispatch the Red Hills Power Plant as a baseload facility. Doing so would fulfill TVA's statutory purpose and its stated mission and further improve the lives of the people living and working in the TVA service area.

5.0 CONCLUSION

As set forth in this comment, the Red Hills Project is uniquely positioned to fulfill TVA's three-fold mission of providing reliable and low-cost energy, while maintaining environmental sustainability and supporting economic development. The Red Hills Project addresses the critical elements of an energy portfolio planning strategy - diversity, reliability, environmental stewardship, and cost-effectiveness. It provides TVA's customers with the most reliable source of electricity in extreme weather events, provides TVA with absolute fuel security, and protects TVA's customers from the risk of dramatic cost increases that are inherent in other fuel sources. The Red Hills Project also excels in promoting a full spectrum of environmental sustainability. The Red Hills Project demonstrates its commitment to stewardship through its award-winning reclamation and stream reconstruction, its quantifiable and documented work in soils management, reforestation and Native Grass re-establishment, its beneficial reuse of coal combustion residuals, and its commitment to air and water quality. Finally, as evidenced by the NSPARC economic impact study, the Red Hills Project is the economic driver for Choctaw County, while having a significant impact on the region and the State of Mississippi. Clearly, TVA's initial commitment to the Red Hills Project has improved the lives of the people in this part of TVA's service area. To continue its positive impact on this region and to continue fulfilling its statutory purpose and mission, TVA should strongly consider dispatching the Red Hills Project as a baseload generating facility.

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[79] *See supra*, n. 57.
[80] *See supra*, n.60.

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[Appendix A]

Red Hills Mine

An Economic Engine for Choctaw County and the Surrounding Region

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ABOUT NSPARC

This report was prepared by NSPARC at Mississippi State University. NSPARC is expanding the boundaries of data science to create knowledge and innovations that drive human progress. Our expertise includes data analytics, predictive analytics, machine learning, artificial intelligence, system of systems, data governance, cybersecurity, cloud technology, and high-performance computing. Known primarily for our work with smart government and more than 50 data innovations, NSPARC has achieved national prominence in the data science field.

For more information, visit nsparc.msstate.edu.

CONTENTS

STUDY HIGHLIGHTS

Red Hills Mine in Choctaw County represents one of the most significant economic development initiatives in central Mississippi in the last 20 years. Since its opening in 2000, the mine has become the top private-sector employer and a major source of skilled high-wage employment in Choctaw County. These attributes have served to buffer Choctaw County from adverse economic forces that have negatively impacted rural communities across Mississippi and the nation.

The 5,900-acre mine is located in Ackerman, Mississippi, and produces approximately 3.5 million tons of lignite coal annually. This coal supplies the Red Hills Generation Facility, which supplies electricity to Tennessee Valley Authority. Red Hills Mine employs more than 200 people who earn an average annual salary of $75,000.

This study provides estimates of the economic benefits of Red Hills Mine to Choctaw County, its surrounding six-county region, and Mississippi. This study does not examine any benefits of the Red Hills Generation Facility. The results show that for every job created at Red Hills Mine, an additional estimated 1.5 jobs are created indirectly. Estimates also show that this direct and indirect employment is associated with $3.8 million in state and local taxes, $35 million in total personal income, and $55 million in state GDP annually.

These outcomes show that Red Hills Mine is an economic engine for the county and surrounding six-county region. A closer look at key economic indicators shows that employment in Choctaw County has increased by more than 11 percent since the opening of Red Hills Mine, and the county's and surrounding six-county region's unemployment rates (4.8 and 5.2 percent, respectively) are among the lowest in the state. Taking inflation into account, average annual earnings have increased by 23 percent in the county and seven percent in the region, easily outpacing the state. This economic growth has helped stave off significant increases in poverty experienced by many rural areas over the last 20 years. For example, while the poverty rate has increased by six percent in Choctaw County since 2000, it has increased by almost 20 percent in Mississippi as a whole.

Red Hills Mine has become an integral part of the Choctaw County community over the last 18 years. The mine's community-oriented approach to reclaiming land is nationally recognized, and its reclamation practices have merited an OSM-RE National Award and a Mid-Continent Regional Award. Red Hills Mine is also heavily invested in local education, offering workshops, training, and access to technology and other resources that would otherwise not be available. Red Hills Mine has hosted and supported initiatives aimed at dropout prevention and improving student academic performance, and it has also provided resources to promote geosciences, STEM education, and skilled high-wage employment in natural resource fields. This community-oriented approach to business has made Red Hills Mine an invaluable part of Choctaw County and surrounding communities.

METHODOLOGY

The economic contributions of Choctaw County's Red Hills Mine were estimated using a well-established econometric model, the Regional Economic Modeling Inc.'s (REMI) PI+. Utilizing data on historical employment, earnings, and demographic trends from sources such as the Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and County Business Patterns, REMI operates as an input/output model to estimate the impacts of targeted changes to the economy of a state or local area.

For this study, a coal mine with 205 jobs was inputted into the REMI model to examine the estimated annual impact on the county, regional, and state economy. Output from the REMI model was used to estimate the impact of Red Hills Mine using four economic indicators: (1) direct and indirect employment, (2) personal income, (3) tax revenue, and (4) gross domestic product.

Finally, the study also produced other economic and demographic indicators using data from the 2000 U.S. Decennial Census, 2016 data from the Census Bureau's American Community Survey, and 2017 data from the U.S. Bureau of Labor Statistics.

Indicators

Direct jobs were measured as the number employed at Red Hills Mine using information provided by Red Hills Mine.

Indirect jobs were measured as the estimated number of jobs created in other sectors by the existence of Red Hills Mine using the REMI model.

Gross domestic product (GDP) was measured as the estimated monetary value of all goods and services attributed to Red Hills Mine using the REMI model.

Personal income was measured as the estimated average annual income generated as a result of Red Hills Mine using the REMI model.

Tax revenue was measured as the estimated average annual amount of state and local income tax generated through Red Hills Mine direct and indirect employment using the REMI model.

Employment was measured as the number of jobs in 2000 and 2017 in Choctaw County, the surrounding six-county region, and Mississippi using data from the U.S. Bureau of Labor Statistics.

Unemployment was measured as the unemployment rate in 2000 and 2017 in Choctaw County, the surrounding six-county region, and Mississippi using data from the U.S. Bureau of Labor Statistics.

Average annual earnings were measured as the average wage for employed persons in Choctaw County, the surrounding six-county region, and Mississippi using data from the U.S. Bureau of Labor Statistics. Wages are reported in 2016 constant dollars.

Poverty was measured as the percent of the population in poverty using data from the the U.S. Census Bureau's Small Area Income and Poverty Estimates program.

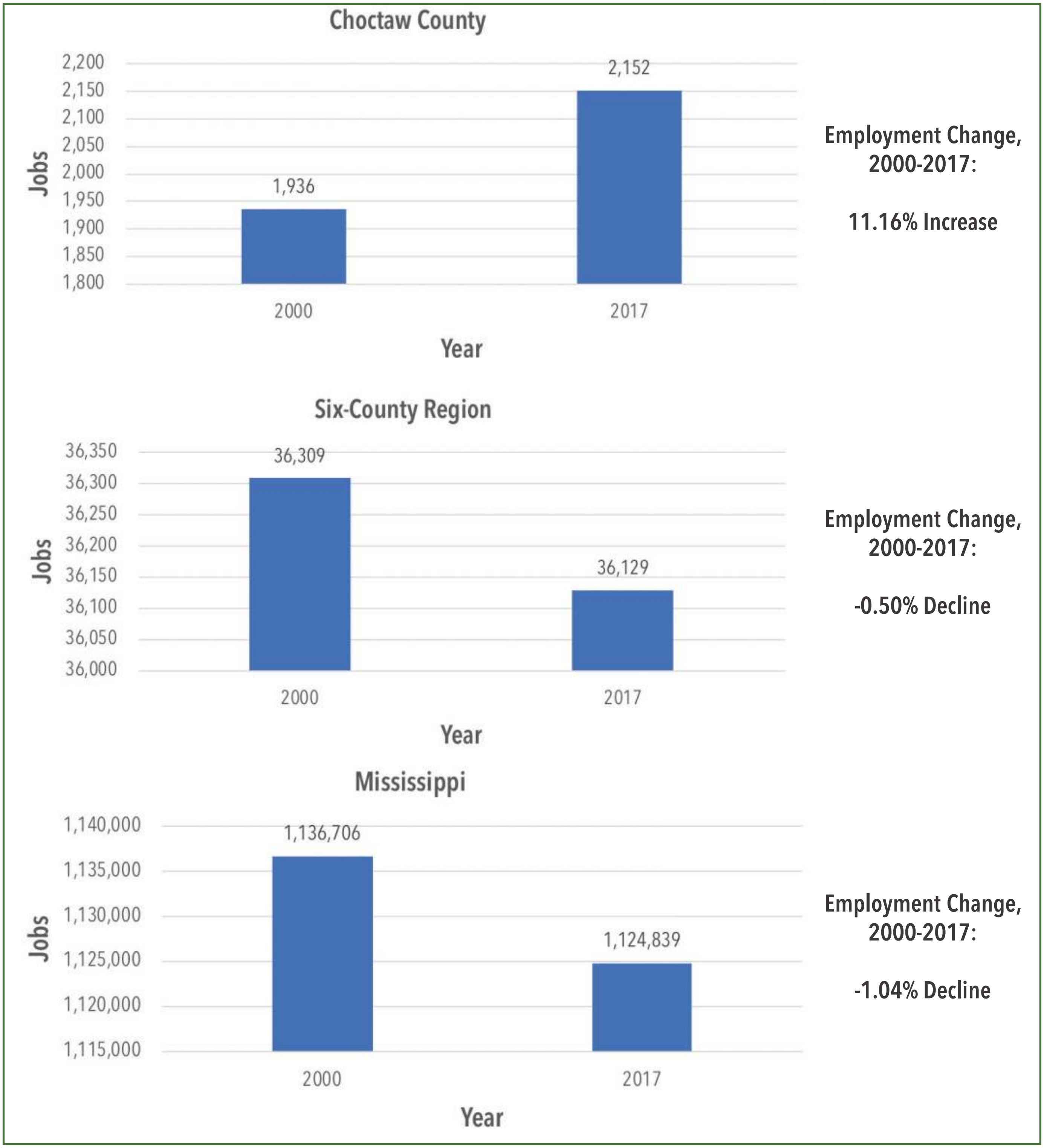
Labor force participation was measured as the percent of the population age 16 and older who were employed or unemployed and looking for a job in Choctaw County, the surrounding six-county region, and Mississippi using data from the U.S. Bureau of Labor Statistocs.

RESULTS

Employment

Employment in Choctaw County has increased by more than 11 percent since the opening of Red Hills Mine, while employment levels for the surrounding six-county region and state have declined during the same period. Red Hills Mine has shown resilience during a challenging economic period that included a major recession (see Figure 1).

Figure 1: Employment

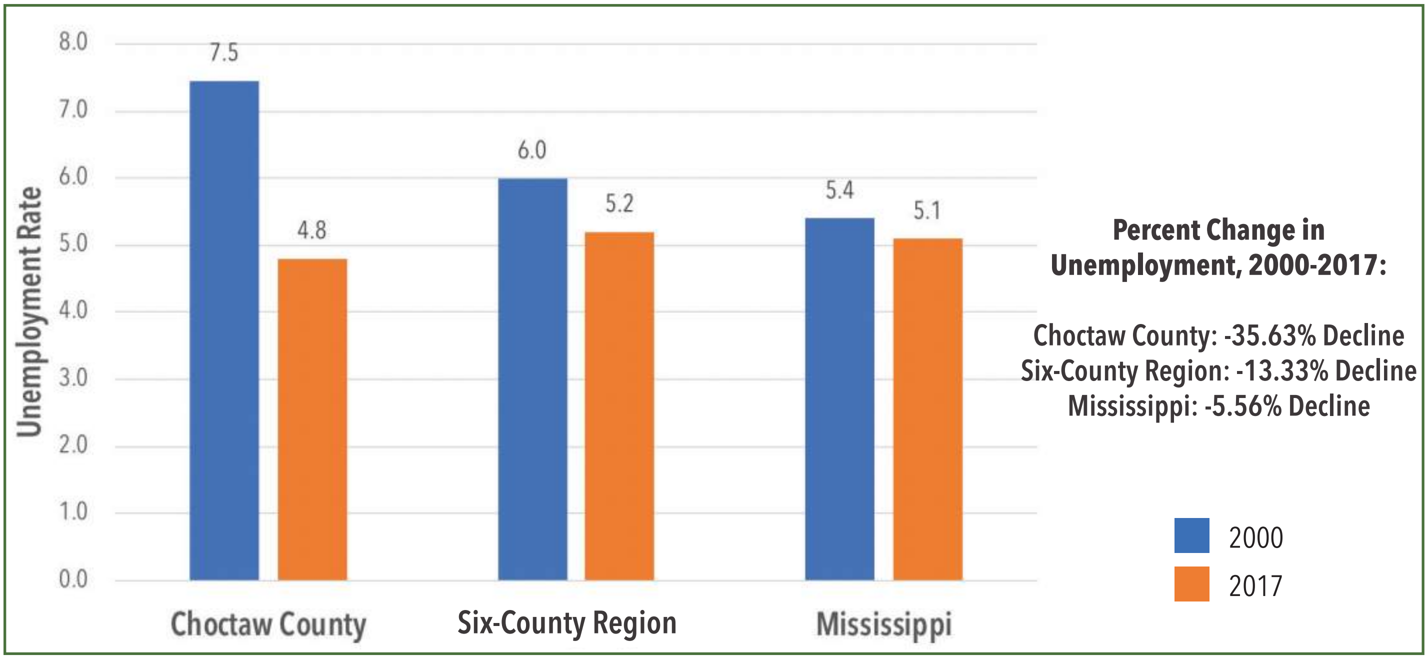


Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2018.

Unemployment

The unemployment rates in Choctaw County (4.8 percent) and the surrounding six-county region (5.2 percent) are among the lowest in the state (see Figure 2). The unemployment rate for Choctaw County has declined by 35.6 percent since 2000.

Figure 2: Unemployment

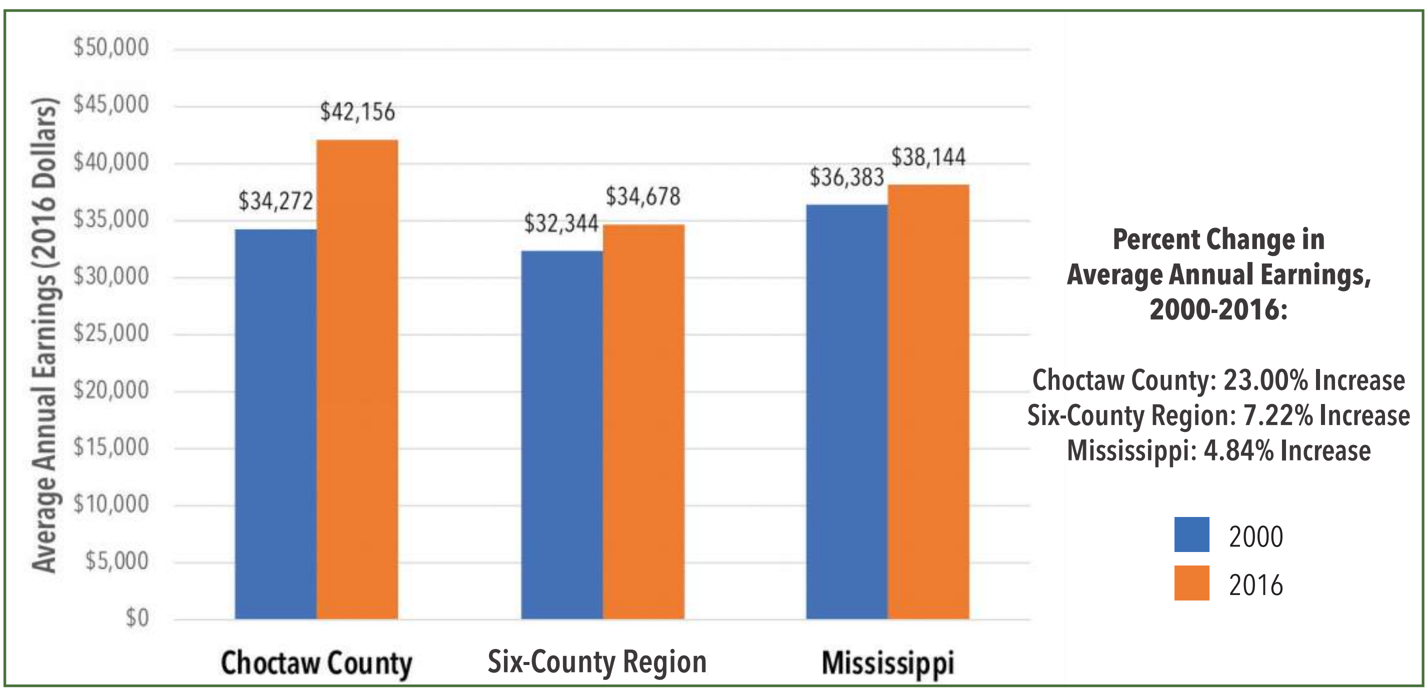


Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2018.

Average Annual Earnings

The benefits of Red Hills Mine are also reflected in increased earnings. Taking inflation into account, average annual earnings have increased by 23 percent in Choctaw County, versus 7.2 percent in the surrounding six-county region and 4.8 percent at the state level (see Figure 3).

Figure 3: Average Annual Earnings

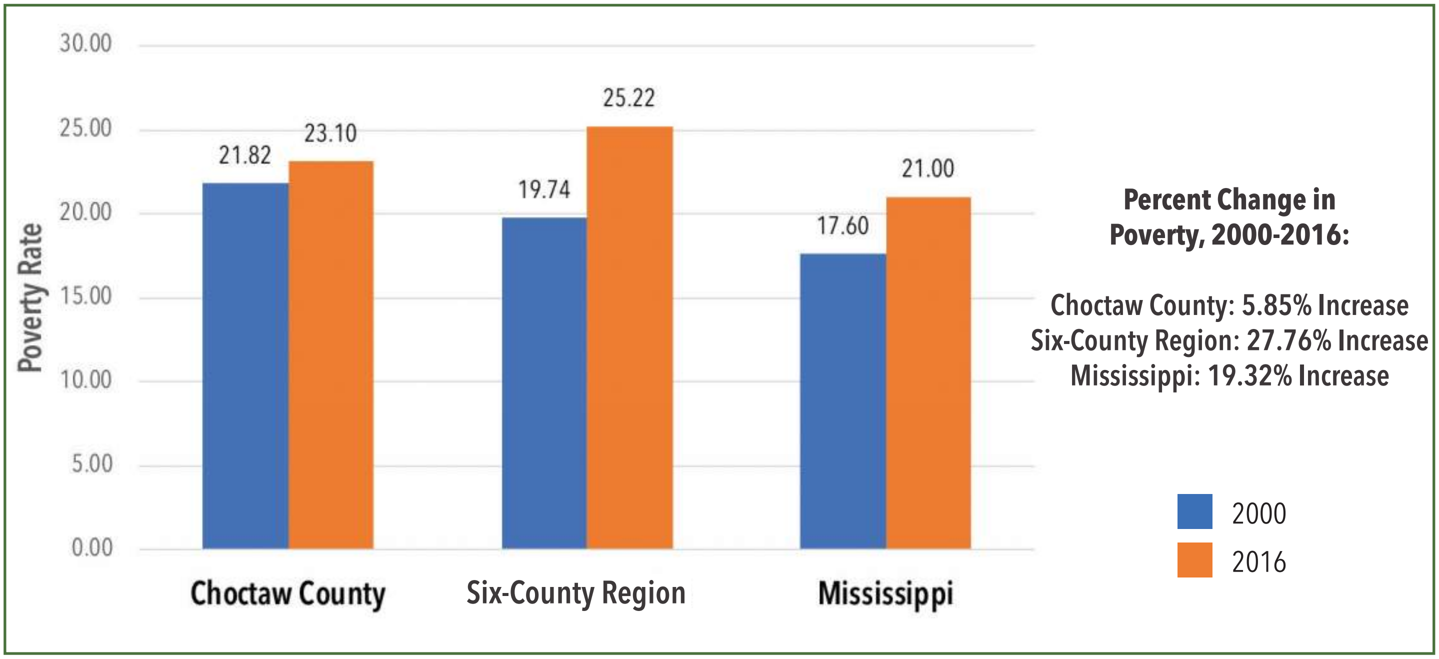


Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2018.

Poverty

While the poverty rate in Choctaw County has increased by six percent since 2000, the poverty rate in Mississippi as a whole has increased by almost 20 percent during the same period (see Figure 4). One factor contributing to the lower poverty-rate increase in Choctaw County is the high-wage employment opportunities at Red Hills Mine.

Figure 4: Poverty

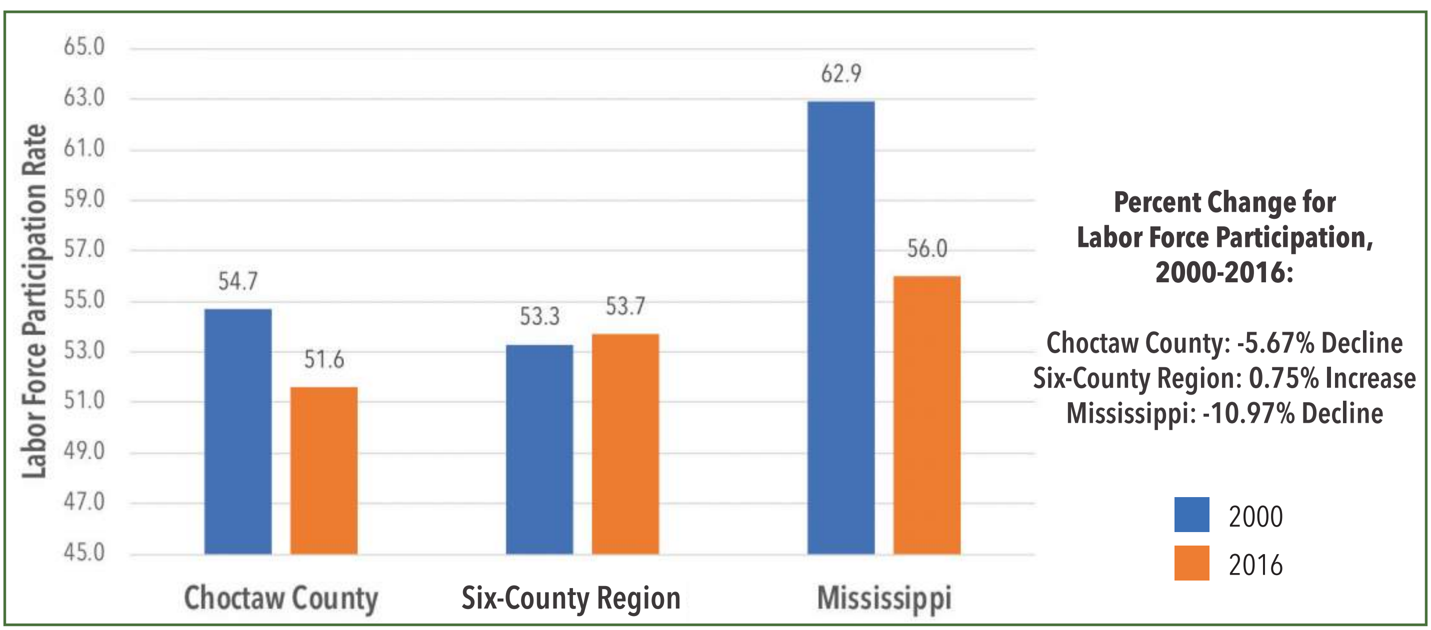


Source: U.S. Census Bureau, Small Area Income and Poverty Estimates, 2018.

Labor Force Participation

Similar to the rest of the nation, the labor force participation rate in Choctaw County has shown a decline. However, on a positive note, this decline is lower than the decline in the state as a whole (see Figure 5).

Figure 5: Labor Force Participation



Sources: U.S. Census Bureau, American Community Survey, 2018; Bureau of Labor Statistics, Local Area Unemployment Statistics, 2018.

ECONOMIC IMPACT

Red Hills Mine directly employs 205 individuals. With an average salary of more than $75,000, the positions at Red Hills Mine are relatively high-paying jobs in comparison to jobs in Choctaw County ($42,156 per year), the surrounding six-county region ($34,678), and the state as a whole ($38,144) based on data from the U.S. Bureau of Labor Statistics. The following sections describe the impact of Red Hills Mine jobs on Choctaw County, the surrounding six-county region, and the state.

Choctaw County

The 205 direct jobs at Red Hills Mine support an estimated 156 indirect jobs in Choctaw County, contribute more than $42.6 million in annual GDP and generate an estimated $19.9 million in personal income. This personal income produces an estimated $2.1 million in state and local tax revenue.

Six-County Region

Red Hills Mine supports an estimated 217 indirect jobs in the six-county region, contributes more than $46.6 million in annual GDP. and generates an estimated $28.4 million in personal income. This personal income produces an estimated $3 million in state and local tax revenue.

Statewide

Red Hills Mine supports an estimated 323 indirect jobs statewide, contributes more than $55.3 million in GDP, and generates an estimated $35.4 million in personal income. This personal income produces an estimated $3.8 million in state and local tax revenue.

Table 1: Economic Impact of Red Hills Mine

	Choctaw County	Six-County Region	Statewide
Total Jobs	361	422	528
Direct	205	205	205
Indirect	156	217	323
GDP	$42,652,891	$46,672,684	$55,346,778
Personal Income	$19,900,648	$28,444,364	$35,432,496
Tax Revenue	$2,109,469	$3,015,103	$3,755,845
State Tax Revenue	$1,512,449	$2,161,772	$2,692,870
Local Tax Revenue	$597,019	$853,331	$1,062,975

nsparc
A UNIT OF MISSISSIPPI STATE UNIVERSITY™

Name: Kerry Livengood

Comments: Coal fired plants are economical and useful. Please also consider plants that can burn wood waste and low quality hardwoods available from forests of the State. Since the shutdown of the International Paper Mill in Alabama and the Verso mill in Kentucky the market for low quality hardwoods in the State has dropped. Dual fuel power plants in certain areas of the State could open markets to forest landowners and remove the build up of low quality hardwoods due to years of 'removing the best and leaving the rest' logging.

close window

Graham, Cierra

From: R Lowe <rlowe2020@gmail.com>
Sent: Saturday, April 14, 2018 5:02 PM
To: Integrated Resource Plan
Subject: IRP

Thanks to TVA for further proposed coal plant retirements reducing sources of the worst pollution. This reduction should be balanced by further increases in solar, wind and hydroelectric production instead of increases in the nuclear sector, which has higher long term costs and very serious waste storage problems.

Sincerely yours

Reginald S. Lowe,MD
Clarksville TN

From: Simon Mahan
To: Integrated Resource Plan
Subject: 2019 IRP scoping comments
Date: Monday, April 16, 2018 11:44:08 AM
Attachments: SREA TVA IRP scoping 4.16.18.pdf

TVA External Message. Please use caution when opening.

Dear Ashley Pilakowski,

As outlined in TVA's 2019 IRP fact sheet, I am submitting the attached comments for consideration. Please let me know if you have any questions.

-Simon

Simon Mahan | Director
Southern Renewable Energy Association
Lafayette, LA 70507
simon@southernwind.org | (c) 337.303.3723
www.southernrenewable.org

Low Cost Renewable Energy Options for the Tennessee Valley Authority

Spring 2018

srea
SouthernRenewable.org

Southern Renewable Energy Association

OVERVIEW

Renewable energy demand is growing. Renewable energy prices have plummeted over the past few years. Wind power prices have declined by 67%, and solar power prices by 86%, just since 2009. In many parts of the country, renewable energy is now cost competitive against traditional energy resources. Utilities like Southwestern Electric Power Company (Louisiana/Arkansas)[1] and MidAmerican (Iowa)[2] have both announced *multi-gigawatt wind power purchases* in the past year. Southern Power owns over 1,400 MW of wind power resources.[3] North Carolina has the second highest level of solar power capacity in the country, with over 4,300 MW installed.[4] Corporations and other non-utility buyers are finding innovative mechanisms to directly invest in renewable energy. These voluntary announcements are due to the low costs of renewable energy.

The Tennessee Valley Authority (TVA) has previously been a leader in purchasing renewable energy. In 2004, the Buffalo Mountain wind project in Tennessee became the south's first utility-scale wind farm, with TVA as its energy customer. In 2010, the TVA Board of Directors "authorized the purchase of as much as 2,000 MW of renewable and clean energy. TVA plans to have half of its power supply from clean and renewable energy sources by 2020."[5] As part of that plan, TVA procured over 1,500 megawatts of wind power. In 2015, TVA completed a long-term planning process to identify future power generation resources and needs. In its 2015 Integrated Resource Plan (IRP), TVA stated that it would add "150 and 800 MW of large-scale solar by 2023, and between 3,150 and 3,800 MW of largescale solar by 2033…[and add]…between 500 and 1,750 MW [of wind energy] by 2033, depending on pricing, performance, and integration costs. Given the variability of wind selections in the scenarios, evaluate accelerating wind deliveries into the first 10 years of the plan if operational characteristics and pricing result in lower-cost options."[6]

CURRENT RENEWABLES ENERGY RESOURCES

For the renewable energy portion of the portfolio, TVA relies primarily on Power Purchase Agreements (PPAs) with private developers. As a public entity, TVA is not eligible to directly take advantage of federal tax credits such as the Investment Tax Credit (ITC, for solar projects) or Production Tax Credit (PTC, for wind projects). However, by entering a PPA with private renewable energy developers, TVA is able to buy the power generated by the wind or solar farm at fixed rates for the duration of a typical 20+ year contract at reduced cost.

Although renewable energy PPAs would be cost-effective for customers, TVA's current portfolio shows a low level of investment in renewable energy relative to its size. Investments in large-scale solar are particularly lagging. TVA has previously acknowledged that solar is one of *"the most abundant and easily deployable renewable resources.*"[7]

TVA currently purchases energy from one "In-Valley" wind project in Tennessee via PPA. The Buffalo Mountain Wind Farm began operation in 2004 in Anderson County, Tennessee with a 27 MW nameplate capacity. The rest of TVA's wind energy resources are made up of PPA contracts for 1,215 MW from wind farms outside the TVA service territory. Wind farm development companies have agreed to wheel energy into TVA from states outside the TVA footprint including Illinois, Iowa and Kansas. When the wind power contracts reach their expiration date (usually up to 20 years after initial operation), TVA has the option to either extend of replace them with comparable wind contracts.

INTEGRATED RESOURCE PLANNING

IRPs are planning tools for a utility to evaluate different resource options and develop formal plans to meet future energy needs. Utilities across the country follow this process, which is routinely updated and repeated. The advantage of anticipating different scenarios is that it allows the utility to respond to quickly changing market conditions. Ultimately, the process ends with selecting a portfolio that offers the best combination of benefits to utility customers.

In 2015, TVA completed an IRP. TVA also files a supplemental environmental impact statement (EIS) alongside its IRP, as part of the federal National Environmental Policy Act review process. TVA describes the process in the following manner:

> *"The purpose of the IRP and EIS processes is to evaluate TVA's current energy resource portfolio and alternative future portfolios of energy resource options at a least system-wide cost to meet the future electrical energy needs of the TVA region while taking into account TVA's mission of energy, environmental stewardship and economic development."*

The core function of the IRP is not only to evaluate the financial and environmental impacts, but also to enable review and participation from the public. Utilities typically maintain transparency in the process by collecting public comments at multiple milestones, holding public meetings, and issuing news releases and meeting notices.

OUTCOMES FROM TVA'S 2015 IRP

The IRP evaluates both different planning strategies and scenarios. *Planning strategies* reflect the different resource choices the utilities can make, i.e. differing amounts of renewables vs. fossil fuels. In 2015, TVA evaluated five planning strategies: A) a reference plan, B) meeting an emissions target, C) focusing on long-term, market supplied resources, D) maximizing energy efficiency, and E) maximizing renewables. *Scenarios* reflect different sets of future conditions such as economic stability, availability of resources, or environmental regulations. TVA evaluated five different scenarios in its 2015 IRP: 1) the current outlook, 2) a stagnant economy, 3) a growth economy, 4) a de-carbonized future, and 5) a distributed marketplace.

Wind Energy

The final outcome of the 2015 IRP called for between 500 and 1,750 MW of additional wind energy by 2033. The amount from this range ultimately added to TVA's portfolio is "*dependent on pricing, performance, and integration costs*." To date, TVA has not made any additional wind energy procurements.

Solar Energy

TVA made a substantial commitment to large-scale solar, with the final IRP stating that they would add "between 150 and 800 MW of large-scale solar by 2023, and between 3,150 and 3,800 MW of large-scale solar by 2033. The trajectory and timing of solar additions will be highly dependent on pricing, performance and integration costs." The sensitivities modeled assumed that utility-scale solar tracking would be selected as early as 2020. To date, TVA has not made any significant solar energy procurements.

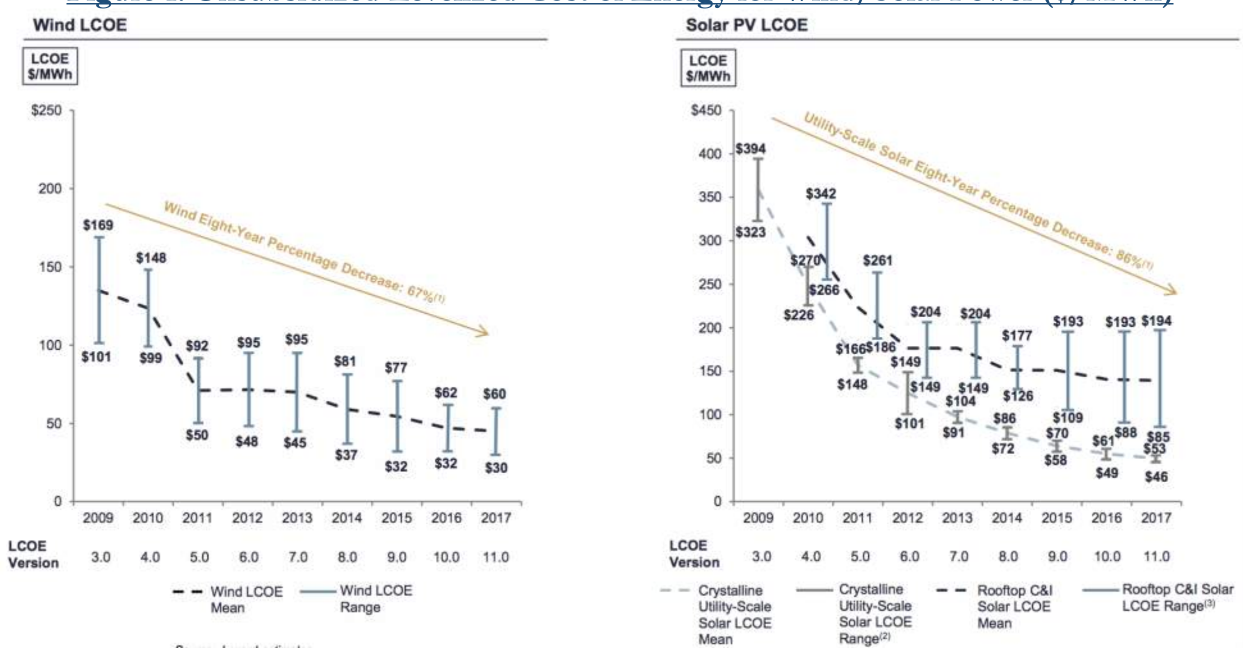
Subsequent Renewable Energy Action and Request for Information (RFI) and Request for Proposals (RFP)

TVA made a major commitment to renewable energy development in the 2015 IRP, but has made little to no progress towards fulfilling that commitment. In May 2016, TVA issued a Request for Information (RFI) to collect information from developers on renewable energy projects. Typically, an RFI is used to evaluate candidates to receive potential future RFPs since an RFP may or may not be publically posted. The RFI stipulates that the proposed arrangement would be a 'sell-all' Power Purchase Agreement (PPA) for 20-25 years, with a commercial operation date no later than December 31, 2020. In late 2017, TVA issued a 200 MW RFP for renewable energy; yet, no public statement regarding this RFP has been made since its proposal deadline has passed.[8]

RENEWABLE ENERGY REVIEW

Renewable energy prices have plummeted over the past few years. Wind power prices have declined by 67%, and solar power prices by 86%, just since 2009. In many parts of the country, renewable energy is now cost competitive against traditional energy resources. Utilities like Southwestern Electric Power Company (Louisiana/Arkansas)[9] and MidAmerican (Iowa)[10] have both announced *multi-gigawatt wind power purchases* in the past year. Southern Power owns over 1,400 MW of wind power resources.[11] North Carolina has the second highest level of solar power capacity in the country, with over 4,300 MW installed.[12]

Figure 1: Unsubsidized Levelized Cost of Energy for Wind/Solar Power ($/MWh)



Source: Lazard Associates 2017[13]

Solar Power Opportunities

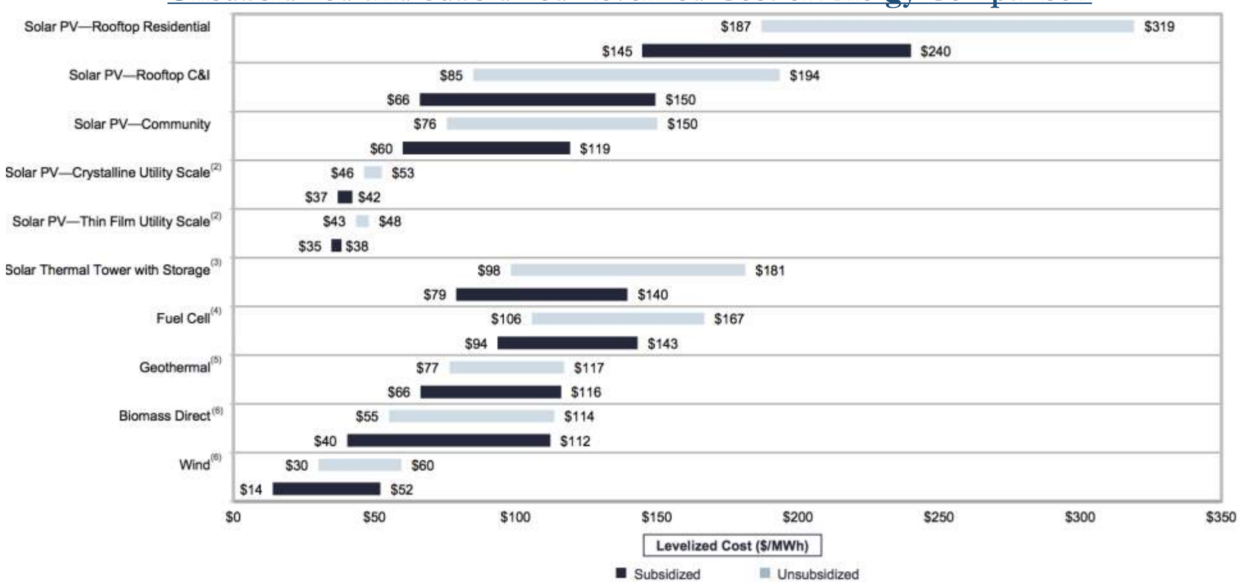
Solar photovoltaic (PV) panels have improved dramatically in performance, as well as price, over the past few years. Generally, panels can be arranged as a "fixed tilt" project, or with a "tracking" system that follows the path of the sun in order to increase output. Both opportunities have unique benefits and costs that are necessary to consider.

Wind Power Opportunities

TVA could utilize existing transmission to connect to projects from outside the region, such as those from the Midcontinent Independent System Operator (MISO) and the Southwest Power Pool (SPP). The power from a wind or solar project outside the region would be delivered to the TVA system. MISO and SPP wind energy resources are fairly reflective of TVA's current renewable energy PPAs. Newly planned HVDC transmission projects are purpose-built for wheeling in wind energy to the Southeast, including the western edge of the TVA service area. Pattern Energy's Southern Cross HVDC project is one example of this type of resource available to TVA.

Renewable energy resources within the TVA footprint are considered "In-Valley" energy resources. These In-Valley resources are generally characterized as having higher installation costs and lower capacity factors compared to other wind energy resources, yet offer a number of co-benefits such job creation from the supply chain (local manufacturers, installers, technicians, etc.).

Figure 2: Wind and Solar Power Are Low-Cost
Unsubsidized and Subsidized Levelized Cost of Energy Comparison

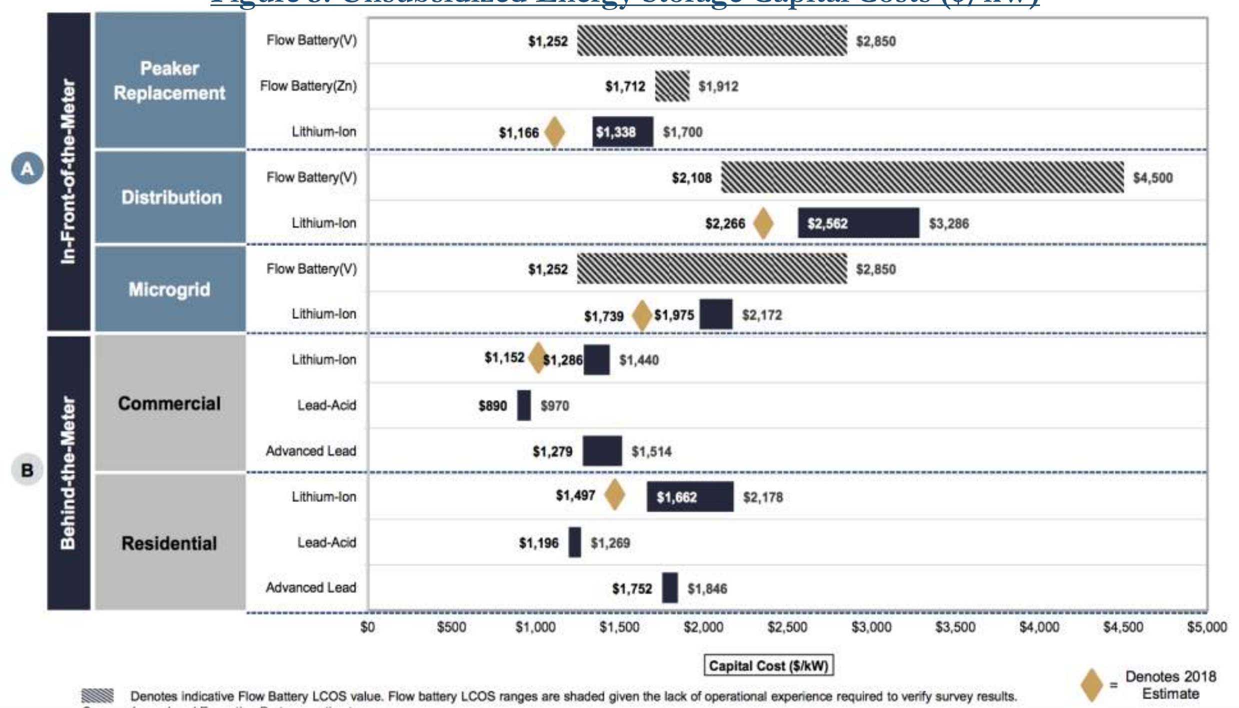


Source: Lazard Associates 2017[14]

Energy Storage Opportunities

Over the past few years, energy storage options have becoming increasingly available. Specifically, battery storage projects are now available in the hundreds-of-megawatts capacity and energy ranges. Because energy storage technology is so drastically different compared to either generation or load, it will be important to ensure modeling of energy storage systems accurately evaluates the full potential value stack. In organized markets (such as MISO and PJM), smaller energy storage projects can offer high-value voltage and frequency regulation; important sources of revenue for energy storage projects. Energy storage can also be coupled with wind energy or solar energy projects to provide load-shifting services, or energy arbitrage as a service. Recently, analysis by GTM Research found that within the next few years, battery storage will nearly always out-compete new peaking generation.[15]

Figure 3: Unsubsidized Energy Storage Capital Costs ($/kW)

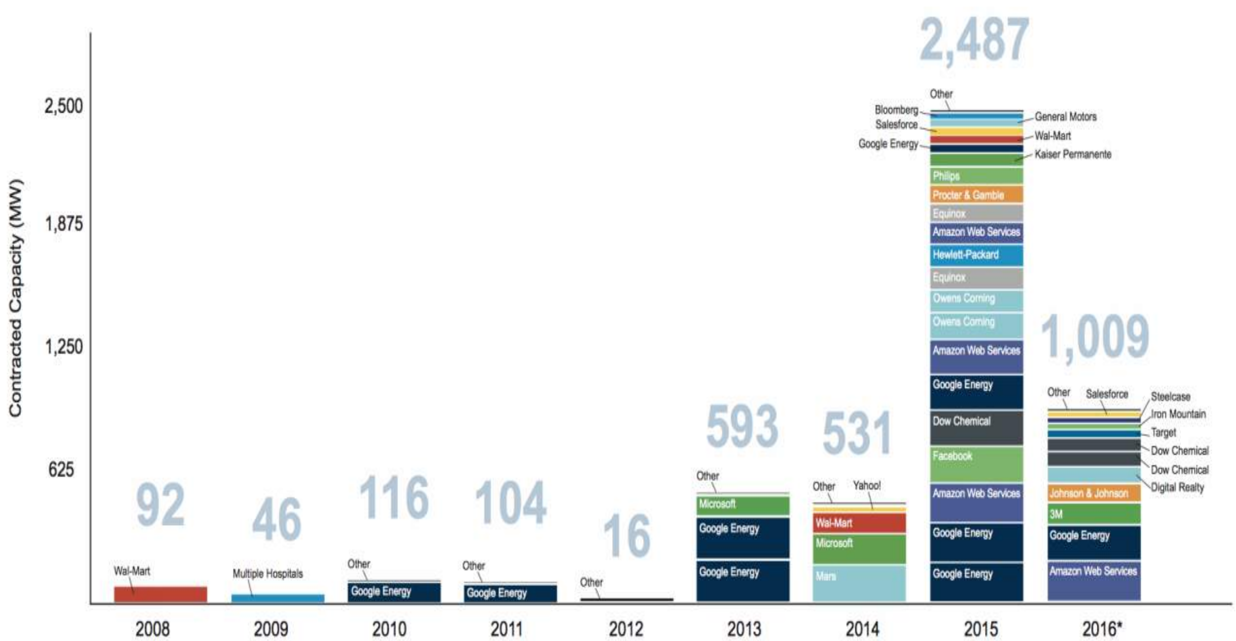


Source: Lazard Associates 2017[16]

BUSINESSES DEMAND RENEWABLE ENERGY

Corporations are increasingly voluntarily purchasing renewable energy, where possible with innovative efforts, such as TVA's work to attract a Google datacenter to Alabama.[17] Like many companies, Google plans to receive 100% of its electricity from renewable energy resources.[18] Businesses are actively seeking locations for new facilities that can access significant quantities of low-cost renewable energy resources. As large commercial customer demand increases for renewable energy, utilities need to adapt in order to serve these customers, or risk losing significant economic development benefits.

Figure 4: Corporate Renewable Energy Demand is Increasing



Source: AWEA 2017[19]

BUY WIND AND SOLAR SOONER RATHER THAN LATER

In December 2015, the United States Congress passed a long-term extension of the federal Production Tax Credit (PTC) for wind energy with a phase-out starting in 2016 and ending by 2020. The legislation also extended the federal Investment Tax Credit (ITC) for solar power projects, which declines from 30% value to 26% in 2020, 22% in 2021, and 10% thereafter. This extension is a prime opportunity that has created a distinct, urgent timeframe for TVA to take action. Recent reports indicate that prices are now so low that many utilities are finding that it makes sense to reach beyond their "needs" and "requirements" to begin locking in fuel savings for customers *now*. Given the extension of the tax credits, there is now a renewed need for TVA to develop a strong renewable energy procurement policy - *soon*.

TVA planning activities towards should be directed towards actively searching for renewable energy developments. TVA is one of many companies that stand to benefit from the extension of the ITC and PTC. A variety of southern electric utilities have announced wind and solar request for proposals (RFPs) this year, including many on a voluntary basis. Companies with a renewable energy policy have a competitive edge since their internal guidelines allow them to move quickly in the procurement process.

Timing is a key factor in the procurement process since the most cost-effective PPA prices will be in the near-term before the tax credits phase-out. The PTC declines annually in value by 20% until the credits phase out completely for wind energy projects starting construction in 2020. By delaying procurement of renewable energy resources, utilities risk losing hundreds of millions of dollars.

Figure 5. Expedited Wind Energy Purchasing Preserves Tax Credit Value

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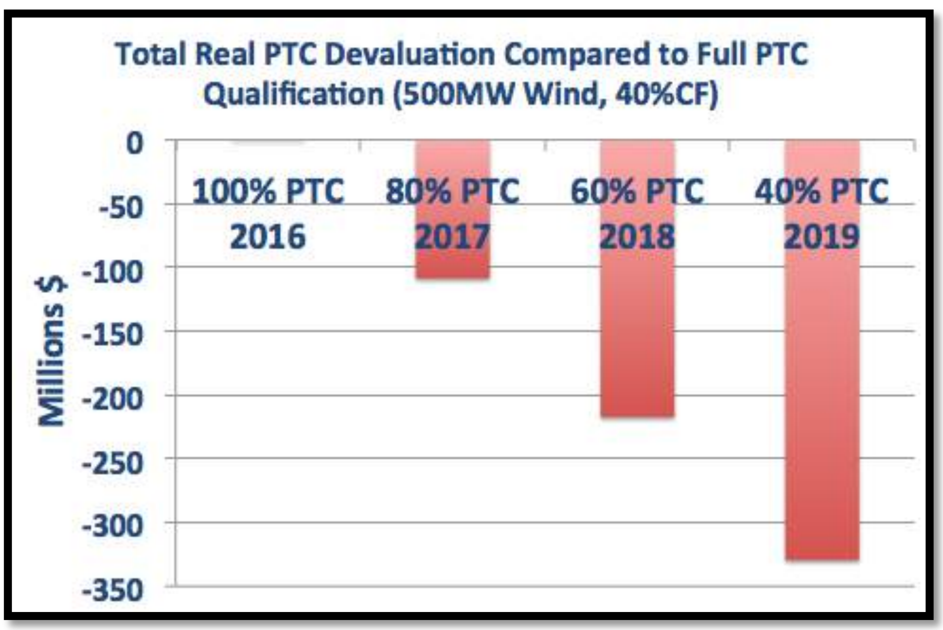

Source: SREA Analysis

Wind energy, solar energy and some energy storage projects can qualify for the PTC or ITC by "safe harboring" components or construction. By expending at least five percent of a project's total costs, a project can qualify for a particular year of the PTC/ITC. The IRS provides up to four years of "continuing construction" timing, so a wind energy project could begin construction in 2016 with an operational date of December 31, 2020, and still qualify for the full PTC. Similarly, a solar energy project could begin construction in 2019, and provide power delivery by December 31, 2023, and still qualify for the full 30% ITC. For energy storage projects that interconnect with either wind energy or solar energy projects (either new renewable projects or already existing projects), energy storage components qualify for the ITC at the same rate as outlined below.

Schedule of PTC/ITC Project Qualification In-Service Dates

	2019	2020	2021	2022	2023	2024	2025	Future
Wind PTC	$19.8/MWh	$19.8/MWh	$16.9/MWh	$14.2/MWh	$11.5/MWh	0	0	0
Solar ITC	30%	30%	30%	30%	30%	26%	22%	10%
+Storage ITC	30%	30%	30%	30%	30%	26%	22%	10%

Source: Adaptation from LBNL 2014[20]

2019 IRP Scoping Recommendations

- Renewable Energy Pricing and Performance:
  - For wind energy, TVA should use the NREL Annual Technology Baseline (ATB) "low" values for multiple wind energy resources, including a high-performance, mid-performance and lower-performance wind projects.
  - For solar energy, TVA should use NREL's ATB's "low" and "mid" values, with both 20% and 28% capacity factors, and evaluate fixed and single-axis tracking systems.
- Energy storage resources should be allowed to access multiple revenue streams including but not limited to frequency control, voltage regulation, energy arbitrage, peaking and other value stacks.
- Cost projections for renewable energy and energy storage should continually decline over time, while performance continually increases.
- Capacity values for renewable energy resources should be resource and geography specific, as well as seasonal (as winter and summer capacity values).
- Federal tax credits, including the PTC and ITC, should be incorporated for renewable energy and energy storage projects, as provided in these comments.
- Levelized cost of energy benchmarks (in $/MWh values) should be provided for all energy resources. LCOE values should be similar to Lazard Associates' and NREL ATB values.
- TVA should incorporate significant procurement of renewable energy and energy storage across all scenarios and strategies.
- TVA should evaluate a strategy that enables direct procurement of renewable energy and energy storage by large customers.

[1] Clean Technica (July 27, 2017). USA's Largest & World's Second-Largest Onshore Wind Farm (2 Gigawatt Farm) To Be Built In Oklahoma. [https://cleantechnica.com/2017/07/27/invenergy-ge-team-2-gw-worlds-second-largest-us-largest-onshore-wind-farm/]
[2] Greentech Media (August 31, 2016). New $3.6B Project in Iowa Could Be One of Many 'Mega' Wind Orders [https://www.greentechmedia.com/articles/read/iowas-new-3.6b-wind-project-could-be-one-of-many-mega-wind-orders]
[3] Southern Power (January 2017). Southern Power Projects - Wind. [https://www.southerncompany.com/our-companies/southern-power/projects.html]
[4] Solar Energy Industries Association (2018). Solar Market Insight Report 2017 Year in Review. [https://www.seia.org/research-resources/solar-market-insight-report-2017-year-review]
[5] Federal Register (February 4, 2010). "Environmental Assessment or Environmental Impact Statement for Purchase of Renewable Energy From CPV Ashley Wind Power Project in North Dakota," Notice by the Tennessee Valley Authority. [https://www.federalregister.gov/documents/2010/02/04/2010-2377/environmental-assessment-or-environmental-impact-statement-for-purchase-of-renewable-energy-from-cpv]
[6] Tennessee Valley Authority (2015). Integrated Resource Plan. [https://www.tva.gov/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf]
[7] TVA 2011 Integrated Resource Plan.
[8] Tennessee Valley Authority (September 2017). Requests for Proposals for Renewable Energy Resources "2017 Renewable RFP". [https://www.tva.com/file_source/TVA/Site%20Content/Information/rfp_2017_renewable_rfp_for_website.pdf]
[9] Clean Technica (July 27, 2017). USA's Largest & World's Second-Largest Onshore Wind Farm (2 Gigawatt Farm) To Be Built In Oklahoma. [https://cleantechnica.com/2017/07/27/invenergy-ge-team-2-gw-worlds-second-largest-us-largest-onshore-wind-farm/]
[10] Greentech Media (August 31, 2016). New $3.6B Project in Iowa Could Be One of Many 'Mega' Wind Orders [https://www.greentechmedia.com/articles/read/iowas-new-3.6b-wind-project-could-be-one-of-many-mega-wind-orders]
[11] Southern Power (January 2017). Southern Power Projects - Wind. [https://www.southerncompany.com/our-companies/southern-power/projects.html]
[12] Solar Energy Industries Association (2018). Solar Market Insight Report 2017 Year in Review. [https://www.seia.org/research-resources/solar-market-insight-report-2017-year-review]
[13] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]
[14] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]
[15] Ravi Manghani (March 2018). "Will Energy Storage Replace Peaker Plants?" GTM Research webinar.
[16] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[17] Tennessee Valley Authority (June 24, 2015). Google Chooses TVA Site for Next Data Center. [https://www.tva.gov/Newsroom/Press-Releases/Google-Chooses-TVA-Site-for-Next-Data-Center]
[18] Google (December 2016). Achieving our 100% Renewable Energy Purchasing Goal and Going Beyond. [https://static.googleusercontent.com/media/www.google.com/en//green/pdf/achieving-100-renewable-energy-purchasing-goal.pdf]
[19] American Wind Energy Association (2017). Evolution of the Corporate wind PPA: Market Insights.
[20] Mark Bolinger (April 2014). "An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives," Lawrence Berkeley National Lab.

Graham, Cierra

From: Aimee Mayer <amayer@cctenn.org>
Sent: Tuesday, April 03, 2018 4:17 PM
To: Integrated Resource Plan
Subject: TVA 2019 Integrated Resource Plan

TVA External Message. Please use caution when opening.

To Whom it May Concern:

Greetings! I am writing to ask that TVA move quickly to shut down greenhouse gas emitting coal plants and replace them with clean, renewable energy sources such as solar and wind power. Ideally, this would include giving financial incentives to individuals, houses or worship, and businesses to install solar panels.

As the biggest utility in the country, TVA can play a huge role in the world-wide effort to cut greenhouse gas emissions steeply on the way to meeting the Paris Climate Accord goal of keeping temperature rise above pre-industrial levels no higher than 1.5 degree Celcius (about 2.7 degrees Fahrenheit).

Thank you for creating more possibilities for earth-protecting (and life-protecting) clean energy!

Sincerely,
Aimee Shelide Mayer

Catholic Charities of Tennessee, Inc.
ACTS OF LOVE, GOODWILL AND KINDNESS

www.cctenn.org

Aimee A. Shelide Mayer
Advocacy & Social Concerns,
Program Coordinator

Administration

2806 McGavock Pike
Nashville, TN 37214
(P) 615-760-1019
(F) 615-352-8591
(M) amayer@cctenn.org

Name: JoAnn McIntosh

Comments: Responding to your questions on the Fact Sheet:
1. How do you think energy usage will change in the next 20 years in the Tennessee Valley?

Use of fossil fuels will diminish due to cost of retrieval, limited quantities, and damaging environmental impacts. Energy sources will have to move toward renewables such as solar and wind.

2. Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?

It should absolutely change. Coal and natural gas should be phased out for reasons above, nuclear should be phased out — certainly no new investments — for safety reasons, and renewables should become the primary generators.

3. How should distributed energy resources be considered in TVA planning?

DER should be developed, not discouraged. Various programs, e.g. community solar, have the potential to benefit TVA and its customers.

4.How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?

TVA should should encourage energy efficiency at all levels, including the promotion of EVs and their necessary infrastructure as fossil-fueled vehicles are phased out.

5. How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?

Reliability and dispatchibility should not suffer because of these decisions, but costs will inevitably fluctuate during transitional periods. It is important that TVA communicates openly with its customers about the necessity for changes and the long-term benefits.

From: Andrew White
To: Integrated Resource Plan
Cc: Colin Meehan
Subject: First Solar, Inc. TVA 2019 IRP scoping comments
Date: Monday, April 16, 2018 10:04:59 PM
Attachments: FSLR TVA IRP Scoping Comments FINAL 16April2018.pdf

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TVA External Message. Please use caution when opening.

Dear Ashley Pilakowski:

Please find attached scoping comments for the TVA 2019 IRP from First Solar, Inc.

Please don't hesitate to contact either of us should you have any questions.

Kind regards,
Andy White

Andrew White
State Government Affairs
Andrew.White@firstsolar.com
First Solar, 11757 Katy Freeway, Suite 400, Houston, TX, 77079
www.firstsolar.com | T: 281 509 6271| M: 303 250 5655

First Solar.

Tennessee Valley Authority
Ashley Pilakowski, NEPA Compliance Specialist
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902–1499

April 16, 2018

Re: Scoping Comments – Tennessee Valley Authority 2019 IRP

Dear Ashley Pilakowski:

On behalf of First Solar, thank you for the opportunity to provide scoping comments for TVA's 2019 IRP. First Solar is the largest U.S.-based manufacturer of photovoltaic (PV) solar modules and a leading global provider of comprehensive utility-scale PV systems, using our advanced module and system technology. First Solar has sold 10 GW of modules in the U.S., facilitated over $14.5 billion project financing, and currently provides operations and maintenance services for over 7.6 GW of PV solar systems. Our industry track record and global profile provides us with a unique vantage point from which to make recommendations for your consideration in the 2019 IRP process. We look forward to collaborating with TVA to ensure ratepayers have an affordable, reliable, clean, and low-risk energy portfolio.

TVA's power generation mix will evolve over the 20-year planning period in the 2019 IRP. These changes will be primarily driven by shifting generation technology economics,[1] production profiles, and demand-driven system needs. In order to deploy the most efficient and least-cost portfolio, we encourage TVA to ensure it is using the most timely and accurate information available in order to allow the planning model to select resource choices. Accordingly, we urge TVA to consider the following points in order to ensure its models yield the most accurate results:

- **Model utility-scale PV at scales of at least 50MWac**. Economies of scale have a substantial impact on cost-per-watt calculations. Modeling at scale ensures that the IRP process more accurately assesses the economics of utility-scale PV.

- **Leverage the most recently available capital cost estimates and PV production profiles**. PV technologies are rapidly evolving. Manufacturers are continuously investing in technology, which is

[1] For example, Lazard has found, on an unsubsidized leveled cost of energy comparison, that utility-scale PV has decreased in price by 86% from 2009 to 2017, demonstrating a downward price trajectory irrespective of the ITC. Presently, utility-scale solar can be cost competitive with lowest-cost conventional energy resources. Lazard, Levelized Cost of Energy Analysis (Version 11.0) 10-11 (Nov. 2017), https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf.

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Tempe, Arizona 85281 USA *Facsimile* 602 414 9400 www.firstsolar.com

First Solar.

driving rapid improvements in production efficiency while simultaneously lowering the cost of products. Due to these rapidly declining costs, and the sensitivity of models to capital cost assumptions, modeling results used to identify resource additions can be wildly inaccurate if the capital cost and production assumptions are even a year old. TVA has several options for ensuring that this data reflects current market realities. First Solar suggests a combination of relying on TVA's September 2017 RFP results and using published third-party market data, such as Bloomberg New Energy Finance's capital cost data, which provides recent price points at various scales for different regions of the country.[2]

- **Model multiple utility-scale PV configurations.** Much like TVA models around multiple natural gas plant configurations, utility-scale PV must be modeled to accurately capture the most effective and efficient configurations for TVA's system. A major advantage of utility-scale PV facilities is their modularity, creating an opportunity for customizable projects in terms of size and layout to meet system needs. This allows a level of optimization with utility-scale PV unavailable for other technologies and can be even more important in assessing value to the system than for other resources. Some examples include modeling configurations in 50MWac increments up to 200MWac using both fixed-tilt (south and west orientations) and single-axis tracking configurations.
- **Model utility-scale PV with battery storage.** Pairing utility-scale PV with battery storage unlocks a wealth of flexibility in terms of energy delivery timing. A battery storage component allows a utility to dispatch energy generated by a utility-scale PV plant at any time of day, and utilities are pursuing battery storage as part of their resource mix, with utilities in 14 states incorporating upwards of 2 GW of storage as part of their integrated resource planning.[3]

In addition to the above modeling suggestions, it is important to take into account capabilities of utility-scale PV that allow systems to meet grid operator needs by providing both ancillary and other grid reliability services. Conducted in partnership with the California Independent System Operator and First Solar, a 2017 National Renewable Energy Laboratory study demonstrated the abilities of a 300 MW PV plant to provide services usually provided by natural-gas-fired peaker plants.[4] The PV plant was able meet North American Electric Reliability Corporation standards for operating flexibility through orchestrated curtailment following ISO/RTO automatic generation control signals, frequency regulation commands, and use of inverters for voltage, power factor, and reactive power control. Importantly, the report concluded that the PV plant demonstrated the ability to deliver

[2] Bloomberg New Energy Finance, *2H 2017 U.S. Renewable Energy Market Outlook,* (Dec. 13, 2017).
[3] Mike Munsell, *US Energy Storage Deployments Up 46 Percent Annually in Q3 2017*, GTM Research (Dec. 7, 2017), https://www.greentechmedia.com/articles/read/us-energy-storage-deployments-up-46-percent-annually-in-q3-2017#gs.hasx3io; *see also*, APS, First Solar Partner on Arizona's Largest Battery Storage Project (Feb. 12, 2018), http://investor.firstsolar.com/news-releases/news-release-details/aps-first-solar-partner-arizonas-largest-battery-storage-project.
[4] National Renwable Energy Laboratory, *Demonstration of Essential Reliability Services by a 300 MW Photo-Voltaic Power Plant* (March 2017) http://www.nrel.gov/docs/fy17osti/67799.pdf.

those capabilities *more* effectively than the gas-fired alternative under all tested solar conditions.

Other capabilities of a utility-scale solar PV plant include:

- Power Ramping (ability to follow AGC dispatch signals by the system operator)
  - Ramping its real-power output at a specific ramp-rate
  - Provide regulation up/down service
- Voltage Regulation Control
  - Control a specific voltage schedule
  - Operate at a constant power factor
  - Produce a constant level of MVAR
  - Provide controllable reactive support (droop setting)
  - Provide reactive support at night
- Frequency Response (spinning reserve capacity)
  - Provide frequency response for low frequency & high frequency events
  - Control the speed of frequency response
  - Provide fast frequency response

These reliability capabilities, used in grid management and in some cases providing increased capabilities compared to conventional resources, are operational and available today for utility-scale PV plants. These capabilities enable PV plants to behave more like conventional generators and contribute actively to grid reliability and stability, providing significant value to utilities and grid operators. TVA should consider recognizing these benefits when planning future resource additions.

Thank you for your consideration, and we look forward to working with TVA in the 2019 IRP process. Should you have any questions, please feel free to reach me at Colin.Meehan@FirstSolar.com or 512.998.2207.

Sincerely,

Colin Meehan
Director, Regulatory and Public Affairs

From:	Madison Coburn
To:	Integrated Resource Plan
Cc:	John Brunini
Subject:	2019 IRP EIS Public Comments
Date:	Thursday, April 05, 2018 7:01:42 PM
Attachments:	TVA IRP Letter -MMA_41432760_1.PDF

TVA External Message. Please use caution when opening.

To whom it concerns:

Attached to this email, please find a letter submitted by the Mississippi Manufacturers Association for consideration in TVA's Integrated Resource Plan Environmental Impact Statement process.

Best personal regards,

Madison Coburn

Madison E. Coburn
Butler Snow LLP

D: (601) 985-4490 | F: (601) 985-4500
1020 Highland Colony Parkway, Suite 1400, Ridgeland, MS 39157
P.O. Box 6010, Ridgeland, MS 39158-6010
Madison.Coburn@butlersnow.com | vCard | Bio

Twitter | LinkedIn | Facebook | YouTube

MMA

Mississippi Manufacturers Association

April 4, 2018

Ms. Ashley Pilakowski
NEPA Project Manager
Tennessee Valley Authority
400 West Summit Hill Dr., WT 11D
Knoxville, TN 37902

Dear Ms. Pilakowski:

Manufacturing plays an important role in our nation's economy and in Mississippi is a significant source of jobs for our citizens. As one of the largest contributors to our state's economy, manufacturers need reliable and sustainable energy sources to ensure their ability to remain competitive and prosperous. Of the more than 3,000 manufacturers that the Mississippi Manufacturers Association represents, many reside in the Tennessee Valley region and rely on the Tennessee Valley Authority to provide affordable, reliable energy to their facilities.

Of the resources that TVA has available, one is the Red Hills Power Plant and in conjunction the Red Hills Coal Mine. The facilities at Red Hills are able to provide safe, clean, reliable and affordable baseload electricity that can be used to supply the region long term. The availability of stable, affordable electricity over the long-term will allow manufacturers in the area to plan and strategize more accurately for their future needs. Additionally, the use of Red Hills supports high-quality, high paying jobs in a rural, less populated area of our state. The economic impact that Red Hills provides is crucial to its region.

In the end, we all share the same goal of providing certainty and reliability to consumers in the Tennessee Valley region that will lead to long-term, sustainable economic growth throughout all of Mississippi. The Mississippi Manufacturers Association hopes that we can all work together to reach a solution that is beneficial to all parties involved while maintaining this shared goal.

Sincerely,

Jay C. Moon

Jay C. Moon, CEcD, FM, HLM
President and CEO

720 North President Street • P.O. Box 22607 • Jackson, MS 39225-2607
Office 601 948-1222 • Fax 601 948-1475 • www.mma-web.org

Name: Derek Moore

Comments: Regarding Fly Ash: In addition to the obvious environmental benefits of re-purposing versus dumping of fly ash, readily available commercial fly ash is important to our (the ready mix concrete) industry, as well as to the construction industry & end users/consumers. The use of fly ash in ready mix concrete lowers the cost of concrete, allows for cooler set times which reduces cracking issues, decreases water demand, makes concrete more water-tight, as well as improves workability, durability, and ultimate strength. Since the recent improvement in construction activity, periodic mild weather in our area has led to several short term fly ash shortages. These shortages necessitate that we change all concrete mix designs to straight cement mixes which are inferior to mixes containing fly ash for the previously noted reasons. These changes also cost our customers and our company/industry money since we must ship the more expensive straight cement mixes. This also causes additional non-productive workl since we must re-submit paperwork for the straight cement mixes on projects for which the engineers' specified & approved fly ash mixes for specific projects. Of course this also reduces LEED points which impact the GC's/owner's wallet.

Our fly ash vendor (SEFA) informed us that when TVAs generators are running beyond a certain level, more fly ash is produced than they (SEFA) can process. This results in the excess being disposed of as waste material. Then when mild weather or maintenance results in low coal burning production, fly ash shortages occur. It seems that some sort of storage facility should be considered so that stockpiles can be stored during peak coal burning in order to prevent pending shortages.

Thank you for your consideration.

Respectfully,
Derek

close window

Name: Perry Newton

Comments: I am almost 70 years old, and have lived in Mississippi since my birth. I think TVA is the best thing to ever happen to the Deep South. I think that, overall, it has been very well administered since its inception and continues to improve and sustain our way of life in America.
I do believe that we must upgrade and strengthen our entire national electric grid as soon as possible, and I believe that we must move rapidly towards the use of 'green' energy sources such as wind and solar energy. I am not a 'tree hugger', but it just makes sense to me to embrace renewable energy production because of all the positives associated with such a move. Even using nuclear energy does not alarm me, but I would want it to be a stop-gap measure to give us time to develop the infrastructure for harvesting renewable energy sources.
I am certainly no authority on this whole matter, but I am voicing the conclusions I have reached by observing the path of our country over the last 55 years or so. Our nation is in trouble and TVA can be a powerful force to help correct our course and sustain our blessed way of life. I pray for those of you who will be making these decisions for the IRP.
Thank you for letting me speak. Please do your best for us.

Sincerely,
Perry M. Newton

close window

From: Vince obrien
To: Integrated Resource Plan
Subject: Solar and wind energy
Date: Thursday, March 8, 2018 11:51:39 AM

TVA External Message. Please use caution when opening.

Dear TVA,
Clean energy is the future of energy. please support the future and give clean power and fresh air and water.

Vince O'Brien

Graham, Cierra

From: Cortney Piper <cortney@piper-communications.com>
Sent: Monday, April 16, 2018 8:48 PM
To: Integrated Resource Plan; Henry, Amy Burke
Cc: Matt Kisber; Thomas Ballard; Steve Bares; Chris Bowles; Trish Starkey; Marc Gibson; Mary Beth Hudson; James DeMouy; Jeff Kanel
Subject: TVA IRP comments

TVA External Message. Please use caution when opening.

April 16, 2018

To whom it may concern:

The Tennessee Advanced Energy Business Council (TAEBC) is pleased to submit the following comments to the Tennessee Valley Authority (TVA) regarding its 2019 Integrated Resource Plan (IRP) scoping.

TAEBC would like to reiterate our commitment to supporting TVA as it takes steps to proactively address the evolving utility marketplace. Our intent is to provide TVA with economic development data to inform the utility's decision on how best to meet future electricity demands.

TAEBC champions advanced energy as an economic development and job creation strategy. We exist to foster the growth of Tennessee's advanced energy technologies, companies and jobs. Advanced energy is technology neutral – anything that makes energy cleaner, safer, more secure or more efficient is in the tent. At its core, we look to energy innovation as an economic development opportunity.

We encourage TVA to examine the advanced energy industry and Tennessee's leadership position within the industry as it considers its 2019 IRP. This is a growing and lucrative sector of our economy. States and regions that provide an attractive home for this industry – and its workforce – will be rewarded with jobs and capital investment.

For example, Tennessee's advanced energy economy contributes $33 billion to our state's GDP, employs nearly 325,000 people, includes more than 17,000 business entities and pays an average annual wage that exceeds the state average.

From: Pritts, Jeremy (PRITTJX15)
To: Integrated Resource Plan
Subject: Comment on EIS; Availabilty, Etc.
Date: Thursday, March 8, 2018 1:25:23 PM
Attachments: EIS Comment.docx

TVA External Message. Please use caution when opening.

Dear Members of the Tennessee Valley Authority,

My name is Jeremy Pritts and I am emailing you today to inform you that my fellow student and I prepared a comment for your company's renewal of the EIS and IRP developed in 2015. Attached is the copy of our comment. Thank you for taking the time out of your day to consider our ideas and critiques.

Thanks,
Jeremy

Jeremy Pritts and Natalie Gibson
3/8/2018
Comment on TVA EIS Renewal

Our names are Jeremy Pritts and Natalie Gibson and we are both juniors at Juniata College, located in Huntingdon, PA. While looking for Environmental Impact Statements to comment on, we were intrigued by your scenario dealing with renewing your IRP and EIS. We are both concerned students that could be affected by some of the issues involved with your company and its legislation.

As concerned Environmental Science students, we are both extremely worried with the unintentional negative effects that the world could experience in the near future. Below is a list that us students believe that you should try to do in order to preserve the environment.

Recommended Actions:

We highly recommend utilizing vast amounts renewable resources when developing your Integrated Resource Plan. Although only 7 percent of your company's energy is from hydro processes, the fact that you have almost 30 hydroelectric dams impresses us and we encourage you to continue using cleaner energy than fossil fuels and other materials.

The major issue that we noticed when viewing the EIS that was prepared in 2015 is the large amount of energy being used to create energy within your company. We believe that 25 percent of your power supply from coal is too high of a number and could pose serious risks to the environment.

To address this issue, we recommend to continue to increase your renewable resource usage and possibly use more nuclear energy. Since nuclear energy contributes so heavily to the current output of power (38%), this resource seems to be working efficiently for you. We recommend either building a new nuclear reactor or innovating the current reactors to maximize nuclear energy output.

In conclusion, we believe that your heavy reliance on coal and other non-renewable resources is dangerous for the surrounding environments. Since TVA operates the nation's largest public power system, your company should be concerned for the future of energy and begin using new and cleaner energy methods. TVA needs to take action within this country and set an example for others in order to avoid the probable energy crisis that the world will face in the near future.

From: Jim Roberts
To: Integrated Resource Plan
Subject: Consideration for Mix of Power Sources
Date: Thursday, February 15, 2018 10:48:45 AM

TVA External Message. Please use caution when opening.

As even Conservative and Republican sources no longer deny that Man Caused Climate Change is a reality, kindly take as an Operational Edict that, as Renewable Energy Sources of Wind and Solar (especially Solar Thermal Power) have the least carbon footprint in manufacture, and the least generation of effluents and greenhouse gases in operation, they should become the largest constituent power source for TVA. Any larger costs of implementation will be recouped by lower operating costs.

Gentlemen, I told you this in 2015, I am telling you again. Kindly take heed- it is your customers and their children who will pay the ongoing costs of your failure to so do.

James D. Roberts
2700 Canton Pike
Hopkinsville, KT 42240-1659

12jim12@twc.com
(270) 985-8574

Graham, Cierra

From: Grace Robertson <grace.s.robertson@gmail.com>
Sent: Friday, April 13, 2018 3:18 PM
To: Integrated Resource Plan
Subject: IRP comments

TVA External Message. Please use caution when opening.

Dear TVA IRP staff,

As a Tennessean, born and raised in Nashville, it pleases me very much to know that demand for electricity in the TVA area is flat or declining, even as we see population and the economy grow. We should celebrate the de-coupling of electricity demand and economic growth. Generating less electricity while meeting demand means we will have less toxic coal ash, less radioactive waste, and fewer air pollutants and greenhouse gas emissions. These benefits are numerous and life-saving for generations to come. Needless to say, energy efficiency gains have saved many homeowners, businesses and municipalities money on their electric bills.

At a time when we see coal ash cleanup workers dying from their work, coal ash ponds leaking toxins into waterways, and no safe way to store spent nuclear fuel, there is every reason for TVA to promote and incentivize energy efficiency, allow much more distributed solar for the commercial and residential sectors, increase participation levels for Community Solar with Local Power Companies, and pursue TVA-owned or PPA utility-scale solar.

Utilities in states surrounding the TVA service area are moving towards more solar to meet the demand of their customers. Here are just two recent news stories about solar growth in Georgia and Arkansas, facilitated by the utility companies:

GA Power: http://markets.businessinsider.com/news/stocks/georgia-power-to-add-177-mw-of-solar-resources-for-c-i-redi-program-1020961133

Arkansas utilities: http://www.arkansasbusiness.com/article/121550/solar-leads-way-as-net-metering-has-record-year

I urge TVA to include in the IRP the following items:

- Continuation and escalation of energy efficiency efforts that have led to flat or declining demand for electricity. EE should be the bed rock of the IRP. Through rate structures, rebates and outreach, TVA should encourage every homeowner, business and organization to become as energy efficient as possible.
- Net-metering for solar, or at least pay escalating retail rate for solar sold as part of Green Power Providers Program (GPP). Increase GPP program cap and system size cap to remove barriers on growth.
- Increase program cap of Distributed Solar Solutions for LPCS to allow LPCs to build as much solar as they can
- Include electric vehicle (EV) incentives like rebates
- Include the costs of coal sludge clean ups and remediation in the cost of your calculation for kWh rates for coal generated power

- No Small Module Reactors. Small modular reactors are too costly, too slow to bring on line, too uncertain, and have a high environmental impact and risk. Current national high level radioactive waste disposal practices would leave this dangerous waste on site for decades or much longer after final reactor shut-down.

- Invest in storage solutions

Innovation in energy efficiency, solar, EVs, and storage are here. Other utilities are moving to modernize in order to reduce pollution, reduce costs and meet their customers' demand for efficiency and clean and cheaper power. Please rise to the occasion! TVA ratepayers want innovation, not business as usual.

Thanks for your time and consideration,

Grace Robertson

8475 Poplar Creek Rd

Nashville, TN 37221

615-812-6861

From:	Rutledge, Nicholas Drake
To:	Integrated Resource Plan
Subject:	A Few Thoughts on the IRP
Date:	Thursday, February 22, 2018 3:32:48 PM
Attachments:	image002.png image004.jpg image006.jpg image008.jpg image010.jpg image012.jpg image014.jpg image016.jpg

Hello,

My name is Nick Rutledge and I am a Protection Engineer in the System Protection department and wanted to take a few minutes to share some of my thoughts on the Integrated Resource Plan (IRP). I've seen a few things change and evolve since the last one and there are some things I think that can be learned from it.

- I question the conclusion of "little to no load increase on the TVA system" for 2025-2030 (depending on the model). I do not feel this conclusion stands the test of basic physics, laws of thermodynamics, or conservation of energy. One can look at the metropolitan area of Nashville alone and the construction/industry moving in and see that can't be true. When you include areas of Mississippi that are experiencing tremendous industry growth, I feel very strongly that our load can and will increase in the next 10-15 years.
- Touching on the point above, one of the conclusions reached in the last IRP stated that the days of 32,000 MW+ system load seen before 2007 would not be seen again until ~2025, eliminating the need to build a major generating asset. 3 of the past 5 winters at TVA have proven that false.
    - There is an old phrase that says "You don't design and build a church for Christmas and Easter." In the case of an electric system, we don't have that luxury. We <u>have</u> to prepare for the worst case system load and I feel strongly that our reserve margin is not sufficient enough to sustain the types of loads possible on an extremely hot summer day or extremely cold winter day. We have to improve our system and design our future generating assets to where we can adequately be prepared for our margin needs. At some point, you can't buy your way or transmit your way out of a megawatt deficit. You have to <u>generate</u> your way out of it.
- For the 161kV System: Distributed resources can be a good thing on the TVA 161kV system. However, wind/solar/cogen/geothermal/etc. IPP partners need to "play nicer" on the 161kV system. I recommend that any new renewable energy installation be placed within 5 miles of a breakered station (whether it's a substation, generating plant or switching station) and be required to terminate their source that station own separate breaker/bay. Doing this will eliminate operational issues they create on some of our relaying schemes and significantly simplify the design and operation of it. Furthermore, it eliminates the risk of an unknown generation asset being able to knock a customer tap offline due to a relay or solar array misoperation on the part of the IPP.
- My last point (and most important): Renewable energy resources must <u>**NEVER**</u> be allowed to connect directly to the TVA 500kV system. It is far too critical and the fault current

requirements are far too high to allow a renewable energy resource to connect to it. An error here could have catastrophic consequences on the TVA and Bulk Electric System.

I appreciate the time being devoted to the IRP and thank you for reading and hearing my thoughts. Please let me know if you have any questions.

Sincerely,

Nick Rutledge, PE
I&C Protection Engineer
TVA Transmission Engineering - System Protection

Tennessee Valley Authority
1101 Market Street, MR 4K-C
Chattanooga, TN 37402

423-751-2486 (w)
ndrutled@tva.gov

Graham, Cierra

From:	Schiller, Joseph <SchillerJ@apsu.edu>
Sent:	Friday, April 13, 2018 11:32 AM
To:	Integrated Resource Plan
Subject:	Comments on TVA SRP

TVA External Message. Please use caution when opening.

Thank you for considering my comments on TVAs 2019 Strategic Resource Planning process. TVA outlines the following objectives for its Strategic Resource Plan (SRP):

Diverse portfolio
Low cost
Reliable
Risk informed
Environmentally responsible
Flexible

While the current SRP is in process, it is instructive to consider how TVA's portfolio has changed over time in order to assess to what extent it has achieved the objectives of the current and previous SRPs.

TVA provides a summary of its past, present, and projected power portfolios at https://www.tva.gov/Energy/Our-Power-System.

Evaluating each generation technology in the projected portfolios in light of the stated objectives of the SRP process it is striking how contradictory the portfolios are relative to the stated objectives of the SRP. It is important to note that the referenced portfolios were presumably derived from the results of the previous SRPs conducted in 2010 and 2015 which shared many of the same objectives.

Considering nuclear first, notice that TVA projects to increase nuclear to 40% or more of its generating portfolio. Since the 2015 SRP TVA has spent an estimated $4.7 billion to complete Watts Bar 2 and is in the process of spending over $0.5 billion to upgrade Brown's Ferry nuclear reactor units. This action directly contradicts the stated objectives of the SRP. First, it is not increasing the diversity of the portfolio. Even if TVA acknowledges the necessity of eventually eliminating fossil fueled generation (something they have never done), the maximum proportion of generation from any one generation technology consisting of nuclear, hydro, wind, and solar would be 25%. Pushing nuclear to over 40% is decreasing portfolio diversity. If TVA continues to rely on coal and natural gas for power generation, then about 16.5% nuclear generation would represent a perfectly balanced generation portfolio. Compounding the contradiction to the stated SRP objectives is the fact that nuclear is the highest cost technology. This contradicts the stated objective of Low Cost. TVA justifies this by citing the operating cost of nuclear while ignoring the construction cost. However the operating cost of nuclear is only low compared to fossil technologies. Hydro, wind, and solar operating costs are lower than nuclear. TVA considers nuclear to be reliable; however, all of TVA's nuclear power plants have experienced safety related shutdowns. Some of these shutdowns have lasted years and required costly fixes—how is this reliable? TVA's pursuit of nuclear in disregard of its SRP objectives is epitomized by the fact that nuclear cannot be considered environmentally responsible if, and until, there is a solution to the disposal of nuclear waste. Lastly, it is widely understood in the power industry that nuclear is among the least flexible of electricity generating technologies. While European nuclear operators have demonstrated that nuclear power has more ramping capability than US operators generally acknowledge, this is achieved at a considerable economic penalty because the economics of nuclear depend upon maximizing power output to amortize its huge capital costs.

Support for the above facts is obtained from independent organizations outside of TVA that monitor relative costs of various power generating technologies. For example, Lazard Asset Management, a $224 billion investment management fund specializing in traditional and alternative energy investments reports that nuclear has the highest Levelized Cost of Energy (LCOE) relative to all other generation technologies (https://www.lazard.com/perspective/levelized-cost-of-energy-2017/), Additional evidence is implicit in the fact that there have been no successful nuclear electricity generation projects completed in The USA since 1996 save Watts Bar 2 by TVA. Finally, five nuclear generating facilities have closed and an additional six are scheduled for closure before the end of their operating licenses because they cannot compete with alternative electricity generation. Several more are teetering on the brink of closure (National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications, Technical Report NREL/TP-6A20-68548 October 2017).

The next largest source of power in TVA's portfolio is coal. Referring to the above portfolio projections from TVA's web page, it appears TVA only anticipates retiring about 4% of its remaining coal fleet. Again this contradicts virtually all of the stated objectives of the SRP given that maintaining this much coal generation impedes TVA's ability to increase the diversity of its portfolio and because coal is widely acknowledged to be among the costliest, dirtiest, and least flexible of power generation technologies. Given the overrepresentation of nuclear in TVA's portfolio which is difficult to now rectify, the best scenario going forward is to balance the surplus of nuclear in the portfolio with a large reduction in coal generation. Thus, the nuclear surplus can serve as the opportunity to substitute cheaper, and cleaner renewable generation for a greater reduction in coal generation.

The cost and other liabilities associated with coal production are demonstrated by the large number of coal plant closures that have occurred and will continue to occur throughout the USA. Since 2010 262 coal plants, representing over half US coal generation in the USA, has retired or announced retirement. In recent RFP solicitations for new utility generating capacity, virtually no coal bids are occurring. This suggests no new coal plants are cost competitive. In addition, in increasing areas of the country generating power with wind is becoming cheaper than continuing to operate existing coal plants.

Currently Natural gas makes up almost as much of TVA's power portfolio as coal and TVA projects little change in this resource. For now gas generation does meet TVA's RPS cost, reliability, and flexibility objectives, but this is likely to change soon. Currently wind generation is the cheapest source of power in 25 states and will become cheapest in another 11 states within a year or two. This includes states geographically close to Tennessee such as Missouri, Illinois, Indiana, Ohio, and West Virginia. While some natural gas plants can be ramped up and down quickly, it is estimated that within a very few years battery storage will begin to displace gas plants for grid management services related to reliability and flexibility. Continued reliance on natural gas does not meet the other SRP objectives. Gas is already overrepresented in a diverse portfolio, has significant negative environmental impacts, and gas prices have historically been subject to volatile price swings.

TVA has long been known for its hydro resources and their management. One way TVA should be exploring ways to increase this cost effective, clean, reliable, risk averse, environmentally safe, and flexible resource is through significantly increased use of pumped storage to support large amounts of renewable generation in its portfolio.

Wind, solar, and energy efficiency currently make up less than 4% of TVA's portfolio. Clearly these resources should be dramatically increased if TVA is serious about the stated objectives of its SRP. The underrepresentation of these generation resources in TVA's portfolio is a direct result of inaccurate past and current cost assumptions on the part of TVA. For example, a direct quote from TVAs current web page on renewables states:

"*Solar is one of the cleanest sources of energy available. And for now, it's also one of the most expensive*."

We call BS. See the latest report from Lazard Asset Management at https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

Utility scale solar is now less expensive than any other new energy source technology save wind. Further, the cost of new solar and wind is projected to continue to decline. Note also that nuclear is one of the highest cost sources of new electricity generation. And yet, referring to projected energy portfolio above, the TVA expects to increase nuclear, the most expensive power source, the most, while increasing the lowest cost sources, wind and solar, the least! Additionally, TVA apparently projects that it will continue to operate most of its coal and natural gas plants despite the fact that most energy industry experts predict that new solar and wind will be less costly than continuing to operate already built coal plants and even some natural gas plants within the next few years!

Collectively, these projections are a direct contradiction of TVA's stated objectives for the SRP. It is not possible to diversify your portfolio by expanding the largest segment of that portfolio. It is not possible to optimize cost by expanding the most costly segment of the existing portfolio at the expense of the least costly. It is not possible to increase reliability by reducing the diversity of the portfolio. It is not a risk informed plan that relies on potentially price volatile fuel resources such as natural gas and coal over resources with no fuel cost. It certainly is not environmentally responsible to continue using large amounts of fossil fuels when too much greenhouse gas emissions are already causing dangerous levels of global climate change. Lastly, it is not possible to increase the flexibility of the power system by increasing the least flexible resource, i.e., nuclear, the most in the portfolio.

No doubt, TVA will object that wind and solar are intermittent and require other generation resources as back-up when the wind does not blow and the sun is not shining. One problem with that argument is the fact that many other utilities across the country have already successfully integrated much larger percentages of wind and solar into their portfolios with no increase in cost or decrease in reliability and flexibility. Many of these utilities do not have the large hydro resource that TVA can use to provide these back-up services. And TVA can expand this hydro resource with strategic additions to its pumped hydro storage capabilities. Additionally, battery prices are already beginning to outcompete coal facilities for providing these services and are projected to be outcompeting gas generation within a few years.

In summary, there is no reason for TVA not to increase the diversity of its power generation portfolio with significant additions of hydro, wind, and solar resources combined, initially, with reductions in costly and environmentally destructive coal plant retirement, followed gradually by retirement of gas plant retirement to further reduce costs and environmental damage.

Joseph R. Schiller, Ph.D.

Name: Amanda Schweighardt

Comments: TVA operates numerous coal-fired power plants and will likely continue to do so for the foreseeable future. Fly Ash produced as a by-product of burning coal is a critically important resource for the ready mix concrete industry, as well as related concrete production industries. As recent events in Tennessee and elsewhere have demonstrated the fly ash produced by the production of electricity through the burning of coal places significant liability on the operators of such power plants, and can become a significant financial liability to the operators and by extension to the rate-payers who use this electricity. The historical methods of landfilling coal combustion byproducts have proven to create significant and ongoing environmental concerns for both the power plants and surrounding communities.

TVA should move quickly to embrace existing technology that allows landfilled (either dry or wet) fly ash to be beneficiated and sold to industry. While not all landfilled fly ash can be beneficiated and sold as a commercial product, a significant portion of such landfilled fly ash can be recovered and sold to industry. This permanently reduces the need to landfill and manage fly ash while improving the quality of the construction in which such fly ash is utilized. In addition, some beneficiation process can be used to treat both landfilled fly ash as well as the fly ash resulting from current electricity production. In these cases, the cost of landfilling fly ash is avoided on the front end and revenue can be realized to offset any additional cost related to the specific beneficiation process.

The concrete industry is currently facing persistent and recurring shortages of commercial grade fly ash even in areas such as Tennessee where much of our electricity is produced from burning coal. This is due primarily to the variability in the fly ash that results from current operational practices utilities employ as they produce electricity. This type of variability can be addressed by various beneficiation processes that are already commercially available in the marketplace.

A key factor here is that commercial grade fly ash has a definitive market-value and a well-established market demand throughout the Southeast. The ongoing need for such fly ash is real and well recognized within the concrete industry where fly ash has become a critical component in the production of everyday commercial concrete as well as high-performance concrete for tall buildings, bridges and other structures that utilize concrete. TVA should recognize and embrace their responsibility to better manage fly ash produced at it's power plants by making this product available to industry as a first priority rather than using landfilling as the first option.

Landfilled fly ash represents an ongoing liability for utilities that is quite likely to grow over time and one that will never completely disappear. Employing technology to beneficiate fly ash and make it available to industry represents a permanent and responsible solution that creates an additional revenue stream for the utility and eliminates the creation of a lingering and potentially immense liability from landfilling fly ash.

TVA's future Integrated Resource Plan should recognize and immediately begin to implement the existing technology described above. This clearly meets the objectives outlined in the request for comments on the 2019 IRP as shown below:

The 2019 IRP will consider many views of the future to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Valley over the next 20 years. As part of the IRP decision-making process, and in alignment with the National Environmental Policy Act (NEPA), TVA will analyze potential environmental implications associated with an updated IRP by issuing an environmental impact statement (EIS).

Implementing a long-term strategy to beneficiate currently produced fly ash and to recover (where feasible) landfilled fly ash meets every criteria listed above:

1. Beneficiated fly ash is commercially viable product with a demand that extends at least 20 years into the future and can help reduce the cost of electricity produced by TVA.

2. Diverting fly ash to beneficial industrial use that safely incorporates the fly ash into the product (like concrete) is a far preferable method for TVA to demonstrate environmental stewardship.

3. A steady, consistent source of fly will allow concrete producers to provide higher-quality, lower cost concrete for construction that will aid in economic development for the communities served by TVA.

4. Employing technology to reduce existing stocks of landfilled fly ash while potentially eliminating the need for future landfilling with fly ash is a crystal-clear environmental benefit as compared to the current practices, and will lower TVA's environmental impact on the communities they serve.

close window

Name: Paul Slentz

Comments: As a United Methodist pastor, I believe strongly that care for the good gift of creation is a matter of faith and a moral issue. Scientists are warning us that all nations must move rapidly to reduce total greenhouse gas emissions in order to avoid catastrophic climate change. TVA can and should be a leader in shifting its portfolio very quickly to a much greater percentage of solar and wind power. It should shut down the remaining coal-fired power plants also as quickly as possible. Furthermore, steps should be taken to encourage individual customers in the TVA region to install roof-top solar. I made the following statement to the TVA Board of Directors at the public hearing on Feb. 16, 2018.

Good morning! My name is Paul Slentz. I am a pastor in the Tennessee Conference of The United Methodist Church and President of Tennessee Interfaith Power and Light, an interfaith Earth care organization. In gratitude for the gift of creation, our focus is confronting the climate crisis by encouraging conservation, promoting a clean-energy economy, and protecting especially vulnerable communities.

I want to start by thanking you for your time and thanking TVA for providing electricity for millions of people in Tennessee and surrounding states. I'm sure that is no small task.

The reason I am here this morning is to say that "we have a problem." And when I say "we," I mean not only us in this room, but all people throughout the whole earth.

Prominent scientists, including ones from NASA and NOAA, are telling us that if humankind doesn't radically reduce our greenhouse gas emissions very quickly, the global climate will be altered in catastrophic ways. And in fact, the climate is already changing in ways that are harmful for humanity and the creatures we share God's good creation with – witness the growing intensity of hurricanes in the Southeast and wildfires in the West.

So, we have a problem. And when I say "we" this time, I do want to focus on the "we" in this room. Because we here today have a great deal more power than most people in the world to do something. The interfaith organization that I help lead has some power. We are exercising it by educating faith communities on ways they can reduce their carbon footprint.

But you members of the TVA Board have a lot more power to do something about the problem.

TVA has taken some steps, such as the closing of some coal-fired power plants and that is good. But I am terribly concerned that too little is being done by TVA to increase the percentage of renewable energy sources in its power portfolio. The 2015 Integrated Resources Plan introduces solar and wind too slowly, relies too heavily on natural gas which is a climate changing greenhouse gas, and does not close coal-fired plants quickly enough.

If the scientists we trust to put humans into space are correct, small tentative steps are not enough to deal with the climate crisis we are facing. Bold strides are needed now. TVA, as the biggest utility in the U.S., should be a leader in clean energy and yet that is not currently the case.

It is our prayer that you will move quickly to address our common problem. We will do our small part. We will conserve and make clean energy choices. But what we can do in our homes and our places of worship is dwarfed by what you can do by shifting TVA's energy portfolio quickly to increase the percentage from solar and wind power.

We have a problem. Let's work on it together. Our children and grandchildren are counting on us. Thank you.

close window

From:	Colleen Smith
To:	Integrated Resource Plan
Cc:	Christopher Bursaw
Subject:	Capital Power Comments - TVA IRP
Date:	Monday, April 16, 2018 1:36:45 PM
Attachments:	TVA 2019 IRP_ Capital Power Comments.pdf

TVA External Message. Please use caution when opening.

On behalf of Capital Power Corporation, please see attached comments addressing questions raised by TVA in developing its 2019 Integrated Resource Plan.   Please do not hesitate to contact us if you have any questions and/or would wish to discuss these comments further.

Kind Regards,

Colleen Smith
Capital Power
155 Federal Street, Suite 1200
Boston, MA 02110
(617) 330-1326

Capital Power Corporation
155 Federal Street, Suite 1200
Boston, MA 02110
www.capitalpower.com
(617) 330-1326

Tennessee Valley Authority
2019 Integrated Resource Plan
Comments of Capital Power Corporation

Capital Power Corporation ("Capital Power") is an independent power producer that currently owns more than 4,500 megawatts of power generation across North America. In the U.S., Capital Power owns the 795 MW natural gas combined cycle plan, Decatur Energy Center, located in northern Alabama within the Tennessee Valley Authority ("TVA") service territory. Capital Power also owns solar and wind facilities, two mixed biomass-fueled plants and has an active development portfolio of additional gas and renewable projects.

Capital Power appreciates the opportunity to provide comments to TVA regarding it's 2019 Integrated Resource Plan ("IRP"). Public involvement is a critical component of the IRP process and we encourage TVA to continue its collaborative effort in developing a blueprint that satisfies its electricity needs with low cost and reliable power generation.

Capital Power respectfully offers the following comments on the specific questions posed by TVA as part of the scoping process.

1. *How do you think energy usage will change in the next 20 years in the Tennessee Valley?*

Load growth has been anemic in many regions of the country including the Tennessee Valley due to conservation measures, efficiency programs, and a slowdown in manufacturing. This trend will continue in the near term, but once the low hanging fruit of conservation and efficiency has been picked, the growing population and industrial sector (as evidenced by Toyota and Volkswagen's recent announcements to increase car manufacturing in the region) will once again put additional demands on the TVA system.

2. *Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?*

The power generation mix should continue its current trajectory of declining coal production, increased natural gas consumption and expansion of renewable energy. These current trends are driven by low natural gas prices, decreasing costs for renewable technologies, and implementation of policies that encourage the use of zero-emitting generation.

TVA is currently following this trajectory with its diverse portfolio of generation, which will likely become more reliant on natural gas as a baseload resource to accommodate the growth of intermittent resources such as solar and wind. With coal retiring and nuclear and hydro likely seeing neither growth nor decline, natural gas will continue to play a critical role in meeting TVA's goal to provide reliable, low cost energy to its customers.

3. *How should distributed energy resources be considered in TVA planning?*

The growth of distributed energy resources will help balance out peak and off-peak load shapes. This should deemphasize the need for peaking units, while placing additional value on base and intermediate type generation units. Combined cycles, with their efficiency and low cost of natural gas, should play a greater role as distributed energy resources change the load shapes to a more constant load.

4. *How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?*

Energy efficiency and demand response play a significant role in keeping load growth flat or slightly negative in the near-term. While these measures can keep energy usage flat on a per-capita basis, at some point in the mid-term (5 – 10 years), the continued growth in population, housing, and the economy, will create an uptick in load growth that cannot be met with energy efficiency and demand response alone.

5. *How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?*

A diverse portfolio of resources supported by baseload generation will be key in ensuring a reliable and cost-effective power supply in the future. Increased renewable generation and DER continue to raise reliability concerns given their intermittent nature and non-dispatchable qualities respectively. With these generation sources expanding, it is now more important than ever to maintain baseload generation. Natural gas generation is the most cost-effective way to ensure reliability for TVA's power grid.

Name: R. Steve Smith

Comments: Text of Comments Filed by Alan Sparkman for TVA's 2019 IRP.

TVA operates numerous coal-fired power plants and will likely continue to do so for the foreseeable future. Fly Ash produced as a by-product of burning coal is a critically important resource for the ready mix concrete industry, as well as related concrete production industries. As recent events in Tennessee and elsewhere have demonstrated the fly ash produced by the production of electricity through the burning of coal places significant liability on the operators of such power plants, and can become a significant financial liability to the operators and by extension to the rate-payers who use this electricity. The historical methods of landfilling coal combustion byproducts have proven to create significant and ongoing environmental concerns for both the power plants and surrounding communities.

TVA should move quickly to embrace existing technology that allows landfilled (either dry or wet) fly ash to be beneficiated and sold to industry. While not all landfilled fly ash can be beneficiated and sold as a commercial product, a significant portion of such landfilled fly ash can be recovered and sold to industry. This permanently reduces the need to landfill and manage fly ash while improving the quality of the construction in which such fly ash is utilized. In addition, some beneficiation process can be used to treat both landfilled fly ash as well as the fly ash resulting from current electricity production. In these cases, the cost of landfilling fly ash is avoided on the front end and revenue can be realized to offset any additional cost related to the specific beneficiation process.

The concrete industry is currently facing persistent and recurring shortages of commercial grade fly ash even in areas such as Tennessee where much of our electricity is produced from burning coal. This is due primarily to the variability in the fly ash that results from current operational practices utilities employ as they produce electricity. This type of variability can be addressed by various beneficiation processes that are already commercially available in the marketplace.

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close window

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close window

From: Jeffrey I. Stein
To: Integrated Resource Plan
Subject: API comments, TVA IRP
Date: Monday, April 16, 2018 12:06:12 PM
Attachments: API TVA comments Apr 16, 2018.pdf

TVA External Message. Please use caution when opening.

Dear Ashley,

Please find attached API's comments for this phase of the TVA IRP. My contact information is below if you have any questions.

Best,
Jeff

Jeffrey I. Stein | Policy Advisor, Market Development | American Petroleum Institute
1220 L Street NW | Washington, DC 20005 | Office: 202.682.8256 | steinj@api.org

April 16th, 2018

Tennessee Valley Authority
400 Summit Hill Dr. SW
Knoxville, TN 37902

RE: Environmental Impact Statement for 2019 Update to the Integrated Resource Plan IRP

The American Petroleum Institute (API) appreciates this opportunity to comment on the Environmental Impact Statement for the 2019 Update to the Integrated Resource Plan (IRP). API's comments are limited to a handful of the IRP scoping questions on page 6669 of the Federal Register and do not address the questions of environmental impact or measurements. As discussions of resource diversity, reliability, resilience, and cleaner power are foundational elements of the IRP process, we have weighed in to provide information on where clean, domestic natural gas provides value.

API is a national trade association representing more than 625 member companies involved in all aspects of the natural gas and oil industry. API's members include producers, refiners, suppliers, pipeline operators and marine transporters, as well as service and supply companies that support all segments of the industry. API members are also large users of energy.

Natural gas is a clean-burning, efficient, and cost-effective fuel. The safe and environmentally responsible development of our domestic natural gas resources has been, and increasingly will be, an important component of America's energy supply and economic vitality. In the electricity sector, natural gas-fired generation plays a key role in providing dispatchable, clean and reliable power as well as providing system support to new, innovative and complementary energy technologies.

Natural gas-fired combustion turbines and reciprocating internal combustion engines are uniquely capable of providing both a dependable, constant power supply as well as flexible, readily available electricity to complement the rapidly changing power demands throughout the day. These attributes provide for reliable power and cleaner air both directly through natural gas' low emissions profile and by supporting the integration of variable renewable energy (VRE) resources. Natural gas also powers efficient distributed and behind the meter power technologies—especially helping businesses and industries use energy more efficiently and nimbly.

The entire natural gas value chain further provides significant economic benefits to the states within the Tennessee Valley Authority footprint and its workers through direct, indirect and induced activity.[1]

Table 1—Economic Impact of Natural Gas in TVA States

State	**Employment (number of workers)**	**Labor Income ($ million)**	**Value Added ($ million)**
Tennessee[2]	86,738	$5,036	$12,944
Alabama[3]	56,641	$3,341	$7,759
Kentucky[4]	56,447	$3,287	$7,760
Mississippi[5]	35,423	$2,148	$5,497
Georgia[6]	85,282	$4,969	$11,360
North Carolina[7]	112,753	$6,410	$13,603
Virginia[8]	73,183	$4,258	$9,721

Through this submission, we have provided our input to three of the questions listed in the Federal Register concerning the questions that the IRP will begin to answer, which are listed on page 6669. The questions to which we have provided input are listed below, in order of appearance in our comments;

[1] ICF "Benefits and Opportunities of Natural Gas Use, Transportation, and Production." June, 2017 http://www.api.org/~/media/Files/Policy/Natural-Gas-Solutions/API-Natural-Gas-Industry-Impact-Report.pdf
[2] Ibid at 227
[3] Ibid at 138
[4] Ibid at 173
[5] Ibid at 188
[6] Ibid at 159
[7] Ibid at 207
[8] Ibid at 236

- *"Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?"*
- *"How should distributed energy resource be considered in TVA planning?"*
- *"And how will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?"*

Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how:

API suggests that TVA look at system reliability from an attributes-oriented framework that recognizes the dynamic changes the Valley will encounter as energy demands and resource availability shifts. System reliability thus would be optimized through efficient deployment of technologies that can respond quickly to both demand pattern and technological changes. While the fuel mix of TVA will change rapidly in the near and medium term, especially as stakeholders push for cleaner, more flexible, and responsive sources of power, a diverse resource portfolio by itself is not the yardstick by which to measure system reliability. The focus on attributes, rather than fuel type or favored technology, is increasingly important in adapting to changing needs of the power system, such as the integration of intermittent renewable power and distributed energy technologies.

Natural gas generation offers a variety of reliability attributes that support these modernization moves of the electric grid. A 2017 report by the Brattle Group[9] identified and defined (Table 2) modern necessary reliability attributes then scored how well different technologies can provide these services (Table 3);

9 Brattle Group, "Diversity of Reliability Attributes—A Key Component of the Modern Grid." (Two page fact sheet about the study's findings—prepared by the American Petroleum Institute). 2017, http://www.api.org/~/media/Files/Policy/Natural-Gas-Solutions/Keys-to-Ensuring-Grid-Reliability.pdf

energy API

Table 2— Reliability Attributes Necessary for the Modern Grid, Defined[10]

Attribute	**Description**
Generation capability	No attribute is more fundamental to system requirements than the ability to generate electrical energy.
Dispatchability	Dispatchable resources have the ability to change their output or consumption levels in response to an order by the system operator. While virtually all resources are dispatchable to some degree, some have greater capabilities than other and shorter required lead times.
Security of fuel supply	Security of fuel supply measures the dependability of a resource's energy inputs, or fuel.
Start times and ramp rates	Closely related to dispatchability, start times and ramp rates determine the speed at which resources can respond to system operators' orders to increase and decrease electricity delivered to the grid.
Inertia and frequency response capability	Inertia and frequency response are attributes of resources that help the system meet the requirement to maintain frequency stability.
Reactive power capability	The ability to provide reactive power is an attribute necessary for meeting the system's requirement to maintain voltage within certain limits to prevent

[10] The Brattle Group, "Diversity of Reliability Attributes: A Key Component of the Modern Grid." May 2017. http://files.brattle.com/files/7351_diversity_of_reliability_attributes.pdf

	generator operation malfunctions or, in the worst case, cascading blackouts.
Minimum load level	A resource's minimum load level describes the lowest level of electrical output the resource can continuously send to the grid.
Black start capability	Black start capability is the ability of a power plant to restart without relying on the transmission network to deliver power.
Storage capability	Resources with the attribute of storing electricity help the system meet multiple requirements including meeting bulk demand, following load or net load, and maintaining frequency stability, but not all resources with the ability to store electricity contribute to meeting all the requirements.
Proximity to load	The ability to site resources close to load is an attribute that helps the system meet bulk demand and maintain voltages. Resources that are close to load that also can generate reduce transmission losses and transmission congestion.

energy API

With the above definitions of necessary system reliability attributes, the Brattle report then illustrates which technologies are relatively advantaged in providing these services.

Table 3—Reliability Attributes of Different Fuels and Generating Technologies[11]

	Natural Gas - CC/CT/RICE/ Aeroderivate	Coal	Nuclear	Wind	Solar	Pondage Hydro	Run of River Hydro	Demand Response	Storage
Generation	●	●	●	●	●	●	●	N/A	N/A
Dispatchability	●	●	◍	○	○	●	○	●	●
Security of Fuel Supply	●	●	●	○	◍	●	◍	◍	◍
Start Times	●	○	○	N/A	N/A	●	N/A	●	●
Ramp Rates	●	◍	○	N/A	N/A	●	N/A	●	●
Inertia	●	●	●	◍	○	●	●	○	○
Frequency Response	●	◍	○	○	○	●	○	○	●
Reactive Power	●	●	●	◍	◍	●	◍	N/A	N/A
Minimum Load Level	●	◍	○	N/A	N/A	●	N/A	●	●
Black Start Capability	●	N/A	N/A	○	○	●	●	N/A	◍
Storage Capability	N/A	N/A	N/A	N/A	N/A	◍	N/A	N/A	●
Proximity to Load	●	◍	◍	◍	●	○	○	●	●

● Relatively Advantaged
◍ Neutral
○ Relatively Disadvantaged

As the table above illustrates, a key benefit to increased deployment of natural gas in the power sector is its capability to provide both sustained and flexible, dynamic power generation. While other traditional, "base load" generating assets can also provide constantly running power, they are unable to quickly change their power output to match the constantly changing needs of the electric system—a need that is growing in importance as TVA incorporates more distributed generation and intermittent renewable energy. Through this transition, natural gas will continue to provide necessary support for the electric grid.

In its 2015 Distributed Generation-Integrated Value study, TVA recognizes the role natural gas plays in backing up increasing integration of intermittent, renewable energy;

> Solar PV along with other 'must take' energy sources, such as wind, provides less system operations flexibility when compared to traditional dispatchable resources. Solar PV generation is a function of solar

[11] Ibid at 21

irradiance which is considered a variable fuel source. Therefore, to meet the needs of continuous energy loads on the utility grid, traditional sources such as natural gas must be dispatched to fill in any 'gaps' in solar energy generation profiles.[12]

How should distributed energy resources be considered in TVA planning?

API recommends that TVA use a neutral approach regarding fuel and technology when planning for the use of more distributed energy resources that would provide for more flexibility, reliability, and cleaner energy.

In addition to powering utility scale generation that supports network reliability and resilience goals, natural gas supplies the power to innovative clean and resilient small scale and distributed technologies deployed at the local level or behind the customer meter. Power generation technologies such as fuel cells, Combined Heat and Power (CHP), and Waste Heat Recovery (WHR) can provide dependable electricity for microgrids and industrial sites. These technologies can also provide power solutions to those customers requiring a high degree of reliability and power quality, seeking greater efficiency and cost reductions or desiring to ride through extended outages.

API notes that TVA has already looked to help encourage more investments in these technologies as they have historically yielded major cost savings and economic benefits to ratepayers in the Valley. The new gas-fired CHP facility in Johnsville, which will generate power for TVA customers and DuPont manufacturing operations, is beneficial in providing cleaner and more stable power in the wake of the coal-fired Johnsville Fossil Plant closure. With the new TVA CHP/WHR initiative to help with initial funding, the Erlanger Health System in Chattanooga is building a $13 million natural gas-fired energy system on its campus, which includes an 8-megawatt CHP facility housed in a former incinerator. The new natural gas-fired energy system at the hospital will, according to the hospital's estimates, cut down on more than 20% of their annual energy expenses. The hospital also estimates that the pollution abatement benefits from the switch are roughly equivalent to "taking 2,000 cars off the road in Chattanooga."[13]

[12] TVA DG-IV study, https://www.tva.gov/file_source/TVA/Site%20Content/Energy/Renewables/dgiv_document_october_2015-2.pdf p. 8
[13] The Chattanoogan, "Erlanger Building New $13 Million Heat, Power Facility On Site For Major Energy Savings, Cleaner And More Reliable Operation." September 19, 2016. http://www.chattanoogan.com/2016/9/19/332296/Erlanger-Building-New-13-Million-Heat.aspx

According to a 2013 study by ICF, Tennessee alone has more than 2.7 GW of small-scale CHP potential (less than 100 MW) while other TVA states also have significant potential for new capacity—for example, Alabama has about 2 GW and Mississippi about 1.3 GW.[14]

How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?

While we discuss the reliability attributes of natural gas generation in the previous section, the reliability of the natural gas system comes from continued fuel assurance and infrastructure integrity—as driven by revolutions in production, consumption, and connectivity.

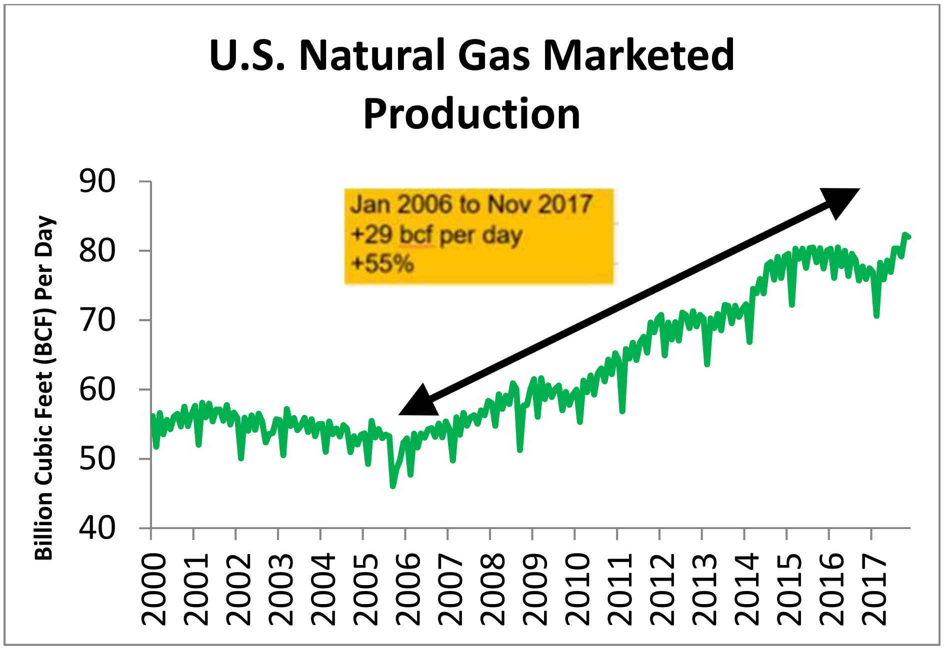
Natural gas is an abundant fuel

In the years since the beginning of the Shale Revolution, the United States has become a global power in natural gas production. The Potential Gas Committee recently released its latest biennial report on total estimated reserves and concluded that there is roughly 2,658 Tcf of traditional gas resources (a nearly 13% increase from its 2014 estimate) plus roughly 159 Tcf of natural gas resources from coalbed methane.[15] Together, this puts total resources at more than 2,800 Tcf of natural gas, a 12% increase from the 2014 estimate.[16] This most recent report marks the fifth consecutive record-breaking estimate in the body's 52-year history.[17]

The resource potential, much of which is driven by development in the nearby Marcellus and Utica Shale plays, underpins much of the ongoing and forecast growth in production. In its recently released Annual Energy Outlook (AEO 2018), the Energy Information Administration (EIA) shows continued sustained growth in natural gas development.

[14] ICF "The Opportunity for CHP in the United States." May 2013.
https://www.aga.org/sites/default/files/sites/default/files/media/the_opportunity_for_chp_in_the_united_states_-_final_report_0.pdf
[15] Potential Gas Agency, "Report of the Potential Gas Committee: Potential Supply of Natural Gas in the United States." P. 1.
[16] Ibid.
[17] Ibid.

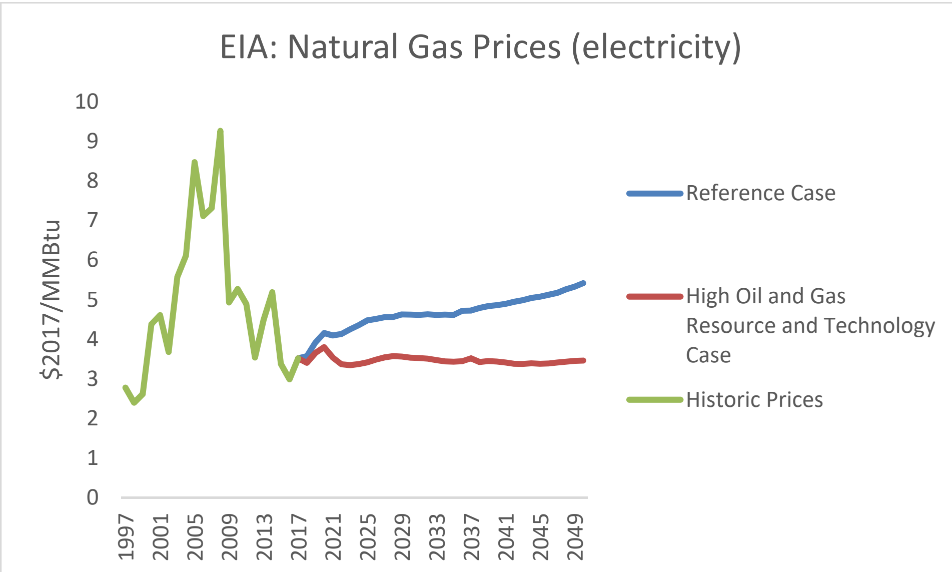
Table 4—U.S. Natural Gas Marketed Production[18] EIA Monthly Production Feb 2018



The high production numbers have also translated into lower natural gas prices, which EIA forecasts throughout its projections.

[18] EIA Monthly Production Feb 2018

Table 5—Historic and Forecast Natural Gas Prices, EIA[19][20]



In 2016, IHS Markit (f/k/a IHS) updated a study on shale gas production economics to better understand the coexistence of high production and a sustained low commodity price environment. The report, "Shale Gas Reloaded: The Evolving View of North American Natural Gas Resources and Costs," estimates about 1,400 Tcf of economically recoverable natural gas at a $4/MMBtu price point with roughly 800 Tcf of the resource base economically recoverable at only $3/MMBtu.[21] The price figures are in real terms and are about one-third of Henry Hub prices from a decade ago.[22]

---

[19] EIA, "Natural Gas: U.S. Natural Gas Marketed Production." https://www.eia.gov/dnav/ng/hist/n9050us2a.htm
[20] EIA, AEO 2018, "Table: Total Energy Supply, Disposition, and Price Summary. Total Energy: Production: Dry Natural Gas." https://www.eia.gov/outlooks/aeo/data/browser/#/?id=1-AEO2018&region=0-0&cases=ref2018~highrt&start=2016&end=2050&f=A&linechart=~~ref2018-d121317a.5-1-AEO2018~highrt-d121317a.5-1-AEO2018&sourcekey=0
[21] IHS-Markit, "North America's Unconventional Natural Gas Resource Base Continues to Expand in Volume and Decrease in Cost." February 2016. http://news.ihsmarkit.com/press-release/north-americas-unconventional-natural-gas-resource-base-continues-expand-volume-and-de
[22] Used 2008 prices as they were right before the Shale Revolution. Data comes from EIA, "Henry Hub Natural Gas Spot Price." https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm

energy API

Table 6—Natural Gas Production Economics Compared to Consumption[23]

The study illustrates that even if there were to be a sustained lower commodity price environment, it could still be economic to continue high domestic production levels—enabling stable, affordable access to natural gas.

To contextualize these supply and demand numbers, total U.S. natural gas consumption in 2017 was about 27 Tcf[24] and the EIA AEO 2018 forecasts consumption to reach between 32.03 Tcf in the Reference Case and 38.84 in the High Oil and Gas Resource and Technology Case by 2050, the last year out in the projections.[25]

Natural gas infrastructure provides resiliency attributes to sustainably connect resources with the TVA footprint

The TVA footprint sits within a well-served natural gas infrastructure system. The national surge in domestic gas production, particularly in the shale gas plays immediately north of the TVA footprint, is met with a changing delivery system that especially serves TVA states well—through new construction, pipeline expansion, and reverse flows. In the greater Southeast, the intra-regional infrastructure capacity is roughly 28.1 Bcf/d, while net

[23] Production numbers account for the Lower 48 and Canada
[24] EIA, Natural Gas Annual data, "U.S. Natural Gas Total Consumption." https://www.eia.gov/dnav/ng/hist/n9140us2A.htm
[25] EIA AEO 2018, "Table: Energy Consumption by Sector and Source." https://www.eia.gov/outlooks/aeo/data/browser/#/?id=2-AEO2018&region=1-0&cases=ref2018~highrt&start=2016&end=2050&f=A&linechart=~~ref2018-d121317a.133-2-AEO2018.1-0~highrt-d121317a.133-2-AEO2018.1-0&map=highrt-d121317a.3-2-AEO2018.1-0&ctype=linechart&sourcekey=0

regional consumption is just 5.5 Bcf/d—leaving a 22.6 Bcf/d surplus in delivery flows.[26] In the past few years, the greater Southeast has been met with 5.4 Bcf/d of new capacity and is expecting about 7.8 Bcf/d in the next few years.[27] If you look regionally at the various infrastructure expansions already in service or under construction, then the intra-regional capacity is 28.1 Bcf/d, which is 22.6 Bcf/d larger than the 5.5 Bcf/d net requirement of the region (taking the balance of production and consumption).[28] Additionally, planned intraregional expansion would add about 73% to the existing capacity.[29]

The robust natural gas infrastructure serving TVA has already facilitated the development of new, efficient gas plants within the service territory. The new 1070-megawatt Allen Combined Cycle Natural Gas Plant replacing the Allen Coal Plant in Memphis will soon go online. The new Allen CCGT only required a 13-mile lateral to connect to the robust natural gas delivery system already serving the area.[30]

The transition towards natural gas further enhances the reliability and resilience of the TVA footprint due to inherent resilient features of the natural gas delivery system. This extensive delivery system that moves gas from production sites to power plants through pipeline infrastructure is a significant contributor to reliability. The natural gas delivery system has inherent physical attributes that contribute to a resilient power system for TVA;[31]

- **Supply redundancy**—Multiple pipeline interconnecting points reinforces system integrity. Therefore, a local disruption would not cascade to a system-wide problem as it would in the electric grid. As cited in a report from the Massachusetts Institute of Technology[32], the natural gas system has very few points of failure or single points of disruption, that can lead to system-wide shortfalls.
- **Predominant use of compressor units that run on natural gas—** Natural gas flows average around 30 miles per hour—giving system operators plenty of time to respond to local disruptions and easily manage the flow through the system. Thus, shortfalls at one point in the system tend to have only very localized effects. Also, the compressibility of natural gas makes it easy to serve as a backup supply to the system.

[26] Rick Smead, RBN Energy, "Natural Gas Infrastructure Study Southeast Region" Presentation to the Southeast Association of Regulatory Utility Commissioners, June 13, 2017. P. 10
[27] Ibid at 8
[28] Ibid at 35
[29] Ibid at 10
[30] http://analysis.fc-gi.com/power-generation/tva-continues-push-cleaner-power-allen
31 For a more comprehensive explanation, please refer to the Natural Gas Council White Paper "Natural Gas Systems: Reliable and Resilient." July,2017. http://www.ipaa.org/wp-content/uploads/2017/07/NGC-Reliable-Resilient-Nat-Gas-WHITE-PAPER-Final.pdf
[32] Massachusetts Institute of Technology, Lincoln Laboratory, "Interdependence of the Electricity Generation System and the Natural Gas System and Implications for Energy Security," May 15, 2013.

- **Network of physical storage infrastructure—** There is an extensive national network of physical storage of natural gas that ensures supply availability. Natural gas is most commonly stored underground in depleted aquifers and oil and gas fields, as well as in salt caverns. It can also be stored above ground in storage tanks as liquefied natural gas ("LNG") for use at import and export facilities and at peak shaving plants, or as compressed natural gas ("CNG") for industrial and commercial uses.
- **Majority of pipelines located underground**—As most natural gas pipelines are buried underground, they are more insulated from physical damage from external forces.

In totality, natural gas provides a backbone of reliability and resilience to the energy system at all points of use—from continued record setting estimates of availability to reliable flows to flexible generating asset that help TVA meet the demands of the modern electric grid.

Concluding remarks

As natural gas-powered technologies, both utility scale and smaller, distributed resources, provide the critical, flexible, reliable, and cleaner power needed to move forward on building a modern energy system, API looks forward to continued engagement with TVA and its stakeholders.

Respectfully submitted,

Todd Snitchler
Group Director, Market Development
snitchlert@api.org

Jeffrey Stein
Policy Advisor, Market Development
steinj@api.org

From:	Madison Coburn
To:	Integrated Resource Plan
Cc:	John Brunini
Subject:	2019 IRP EIS Public Comments
Date:	Monday, April 09, 2018 4:55:48 PM
Attachments:	TVA IRP Letter -Choctaw County Board of Supervisors_41464441_1.pdf TVA IRP Letter -Central Electric Power Association_41464478_1 (2).pdf

TVA External Message. Please use caution when opening.

To whom it concerns:

Attached to this email, please find letters submitted by the Choctaw County Board of Supervisors and Central Electric Power Association for consideration in TVA's Integrated Resource Plan Environmental Impact Statement process.

Best personal regards,

Madison Coburn

Madison E. Coburn
Butler Snow LLP

D: (601) 985-4490 | F: (601) 985-4500
1020 Highland Colony Parkway, Suite 1400, Ridgeland, MS 39157
P.O. Box 6010, Ridgeland, MS 39158-6010
Madison.Coburn@butlersnow.com | vCard | Bio

Twitter | LinkedIn | Facebook | YouTube

CHOCTAW COUNTY BOARD OF SUPERVISORS
POST OFFICE BOX 250
ACKERMAN, MS 39735
Telephone (662)285-6329
facsimile (662) 285-3444

BOARD OF SUPERVISORS
Greg Fondren, District No. 2
Chris McIntire, District No. 3
John Shumaker, District No. 4
Eric Chambers, District No. 5

Joey Stephenson, Board President
District No. 1

April 2, 2018

Ms. Ashley Pilakowski
NEPA Project manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Ms. Pilakowski:

The Choctaw County Board of Supervisors provide regional leadership over critical policy areas, including policy that is necessary to ensure safe communities, protect public health, promote economic development, and plan and manage when used for sustainable development. We also provide important oversight of county operations including overseeing strategies to promote sound fiscal management and to develop a high-quality county government workforce. We want to help you promote the interest in general welfare of State of Mississippi, but also to the TVA service territory and the benefits that it brings. We'd like to exchange ideas and to develop, as far as practical, the uniform decision that benefits all parties involved. We believe and want to create and promote a feeling of fellowship, sympathy, and understanding among and between the counties and the people in the State of Mississippi.

We believe that we can offer our timber, crops and our coal to benefit the people of our state and region. Our industries range from lumber production, manufacturing, electrical wire harness manufacturing, coal mining, and one of the top energy producers in the south. We hope that you will consider supporting all of these industries and continue to use all of our resources which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority Region.

Before you can achieve your goal you need to identify the issue that you are trying to solve. If the goal is to meet TVA's purpose and mission of providing for agricultural and industrial develop, then we would encourage TVA to look no further than the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of a success in all three major factors of TVA's goals: reliable and clean energy at the lowest cost, environmentally sustainable energy production, and direct and indirect economic development for its people. By optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit-TVA will obtain baseload support for the electrical grid.

CHOCTAW COUNTY BOARD OF SUPERVISORS

We urge TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this region as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

Sincerely,

Joey Stephenson
President, Board of Supervisors
Choctaw County Mississippi

From: Parker Temple
To: Integrated Resource Plan
Cc: jonathan.leach@nacoal.com
Date: Wednesday, April 11, 2018 12:16:56 PM
Attachments: TVA from contractors and suppliers-1.docx

TVA External Message. Please use caution when opening.
Please see attached.

Parker Temple
Sales Representative
Newell Paper Company
Meridian, MS
Cell# 601-480-7339
Office# 601-693-1783
Fax# 601-483-4900
ptemple@newellpaper.com

April 11, 2018

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

My name is Parker Temple your sales representative for Newell Paper Company. Newell offers broad range janitorial, paper, office supplies, ware wash, industrial and packaging supplies. We have over 200 employees with 8 warehouses including Meridian, Jackson, Hattiesburg, Columbus, Tupelo, Demopolis, Vicksburg and the Gulf Coast. We have been a supplier for Red Hills mine for 18 years. As a sales representative it has been a pleasure to work with so many great people. Not only does it help our business but also the town of Ackerman and the state of Mississippi. I am very thankful for your business and the friendship made along the way. We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid.

We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Parker Temple

TenneSEIA

Tennessee Solar Energy Industries Association

April 16, 2018

Ashley Pilakowski
NEPA Project Manager
400 West Summit Hill Dr., WT 11D
Knoxville, TN 37902–1499
IRP@tva.gov

Re: Scoping Comments on the Tennessee Valley Authority (TVA) Draft Integrated Resource Plan (IRP)

Dear Ms. Pilakowski,

On behalf of the Tennessee Solar Energy Industries Association (TenneSEIA), we would like to express our appreciation for the opportunity to provide input on the TVA IRP Scoping process. TenneSEIA (Tennessee Solar Energy Industries Association) is the state chapter for the national Solar Energy Industries Association and represents the interest of the solar energy industry in Tennessee. The mission of TenneSEIA is to make solar energy a mainstream energy source and realize the full potential of the solar industry in Tennessee.

TenneSEIA participated in DGIX (Distributed Generation Information Exchange) and provided detailed cost and generation production profiles for solar energy through that stakeholder process to TVA for the IRP. Also, recent updated cost information for solar was received by TVA in response to its Request for Information (RFI) and Request for Proposals (RFP), and it is highly recommended that TVA incorporate that knowledge and technical input for its 2019 IRP modeling exercises. While solar cost trends in 2017 and 2018 were impacted by changes to tax laws and import tariffs, the general direction of continued reductions of installed cost driven by technological advancement and innovation over the next few years should reduce those impacts, thus these recent cost projections should hold accurate for purposes of the 2019 IRP.

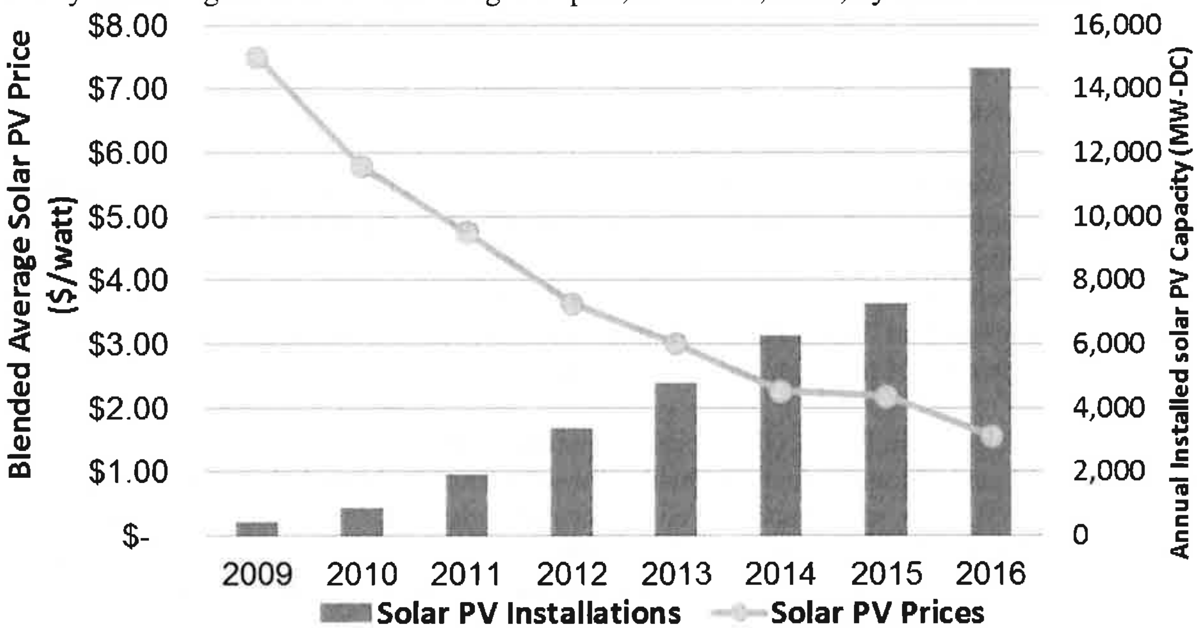
TenneSEIA has concerns that TVA, as a generation and transmission company, leading the IRP focusing on distributed energy resources (DER) is premature at this point because neither TVA nor the local power company (LPC) distributors have engaged in distribution resource planning. TVA's approach is inconsistent with its obligation to treat demand-side resources in a consistent and integrated manner, under the TVA least cost planning statute.

The purpose of the IRP is to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Tennessee Valley over the next 20 years. We believe that there is no better way to accomplish this than for TVA to embrace solar and other clean, renewable energy technologies.

TVA requested specific comments on questions that will be addressed in this IRP. Those expanded comments are addressed in the following section. We follow the specific comments section with some additional changes and improvements for scoping of the 2019 IRP.

Specific comments on questions that will be addressed in this IRP

How do you think energy usage will change in the next 20 years in the Tennessee Valley?
The solar industry is one of the fastest growing industries in the U.S., and solar energy is a proven technology to establish a balanced energy portfolio. The United States has some of the most abundant solar resources in the world. Last year, The U.S. installed 10.6 gigawatts (GW) of solar PV capacity in 2017 to reach 53.3 gigawatts (GW) of total installed capacity, enough to power 10.1 million American homes. Total installed U.S. PV capacity is expected to more than double over the next five years, and by 2023, over 15 GW of PV capacity will be installed annually according to Solar Market Insight Report, March 15, 2018, by GTM Research.



Source: SEIA/GTM Research *U.S. Solar Market Insight*

TVA has both the opportunity and the responsibility to use its 2019 IRP to be proactive in addressing the opportunities and challenges presented by the energy transition to a more distributed low cost and clean energy system from their legacy infrastructure.

Should the diversity of the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable resources) change? If so, how?
The steady decline in solar energy costs makes it a cost-effective solution to increasing energy independence, reducing greenhouse gas emissions, modernizing grid operations, and addressing water supply challenges, while simultaneously lowering long-term electricity supply costs and providing significant economic benefits. Solar contributes to a balanced portfolio of energy resources and can help achieve an optimal long-term strategy for the economy and the environment.

Coal-fired power plants are quickly becoming an antiquated means of generating electricity. They are expensive, dirty, and old. TVA has retired several coal units in recent years, following an international trend of movement away from coal as a generating fuel. Economics remains the primary driver of coal retirements, though the economics are made worse for coal plants when regulations or lawsuits force plant owners to pay to clean up some of the damage their resources have caused for human health and the environment. The 2019 IRP should include an assumption that TVA retires at least half of its coal capacity by the end of the study period.

Nuclear generation also presents risks, and TVA's resource planning should include the latest real-world examples of that risk, including cost overruns and delays as well as the likelihood of nuclear plants presently in the fleet not getting re-licensed by the NRC (United States Nuclear Regulatory Commission). In addition, the 2019 IRP should consider the cost-effectiveness of continued investments in Small Modular Reactors (SMRs). TVA's resource plan should evaluate the benefits to customers and Valley residents of halting SMR investments and using those funds for energy efficiency, renewable energy, and storage resources in the region.

We urge TVA to adopt an IRP strategy that promotes the increased deployment and use of solar energy. Solar energy reduces carbon pollutants and offers a positive economic return while generating affordable and reliable energy. As a cost-effective clean energy source, solar avoids a number of costs associated with fossil fuel resources. Further, solar enjoys widespread bi-partisan support from the general public throughout the United States, and within the TVA region. As fossil energy production declines, solar energy will be available to help meet energy demands in the TVA region in a clean and sustainable manner.

How should distributed energy resources be considered in TVA planning?
TenneSEIA urges TVA in this scoping process to look at the impact of DER (Distributed Energy Resources) in a comprehensive way that plans how TVA can best integrate complementary resources. For example, storage is on a similar declining cost trajectory that solar PV has been on for the past decade. Smart inverter technology paired with advanced forecasting and communication and control technology is allowing much higher penetration of renewable technologies on the grid. Therefore, solar and other clean, renewable generation technologies should be planned for in this IRP in conjunction with storage and control technologies and those resources need to be assessed as complementary parts of a new disturbed energy future and not as individual pieces.

The steady decline in solar energy costs makes it a cost-effective solution to increasing energy independence, reducing greenhouse gas emissions, modernizing grid operations, and addressing water supply challenges, while simultaneously lowering long-term electricity supply costs and providing significant economic benefits. Solar contributes to a balanced portfolio of energy resources and can help achieve an optimal long-term strategy for the economy and the environment. Rather than have TVA try to determine the best strategy and study process on DERs, why not truly bring those resources closer to the customer and allow the LPCs, who manage these resources and systems, the contract flexibility via some relief from the all-requirements power contracts – that would be an innovative solution to let TVA actually focus on what it does best, generate central system plants and build/maintain transmission lines.

How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?
Energy efficiency is the lowest cost and the most effective way to reduce the cost of power to the consumer and should always be the first resource option for TVA and the LPCs.

How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources) and cost of electricity?
On the issues of reliability and dispatchability modern PV systems using Plant Control Systems are controllable to meet economic and reliability dispatch signals.

Utility-scale PV plants can behave like conventional generators and contribute actively to grid reliability and stability by providing grid support, including active power control. In a 300 MW demonstration project conducted by CIASO, NREL, and First Solar, PV plants have demonstrated the ability to deliver capabilities more effectively than gas-fired alternatives in the following areas: (1) Power Ramping (ability to follow AGC dispatch signals by the system operator) by ramping real power output at a specific ramp-rate and providing regulation up/down service; (2) Voltage Regulation Control by controlling a specific voltage schedule, operating at a constant power factor, producing a constant level of MVAR, providing controllable reactive support, and providing reactive support at night; (3) Frequency Response (spinning reserve capacity) by providing frequency response for low and high frequency events, controlling the speed of frequency response, and providing fast frequency response.
National Renewable Energy Laboratory, Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant (March 2017)
https://www.nrel.gov/docs/fy17osti/67799.pdf.

Distributed PV can provide wholesale ancillary services in the same fashion as utility-scale assets and can also provide incremental ancillary services on the local or distribution level with supportive policies and standards in place. Local voltage support is critical to operating the distribution system within system constraints, and distribution system operators rely on a distributed set of voltage regulating equipment to provide that support. Distributed PV can augment and sometimes replace this equipment, providing real and reactive power support as identified by the distribution operator.

On an aggregated basis, utility-scale and distributed PV resources provide significant reliability and transmission benefits to a state or regional grid. Even if solar PV output varies at a few individual locations due to localized cloud coverage, when the sum of the solar installations in a geographic area is assessed, the variability is reduced and can be managed by the grid operator. In a recent study regarding the integration of wind and solar in PJM, General Electric International, Inc. (GE) found that PJM's large geographic footprint significantly reduced the magnitude of variability-related challenges as compared to smaller balancing areas. GE noted that an individual solar PV plant's variability is reduced substantially when solar plants are aggregated and located in a geographically diverse manner throughout PJM.

Finally, solar technologies that require transmission investment often do not require pipelines, coal transport or the associated production and processing infrastructure needed by coal and gas industries. This has the potential to save immense costs as the energy infrastructure in the U.S. ages and requires repairs.

Suggested Changes and Improvements to the 2019 TVA IRP

TenneSEIA recommends that TVA adopt an IRP that recognizes the value of solar energy as part of a balanced energy portfolio through a diverse collection of solar programs, including rooftop distributed generation and commercial and utility-scale systems, and incorporating both Local Power Company and investor-owned assets. We recommend the following scope be included in the Integrated Resource Plan to reflect more accurately the value of solar within TVA's overall energy portfolio:

Include Distributed PV within the energy-planning model that TVA utilizes
Since distributed PV is purchased and contracted by consumers and utilities at retail rates, and not wholesale prices, distributed PV is not generally entered into a utility energy planning model using simple capital cost valuation. However, this challenge in modeling distributed PV versus other energy sources should not be grounds to exclude distributed PV from the overall TVA energy portfolio. Below we present two methods for including distributed PV within TVA's energy planning model.

Specifically, we suggest that the IRP would more effectively reflect the value that solar assets offer TVA by incorporating distributed PV within the energy-planning model that TVA utilizes; using accurate and updated solar cost data for utility-scale and distributed PV that accounts for the evolving industry standards for Smart Inverters which lead to a better functioning grid; including the Social Cost of Carbon; updating Power Purchase Agreement term lengths; and continuing and expanding the Renewable Energy programs and offers at TVA.

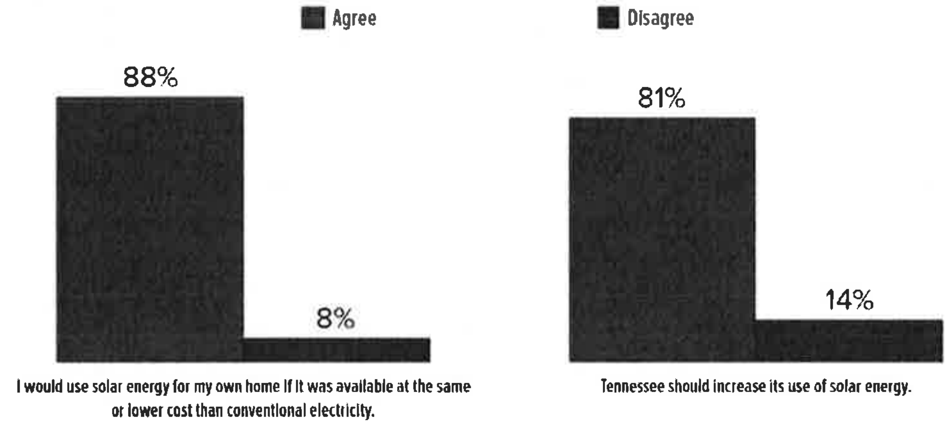
Utilize the Price Differential between the Wholesale Avoided Cost and the Retail Rate for Distributed PV
To more accurately model distributed PV adoption based on cost it is necessary to adjust the capital cost to reflect the differential between retail and wholesale rates, which can be a complicated exercise. Typically in a production cost modeling environment or other utility resource planning modeling, capital and fuel costs are the primary economic drivers of a utility's decision regarding what type of new capacity to build once the need for additional capacity is identified. Since solar PV has no meaningful fuel cost, the primary economic driver is the capital cost to install, which is often adjusted to reflect a long-term "Levelized Cost of Energy" (LCOE) to enable a comparison with the current wholesale price of generation. As discussed above, in the case of Distributed PV this comparison is complicated by the fact that Distributed PV is offsetting generation at the point of consumption, not generation. Thus it is primarily competing against avoided cost at the point of consumption.

TVA should take into account how its Ratepayers and Customers want their energy generated
North Star did a survey of Tennessee Registered Voters between October 21-26th that overwhelming showed that solar energy was their preferred way to generate energy.

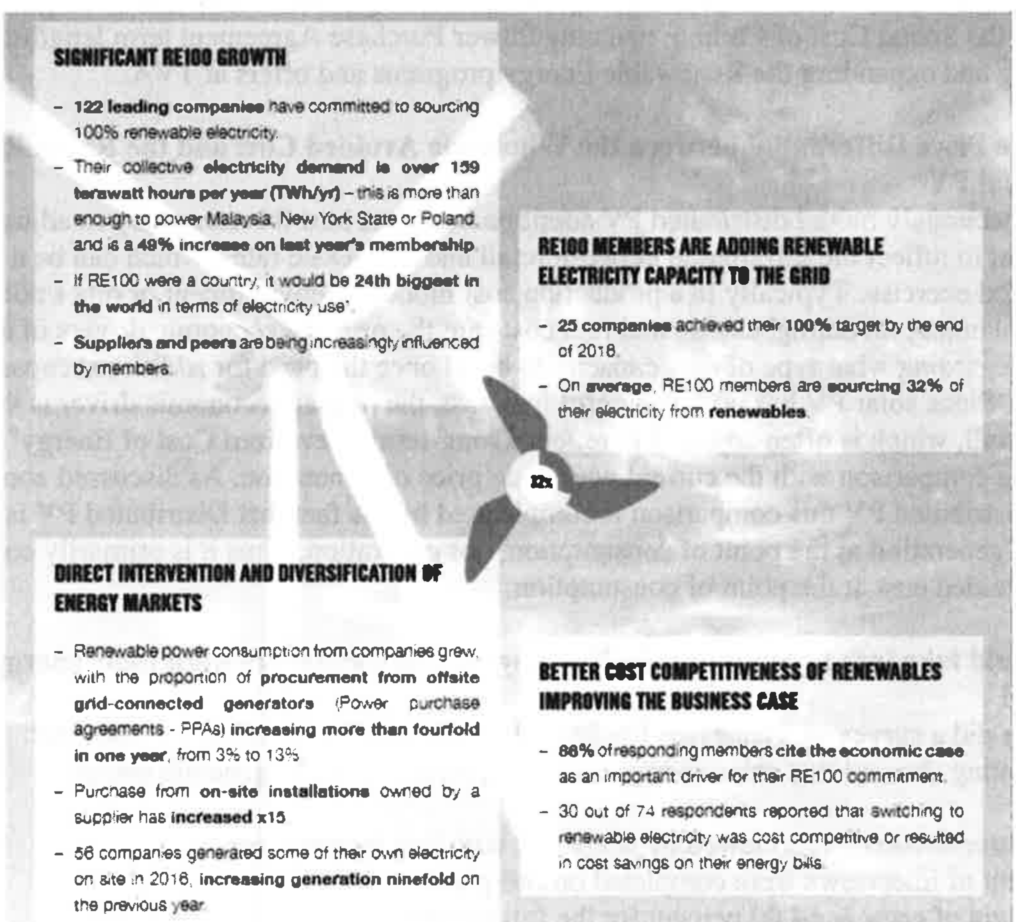
- 600 registered voters interviewed by telephone with live interviewers.
- 44 percent of interviews were completed on cell phones.
- The margin of error is ±4.00 percent for the full sample.

Voters overwhelming agree that Tennessee should increase its use of solar energy, and that they would use solar energy for their own home.

Now I would like to spend a few minutes talking about solar energy use in Tennessee. I am going to read you a list of statements regarding solar energy use. For each one, please tell me if you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with that statement:



The IRP should also note that business community also wants generation from solar as highlighted by a recent report. Key Finding of RE100 report: Approaching a Tipping Point, January 2018



SIGNIFICANT RE100 GROWTH

- **122 leading companies** have committed to sourcing 100% renewable electricity.
- Their collective **electricity demand is over 159 terawatt hours per year (TWh/yr)** – this is more than enough to power Malaysia, New York State or Poland, and is a **49% increase on last year's membership**.
- If RE100 were a country, it would be **24th biggest in the world** in terms of electricity use[1].
- **Suppliers and peers** are being increasingly influenced by members.

RE100 MEMBERS ARE ADDING RENEWABLE ELECTRICITY CAPACITY TO THE GRID

- **25 companies** achieved their **100%** target by the end of 2016.
- On **average**, RE100 members are **sourcing 32%** of their electricity from **renewables**.

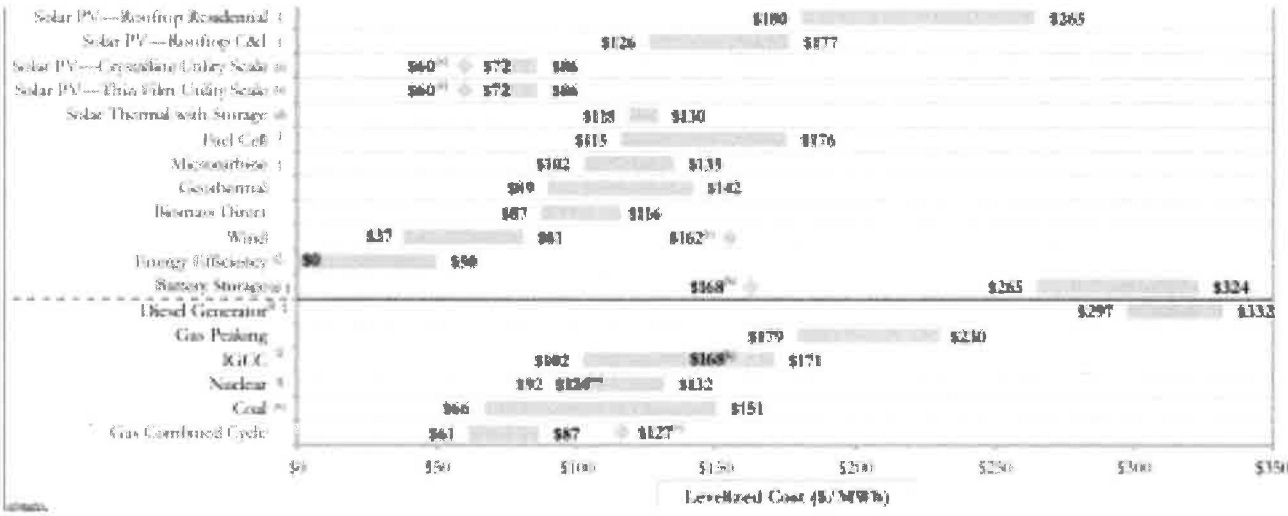
DIRECT INTERVENTION AND DIVERSIFICATION OF ENERGY MARKETS

- Renewable power consumption from companies grew, with the proportion of **procurement from offsite grid-connected generators** (Power purchase agreements - PPAs) **increasing more than fourfold in one year**, from 3% to 13%.
- Purchase from **on-site installations** owned by a supplier has **increased x15**.
- 56 companies generated some of their own electricity on site in 2016, **increasing generation ninefold** on the previous year.

BETTER COST COMPETITIVENESS OF RENEWABLES IMPROVING THE BUSINESS CASE

- **86%** of responding members **cite the economic case** as an important driver for their RE100 commitment.
- 30 out of 74 respondents reported that switching to renewable electricity was cost competitive or resulted in cost savings on their energy bills.

The IRP needs to take into account the new economics of the Cost of Energy
Lazard Associates develops an annual estimate of the levelized cost of energy (LCOE) for a variety of generation technologies including wind energy, solar power, battery storage, and others. Utility-scale solar is now cost competitive with traditional power sources.



Conclusion

The solar industry is one of the fastest growing industries in the U.S. For all of the above reasons; we respectfully request that TVA adopt an IRP that accurately reflects the potential for solar to contribute to a balanced energy portfolio as discussed in these comments.

The opportunities gained from using solar PV technology are unrivaled. PV technology is proven and commercially available and TenneSEIA and SEIA firmly believe that:

(1) The ratepayers of the valley want more solar energy
(2) Solar is cost-effective and can be smoothly integrated into the grid with planning
(3) Solar in the Tennessee Valley supports jobs and investments at home in the TVA region.

The comments contained herein reflect the views of TenneSEIA and not the views of any individual member company. Thank you for your consideration of our input. We look forward to working with you. If you have any questions, please do not hesitate to contact Gil Hough at execdirector@tenneseiasolar.com or (865) 789 5482.

Thank you for your consideration.

Sincerely,

Matt Beasley
President
Tennessee Solar Energy Industries Association (TenneSEIA)

Name: Larry Trent

Comments: I have been in Ready Mix concrete many years and have suffered the shortages of fly many times in the spring and the fall. I have planned for these shortages but there never seems to be a good enough plan due to how the weather changes here in East Tennessee. i have been designing high Fly ash content concrete mixes for a long time and in focusing on these type of mixes takes careful changes. we do about 50,000 cubic yards of concrete per year and focus primarily on areas where we can use high fly ash contents so when we can't get it it has drastic affects on our revenue. it would be great if there were ways to keep this product out of landfills by using larger storage facilities.

close window

From: Troyani, Anthony L Jr
To: Integrated Resource Plan
Subject: Just a thought...
Date: Friday, February 23, 2018 7:18:24 AM

•*How should energy efficiency and demand response be considered in planning for future energy needs and how can TVA directly affect electricity usage by consumers?*

Back in the 80's in Nashville, there was a program (which may have been sponsored by TVA) where computers were added to select homes which altered the time that appliances ran. These homeowners were billed similar to commercial with less cost during off peak hours and therefore were able to have control over their energy bill by actually seeing the savings of delaying dishwasher usage, dryer usage, etc. to off peak hours.

I think this program was ahead of its' time and with most appliances marketed today having 2, 4, 6 hour delay settings, if the residential customer could see a benefit of using these features by being offered a variable rate based on peak/ non-peak usage, a program like this may have some benefit to reduce peak load demand.

Just a thought,

Tony Troyani
altroyani@tva.gov
S.I.M. Foreman
(c)--931.444.0619
(w)—931.827.6211

In the beginning of a change the patriot is a scarce man, and brave, and hated and scorned.
When his cause succeeds, the timid join him, for then it costs nothing to be a patriot.
~Mark Twain

Comments
[redacted] for the TVA IRP Memphis Meeting
March 5th, 2018

TVA's planning process matters because far too many citizens, in particular citizens of color, in cities and rural areas across Tennessee, are having to choose between paying utility bills rather than acquiring necessary food and medicines

TVA should be encouraging more energy efficiency and clean energy use, not discouraging it by imposing unnecessary fees on their customers and making it even harder for people across the Valley to make ends meet.

The NAACP principal objective is to ensure the political, educational, social and economic equality of minority group citizens of United States and eliminate race prejudice. The NAACP seeks to remove all barriers of racial discrimination through the democratic processes.

Sandra Upchurch, Chair of the Memphis NAACP Energy & Environmental Justice Committee and Co- Chair-TN State Conference NAACP Environmental Justice Committee

sandraupchurch3@gmail.com
901-826-1658

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Tennessee ES Office
446 Neal Street
Cookeville, Tennessee 38501

April 3, 2018

To: Acting Chief, Division of Environmental Review, ES, Southeast Regional Office, Atlanta, GA

From: Field Supervisor, ES, Cookeville, TN

Subject: ER 18-0083 – Notice of Intent for Tennessee Valley Authority 2019 Update to the Integrated Resource Plan.

U.S. Fish and Wildlife Service (Service) personnel have reviewed the Tennessee Valley Authority's (TVA) Notice of Intent (NOI) to update its existing Integrated Resource Plan (IRP), last revised in 2015. The NOI indicates that the purpose of the plan is to determine how TVA can continue to provide low-cost, reliable electricity; support environmental stewardship; and spur economic development in the Tennessee Valley over the next 20 years. As part of the IRP, and in alignment with the National Environmental Policy Act, TVA will analyze potential environmental implications associated with an updated IRP in an environmental impact statement (EIS).

The 2019 IRP will consider many potential future and different generation resources (coal, natural gas, nuclear, hydro, solar, and other renewables) that can be used, along with energy efficiency and distributed energy resources (DER), to meet future electricity demand. The 2019 IRP will:

- Explore various DER scenarios, considering the speed and amount of DER penetration;
- Improve TVA's understanding of the impact and benefit of system flexibility with increasing renewable and distributed resources;
- Determine the implications to TVA's diverse portfolio mix for the next 20 years.

The IRP EIS will address the effects of power production on the environment, including climate change, the effects of climate change on the Tennessee Valley, and the waste and byproducts of TVA's power operations. Site-specific environmental effects of new resource options will be addressed in later site-specific assessments tiered off this programmatic EIS. Therefore, in this programmatic EIS, TVA anticipates that the environmental effects examined will primarily be those at a regional level with some extending to a national or global level. Preliminary issues identified by TVA that will be reviewed in this analysis include:

- Emissions of greenhouse gases;
- Fuel consumption;
- Air Quality;
- Water quality and quantity;
- Waste generation and disposal;
- Land use;
- Ecological;
- Cultural resources;
- Socioeconomic impacts and environmental justice.

The following comments were obtained from Service field offices in the seven-state TVA power service area:

- Consider the "cumulative impacts" of DER sources on listed species;
- Assess the potential impacts of large-scale facilities (solar, biomass, etc.) on space used (i.e., loss, fragmentation and displacement of species habitat), and site energy projects to avoid lands with known high-resource values and minimize conflicts with wildlife habitat, particularly threatened, endangered and sensitive species habitats, and habitat elements that support biodiversity (e.g., using landscape assessment tools to avoid placing wind turbines near bat roosting areas or major migratory bird pathways);
- Site energy projects on disturbed sites, such as abandoned mines, landfills and agricultural fields, when possible, reducing overall environmental impacts and potential effects to listed species and their habitats;
- Consider the introduction of invasive plant species from disturbance of proposed energy project sites and potential impacts;
- Review and incorporate guidelines for best management practices to ensure that projects are installed and managed in ways that reduce their environmental impacts and effects to listed species, migratory birds, and bald and golden eagles, if any [e.g., best practices identified by the Service in its "Land-Based Wind Energy Guidelines" (2012) if considering development of wind energy projects];
- Reduce the footprint of proposed energy projects to minimize impacts on wildlife habitat by researching the newest innovations (e.g., installing wind turbines with "wind lenses", installing solar panels on rooftops, etc.);
- Research the latest innovations to reduce injury and mortality to listed species and migratory birds (e.g., wind turbine collision-avoidance technology to reduce impacts to listed bats and migratory birds, utilizing approaches such as bladeless wind energy collectors, enclosing blades in cones or drums, raising the turbine's "cut-in speed", etc.);
- Consider effects from facility construction and operation (e.g., water discharges, leachate from coal combustion residuals landfills) on aquatic resources during project siting and design, and chose alternative that would minimize impacts; and
- All new and proposed energy projects should include requirements to monitor and measure impacts to listed species and their habitats, when applicable; information generated by monitoring can be used to inform and improve future energy development projects.

After TVA develops a draft EIS and selects a "Preferred Alternative," we will provide additional comments specific to the action and action area. If you have any questions or require additional information, please contact Todd Shaw at (931) 525-4985 or by email at *ross_shaw@fws.gov*.

xc: Troy Andersen/Cindy Schulz, FWS – VA ESO
Nancy Cole/Bryan Tompkins, FWS – Asheville, NC ESO
David Felder, FWS – MS ESO
Robin Goodloe, FWS – Athens, GA ESO
Teresa Hyatt/Jessica Miller, FWS – KY ESO
Jeff Powell, FWS – Daphne, AL ESO

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
www.deq.virginia.gov

Matthew J. Strickler
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

February 15, 2018

Ashley Pilakowski
NEPA Compliance Specialist
400 West Summit Hill Dr., WT 11D
Knoxville, Tennessee 37902–1499

RE: Tennessee Valley Authority, 2019 Update to the Integrated Resource Plan

Ms. Pilakowski:

This letter is in response to the scoping request for the above-referenced project.

As you may know, the Department of Environmental Quality, through its Office of Environmental Impact Review (DEQ-OEIR), is responsible for coordinating Virginia's review of federal environmental documents prepared pursuant to the National Environmental Policy Act (NEPA) and responding to appropriate federal officials on behalf of the Commonwealth. .

DOCUMENT SUBMISSIONS

In order to ensure an effective coordinated review of the NEPA document, notification of the NEPA document and federal consistency documentation should be sent directly to OEIR. We request that you submit one electronic to eir@deq.virginia.gov (10 MB maximum) or make the documents available for download at a website, file transfer protocol (ftp) site or the VITAShare file transfer system (https://vitashare.vita.virginia.gov).

The NEPA document should include U.S. Geological Survey topographic maps as part of their information. We strongly encourage you to issue shape files with the NEPA document. In addition, project details should be adequately described for the benefit of the reviewers.

ENVIRONMENTAL REVIEW UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT: PROJECT SCOPING AND AGENCY INVOLVEMENT

As you may know, NEPA (PL 91-190, 1969) and its implementing regulations (Title 40, *Code of Federal Regulations*, Parts 1500-1508) requires a draft and final Environmental Impact Statement (EIS) for federal activities or undertakings that are federally licensed or federally funded which will or may give rise to significant impacts upon the human environment. An EIS carries more stringent public participation requirements than an Environmental Assessment (EA) and provides more time and detail for comments and public decision-making. The possibility that an EIS may be required for the proposed project should not be overlooked in your planning for this project. Accordingly, we refer to "NEPA document" in the remainder of this letter.

While this Office does not participate in scoping efforts beyond the advice given herein, other agencies are free to provide scoping comments concerning the preparation of the NEPA document. Accordingly, we are providing notice of your scoping request to several state agencies and those localities and Planning District Commissions, including but not limited to:

Department of Environmental Quality:
- DEQ Regional Office
- Air Division
- Office of Wetlands and Stream Protection
- Office of Local Government Programs
- Division of Land Protection and Revitalization
- Office of Stormwater Management

Department of Conservation and Recreation
Department of Health
Department of Agriculture and Consumer Services
Department of Game and Inland Fisheries
Virginia Marine Resources Commission
Department of Historic Resources
Department of Mines, Minerals, and Energy
Department of Forestry
Department of Transportation

DATA BASE ASSISTANCE

Below is a list of databases that may assist you in the preparation of a NEPA document:

- DEQ Online Database: Virginia Environmental Geographic Information Systems

  Information on Permitted Solid Waste Management Facilities, Impaired Waters, Petroleum Releases, Registered Petroleum Facilities, Permitted Discharge (Virginia Pollution Discharge Elimination System Permits) Facilities, Resource Conservation and Recovery Act (RCRA) Sites, Water Monitoring Stations, National Wetlands Inventory:
    - www.deq.virginia.gov/ConnectWithDEQ/VEGIS.aspx

- DEQ Virginia Coastal Geospatial and Educational Mapping System (GEMS)

  Virginia's coastal resource data and maps; coastal laws and policies; facts on coastal resource values; and direct links to collaborating agencies responsible for current data:
    - http://128.172.160.131/gems2/

- MARCO Mid-Atlantic Ocean Data Portal

  The Mid-Atlantic Ocean Data Portal is a publicly available online toolkit and resource center that consolidates available data and enables users to visualize and analyze ocean resources and human use information such as fishing grounds, recreational areas, shipping lanes, habitat areas, and energy sites, among others.

http://portal.midatlanticocean.org/visualize/#x=-73.24&y=38.93&z=7&logo=true&controls=true&basemap=Ocean&tab=data&legends=false&layers=true

- DHR Data Sharing System

  Survey records in the DHR inventory:
  - www.dhr.virginia.gov/archives/data_sharing_sys.htm

- DCR Natural Heritage Search

  Produces lists of resources that occur in specific counties, watersheds or physiographic regions:
  - www.dcr.virginia.gov/natural_heritage/dbsearchtool.shtml

- DGIF Fish and Wildlife Information Service

  Information about Virginia's Wildlife resources:
  - http://vafwis.org/fwis/

- Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Database: Superfund Information Systems

  Information on hazardous waste sites, potentially hazardous waste sites and remedial activities across the nation, including sites that are on the National Priorities List (NPL) or being considered for the NPL:
  - www.epa.gov/superfund/sites/cursites/index.htm

- EPA RCRAInfo Search

  Information on hazardous waste facilities:
  - www.epa.gov/enviro/facts/rcrainfo/search.html

- EPA Envirofacts Database

  EPA Environmental Information, including EPA-Regulated Facilities and Toxics Release Inventory Reports:
  - www.epa.gov/enviro/index.html

- EPA NEPAssist Database

  Facilitates the environmental review process and project planning:
  http://nepaassisttool.epa.gov/nepaassist/entry.aspx

If you have questions about the environmental review process, please feel free to contact me (telephone (804) 698-4204 or e-mail bettina.sullivan@deq.virginia.gov).

I hope this information is helpful to you.

Sincerely,

Bettina Rayfield, Program Manager
Environmental Impact Review and
Long-Range Priorities

From: Fulcher, Valerie (DEQ) [mailto:Valerie.Fulcher@deq.virginia.gov]
Sent: Thursday, February 15, 2018 2:32 PM
To: Narasimhan, Kotur (DEQ) <Kotur.Narasimhan@deq.virginia.gov>; Dacey, Katy (DEQ) <Katy.Dacey@deq.virginia.gov>; Henicheck, Michelle (DEQ) <Michelle.Henicheck@deq.virginia.gov>; Gavan, Larry (DEQ) <Larry.Gavan@deq.virginia.gov>; Sepety, Holly (DEQ) <Holly.Sepety@deq.virginia.gov>; Frazier, Teresa (DEQ) <Teresa.Frazier@deq.virginia.gov>; Tignor, Keith (VDACS) <Keith.Tignor@vdacs.virginia.gov>; Rhur, Robbie (DCR) <Robbie.Rhur@dcr.virginia.gov>; Evans, Gregory (DOF) <Gregory.Evans@dof.virginia.gov>; dgif-ESS Projects (DGIF) <ESSProjects@dgif.virginia.gov>; odwreview (VDH) <odwreview@vdh.virginia.gov>; Kirchen, Roger (DHR) <Roger.Kirchen@dhr.virginia.gov>; Spears, David (DMME) <David.Spears@dmme.virginia.gov>; Cromwell, James R. (VDOT) <James.Cromwell@VDOT.Virginia.gov>; Jordan, Elizabeth (VDOT) <Elizabeth.Jordan@VDOT.Virginia.gov>; Miller, Duane <dmiller@lenowisco.org>; jimbaldwin@bvu.net; asizemore@mrpdc.org; Berry, Jason <jberry@washcova.com>; ddpoe@leecova.org; Starnes, Freda <fstarnes@scottcountyva.com>; Scott, Shannon <scott_s@wisecounty.org>; Lester, Lonzo <lonzo.lester@russellcountyva.us>; Carter, Michael L. <mcarter@smythcounty.org>; info@graysongovernment.com; randallceads@yahoo.com; gkelly@abingdon-va.gov; Watkinson, Tony (MRC) <Tony.Watkinson@mrc.virginia.gov>
Cc: Integrated Resource Plan <irp@tva.gov>
Subject: SCOPING REQUEST TVA 2019 IRP

TVA External Message. Please use caution when opening.

Good afternoon—attached is a request for scoping comments on the following:

Tennessee Valley Authority Environmental Impact Statement for 2019 Update to the Integrated Resource Plan

If you choose to make comments, please send them directly to the project sponsor (IRP@tva.gov) and copy the DEQ Office of Environmental Impact Review: eir@deq.virginia.gov. **We will coordinate a review when the environmental document is completed.**

DEQ-OEIR's scoping response is also attached.

If you have any questions regarding this request, please email our office at eir@deq.virginia.gov.

Valerie

Valerie A. Fulcher, CAP, OM, Environmental Program Specialist
Department of Environmental Quality
Environmental Enhancement - Office of Environmental Impact Review
1111 East Main Street (new street address effective 12/27/17)
Richmond, VA 23219

804/698-4330
804/698-4319 (Fax)
email: Valerie.Fulcher@deq.virginia.gov
http://www.deq.virginia.gov/Programs/EnvironmentalImpactReview.aspx

For program updates and public notices please subscribe to the OEIR News Feed

From: Michael Walton
To: Integrated Resource Plan
Subject: Integrated Resource Plan Comments
Date: Monday, March 19, 2018 12:24:48 PM
Attachments: $10_greenringsm2[13].png

TVA External Message. Please use caution when opening.

I attended the Educational Open House in Chattanooga and appreciated the opportunity to hear more about the IRP process and speak to the staff.

I would encourage the IRP team to consider the following:

1. Effects of Rate Design on Solar

Between moving to higher fixed costs and reducing the value of solar through Green Power Providers, the effect we are seeing in the on-site/rooftop solar marketplace is to encourage users to install on the demand side and use storage to go partially or completely off-grid. The effect of this hurts the potential for leveraging these resources for the benefit of the grid.

Also, we would like to see the amount of current and projected utility scale, community, and on-site solar rather than always bundling it with wind. This will help clarify the data underpinning the solar discussion.

2. Incorporation of Distributed Storage

Related to the solar rate design discussion, the last IRP provided no projections for the distributed storage. Almost every IOU's resource planning includes these to some extent. Distributed grid-tied storage, if widely implemented can benefit the long-term sustainability, resilience, and lowest-cost electricity delivery, helping meet all of TVA's missions. The key is incentivizing users to keep their storage grid-tied rather than using it to go off-grid. In addition to energy storage, thermal storage, like Calmac, can help shift load to off-peak times.

3. Incorporation of Central Storage

Similarly to distributed storage, there should be a consideration in the IRP for adding utility scale storage. The primary argument in TVA's study determining the value of renewables determined that the intermittence of renewables impacted the potential value. Raccoon Mountain provides a great deal of value to ensure nuclear plants can keep running even when demand does not match the supply. A similar strategy to incorporate other forms of large-scale central storage should be considered in the IRP.

4. Incorporation of Electric Vehicles

Most major car manufacturers have announced plans to shift partially or entirely to electric vehicles. Depending on how quickly it happens, the shift could precipitate a collapse of the fossil fuel extraction and delivery infrastructure during the time frame covered by the next IRP. (https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/591a2e4be6f2e1c13df930c5/1494888038959/RethinkX+Report_051517.pdf)

5. Incorporation of Fuel Availability and Cost

The last IRP recommended heavy investments in natural gas generation based on projections that natural gas would remain cheap for the foreseeable future. The forthcoming IRP should provide clear contingencies for the constriction of supply of all non-renewable resources that the system currently relies upon and what the effect would be on rate-payer costs between those contingencies.

6. Potential for Rate Design for Low Income Neighborhoods

Finally, we would recommend piloting "economic development energy zones." We see the proliferation of racially concentrated areas of poverty in every major city in TVA's footprint. Even in smaller cities there are often neighborhoods with concentrations of poverty. Many of these neighborhoods are colocated with historic employers and much of the housing was built before 1940 meaning much of it is extremely inefficient (as demonstrated in EEM) which leads to outrageously high energy bills. Economic Development Energy Zones would be focused on low-income neighborhoods and leverage community scaled renewables and storage that would allow for the aggregated demand of the customers in the area to be centrally controllable enough to warrant the same rate structure as TVA's BCD customers including available IP credits. These zones would not only help protect low-income rate payers who often do not have the luxury of choice when it comes to available housing in any market, it would also encourage employers to locate or grow in those neighborhoods and provide strong economic development to areas that need it most.

Please let me know if you have any questions about any of these comments or would like our input on any potential strategies to address them.

Best Regards,

Michael Walton AIA, NCARB, LEED AP
Executive Director

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Chattanooga, TN 37408

o: 423.648.0963
www.greenspaceschattanooga.com
michael@greenspaceschattanooga.com

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From: Watzman, Bruce
To: Integrated Resource Plan
Subject: IRP/EIS Scoping Comments
Date: Monday, April 16, 2018 12:32:40 PM
Attachments: image001.png
Combined.pdf

TVA External Message. Please use caution when opening.

Attached are comments of the National Mining Association is response to the Notice of Intent that appeared in the Federal Register on Feb. 14, 2018, 83 FR 6668.

Please contact me if you have any questions on NMA filings.

Bruce Watzman
Senior Vice President, Regulatory Affairs
National Mining Association
101 Constitution Ave. NW, Suite 500 East
Washington, D.C. 20001
Phone: (202) 463-2600
Direct: (202) 463-2657
bwatzman@nma.org

April 16, 2018

Ashley Pilakowski
Tennessee Valley Authority
400 West Summit Hill Drive
WT 11D
Knoxville, TN 37902

Via electronic mail to IRP@tva.gov

Re: Tennessee Valley Authority, Environmental Impact Statement (EIS) for 2019 Update to the Integrated Resource Plan (IRP)

Dear Ms. Pilakowski:

The National Mining Association (NMA) submits these comments in response to the Tennessee Valley Authority (TVA) Environmental Impact Statement for 2019 Update to the Integrated Resource Plan, 83 Fed. Reg. 6,668 (Feb. 14, 2018). NMA is a national trade association whose members include the producers of most of America's coal, metals, and industrial and agricultural minerals; manufacturers of mining and mineral processing machinery, equipment, and supplies; and engineering and consulting firms that serve the mining industry.

NMA's comments address three topics that TVA should take into account as a part of its IRP Update:

1. TVA must maintain a diverse, reliable and affordable supply of electricity for its customers, including, at least, current levels of coal generation.
2. Reducing TVA coal generation will have no discernable impacts on global concentrations of greenhouse gases (GHG); and
3. TVA must take into consideration the fact that reducing coal generation will raise electric rates and lower employment, and this in turn will have adverse socioeconomic impacts for residents within the TVA service area.

I. <u>TVA Must Maintain a Diverse and Reliable Supply of Electricity for its Customers</u>

Concern is growing that the wave of coal retirements that the country has recently experienced has imperiled the reliability and resilience of the power grid. This is particularly germane to TVA which has slashed coal generation on its system, from 58 percent in FY 2007 to just 26 percent in FY 2018.[1]

A recent analysis by IHS Markit shows that a less diverse generation portfolio with less coal generation and lower nuclear generation will cost more, impair the reliability and resiliency of the grid and produce little or no reduction in electric sector carbon dioxide emissions because the emissions profile of the prematurely retiring resources is less than or equal to the profile of the replacement sources.[2]

The current diversified electric supply portfolio as compared to a less diverse one:

- Lowers the cost of electricity by$114 billion annually and lower the average retail price by 27 percent;
- Avoids an annual $98 billion loss in consumer net benefits;
- Reduces the variability of monthly consumer electricity bills by 22 percent through the resilience it provides to the delivered price risk profile of the fuel inputs; and
- Mitigates an additional cost of $75 billion per hour associated with more frequent power supply outages inherent with a less resilient electric supply portfolio.[3]

As the Department of Energy has pointed out in a recent report, the United States grid is facing serious challenges owing to the number of ongoing retirements of baseload generating units, particularly coal units but also nuclear units.[4] These concerns are important enough that DOE took the extraordinary action of exercising authority under the Department of Energy Organization Act to formally propose, "in light of these threats to grid reliability and resilience," that FERC take action to ensure that baseload resources like coal and nuclear are fully compensated for the benefit they provide the grid.[5] While FERC did not adopt the specific relief DOE proposed, it stated that recent changes to the power system make it a "priority" that the continuing reliability and resiliency of the grid be ensured and, towards that end, it established a new proceeding to examine that issue in more detail.[6]

---

[1] Information taken from TVA Highlights Report 2017, https://www.tva.gov/Energy.

[2] IHS Markit, *Ensuring Resilient and Efficient Electricity Generation*, pp 4-5 (Sept. 2017) https://www.globalenergyinstitute.org/sites/default/files/Value%20of%20the%20Current%20Diverse%20US%20Power%20Supply%20Portfolio_V3-WB.PDF.

[3] Id. at 5.

[4] *See* U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability" (Aug. 2017) at 22.

[5] Department of Energy, Grid Resiliency and Pricing Rule, Notice of Proposed Rulemaking Before the Federal Energy Regulatory Commission, Docket No. RM17-3-000 (DOE NOPR).

[6] Federal Energy Regulatory Commission, *Grid Reliability and Resilience Pricing*, Docket No. RM18-1-000, *Grid Resilience in Regional Transmission Organizations and Independent System Operators*, Docket No. AD18-7-000, Order Terminating Rulemaking Docket, Initiating New Procedures, and Establishing Additional Proceedings (Jan. 8, 2018).

A study performed for the NMA by Energy Ventures Analysis (EVA)[7] showed how important the existing coal fleet was in maintaining grid reliability during the Polar Vortex winter of 2014. EVA found that had units then scheduled to retire under the Mercury and Air Toxics rule not been available, the following would have resulted:

- There would have been 34 hours in PJM where the reserve margin was less than 5% and 4 hours where there would have been a negative reserve margin (insufficient supply) and would have forced power curtailments;

- The reserve margin for ISO-NE would have been negative for 16 hours in January 2014, which would have forced power curtailments;

- PJM wholesale power prices would have been 40% greater without the coal plants, while ISO-NE wholesale prices would have been 50% greater and other regions would also have experienced large increases in wholesale prices;

- Consumers would have experienced an additional $35 billion in natural gas heating costs; and

- Similarly large impacts would have occurred had there been extreme weather this past summer.

These extreme market swings did not occur because the grid at that point was 50 percent coal-fired. As a result, consumers saved millions of dollars.

In its recent study, DOE examined the 2014 Polar Vortex with the benefit of hindsight and expressed continuing concern. As it said:

> Sixty-five million people within the PJM footprint could have been affected if these [coal] units were not available. The 2014 Polar Vortex was a warning that the current and scheduled retirements of fuel-secure plants could threaten the reliability of the grid.[8]

While the system is more resilient now, and the recent “bomb cyclone” event (December 27, 2017 through January 8, 2018) had a somewhat lesser impact on the grid than the Polar Vortex, concerns remain high. Manufacturing and production in the U.S. right now are low compared with historical levels, and economic indicators show a strong potential for a surge in energy needs in response to accelerating economic growth rates brought on by tax reform and other administration policies. Based on the analysis done after the 2014 and 2017 weather events, the system is not likely prepared to address additional power demand that economic growth could produce. In essence, with the retirement of so much coal generation, the grid has lost its buffer against renewed load growth.

---

7 EVA, “The Impact of Early Coal Retirements on Key Power Markets,” May 2014 (attachment 1 hereto).

8 DOE NOPR at 5.

The North American Electric Reliability Corporation (NERC) also recently highlighted that concerns as to insufficient electric capacity have not gone away:

> The North American electric power system is undergoing a rapid and significant transformation with ongoing retirements of fossil-fuel and nuclear capacity, as well as growth in natural gas, wind and solar resources … The changing resource mix is alternating the operating characteristics of the bulk power system (BPS). These changing characteristics must be well understood and properly managed in order to assure continued reliability and ensure resiliency.[9]

As NERC stated, "… coal-fired and nuclear generation have the added benefits of high availability rate, low forced outages, and secured on-site fuel. Many months of on-site fuel allow these units to operate in a manner independent of supply chain disruptions."[10] NERC went on to warn that "… premature retirements of fuel secure baseload generating stations reduces resilience to fuel supply disruption."[11] And even more recently, NERC expressed concern about the country's increased reliance on natural gas for power generation, given that gas generation typically has limited on-site storage and therefore is vulnerable to disruption during extreme events. NERC performed a power flow simulation that "demonstrated that 18 out of 24 groups of gas-dependent generators studied experience transmission challenges during an extreme event."[12]

The recent bomb cyclone weather event again showed the importance of coal to the grid. With the surge in demand, coal was the leading electricity supplier in many of the markets subjected to the deep freeze, providing a critical measure of reliability and resiliency to the nation's grid operators. For example, in the PJM region (13 eastern states and the District of Columbia), coal provided nearly 20,000 megawatts (MW) more power than natural gas; 10,000 MW more than nuclear; and five times more power than renewables on January 3. While it is true there were no blackouts, there would have been had current supplies of coal fired electricity not been available. It is also true that New England had to switch to oil backup for gas – oil was 33% of power supply in the cold. Plants would have run out of oil if the cold had lasted longer. Moreover, it is impossible to say that the system functioned well during the cold given that power prices were higher than $100 per MWh for two weeks in PJM, New York and New England.

The Department of Energy released figures showing actual generation by resource type on January 4 at 8:00 a.m., as compared with installed capacity.[13] These figures, shown

---

9 NERC Letter to Secretary of Energy Rick Perry, May 9, 2017, Attachment "Synopsis of NERC Reliability Assessments" at 1.

10 *Id*. at 2.

11 *Id*. at 3.

12 NERC, "Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System" (Nov. 2017) at viii.

13 Department of Energy, *Power Generation Response to Extreme Cold* (January 4, 2018).

below, demonstrate the degree to which coal was depended on during the weather event and the degree to which other resources could not be depended on.

	PJM		ISO New England		SPP	
	Installed	Actual	Installed	Actual	Installed	Actual
Coal	30.9%	39%	2.6%	7%	30.9%	59%
Gas	35.6%	22%	52.1%	30%	37.5%	21%
Wind	17.1%	4%	12.2%	3%	2.3%	12%
Nuclear	4.1%	28%	4.2%	28%	20.1%	6%
Oil	1.2%	5%	2.9%	21%	N/A	N/A
Solar	1.1%	0%	3.5%	N/A	0.4%	0%

As can be seen, in all markets, coal production considerably exceeded installed capacity. In contrast, in two markets (PJM and ISO New England), wind production collapsed. Natural gas generation, whether because of supply problems or because of significantly higher natural gas prices, was significantly less than installed capacity.

Recently, DOE's National Energy Technology Laboratory (NETL) issued a report analyzing the resilience of different electricity resources — coal, oil, natural gas, nuclear and renewables — in six RTOs/ISOs during the bomb cyclone event.[14] To evaluate their resilience, NETL used the National Infrastructure Advisory Council's definition of resilience which says in part, *"… The effectiveness of a resilient infrastructure or enterprise depends on its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."* In this case, NETL evaluated resilience based on the contribution of each electricity source to meeting incremental electricity demand during the bomb cyclone. Incremental refers to the additional demand for electricity during the bomb cyclone as compared to a typical winter day. The report concluded that the coal fleet was the most resilient source of electricity:

- "… across RTOs, coal is the most resilient form of generation …" (p. 18 of NETL report)
- "In PJM, the largest of the ISOs, coal provided the most resilient form of generation, due to available reserve capacity and on-site fuel availability, far exceeding all other sources … without available capacity from partially utilized coal units, PJM would have experienced … blackouts." (p. 1)
- "In PJM, of the three major sources of electricity generation, only coal-fired generation exhibited significant resilience in response to the extreme weather event." (p. 4)
- "The most prominent example of generation resilience occurred in PJM … some coal-fired units were suddenly brought on line and others ramped up to

[14] *Reliability, Resilience and the Oncoming Wave of Retiring Baseload Units Volume 1: The Critical Role of Thermal Units During Extreme Weather Events,* March 13, 2018, DOE/NETL-2018/1881.

accommodate the rapid increase in PJM electricity demand … coal units in PJM were uniquely positioned to provide the resilience needed at this critical point in time." (p. 12)

- The two charts below show the percentage contribution of electricity sources to meeting incremental electricity demand during the Bomb Cyclone. These charts are based on data in the NETL report.

Chart 1: Contribution to Meeting Incremental Electricity Demand in the Six RTOs

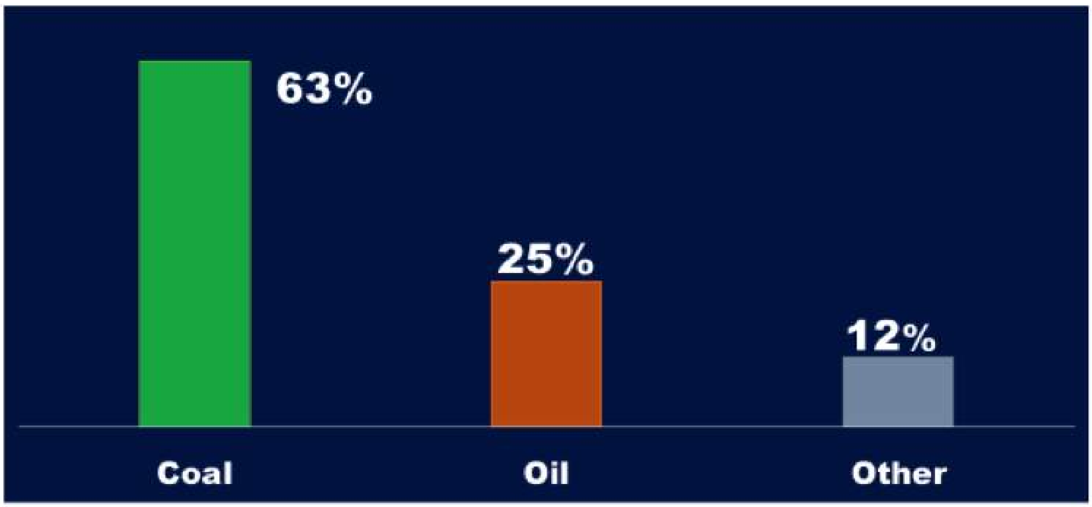
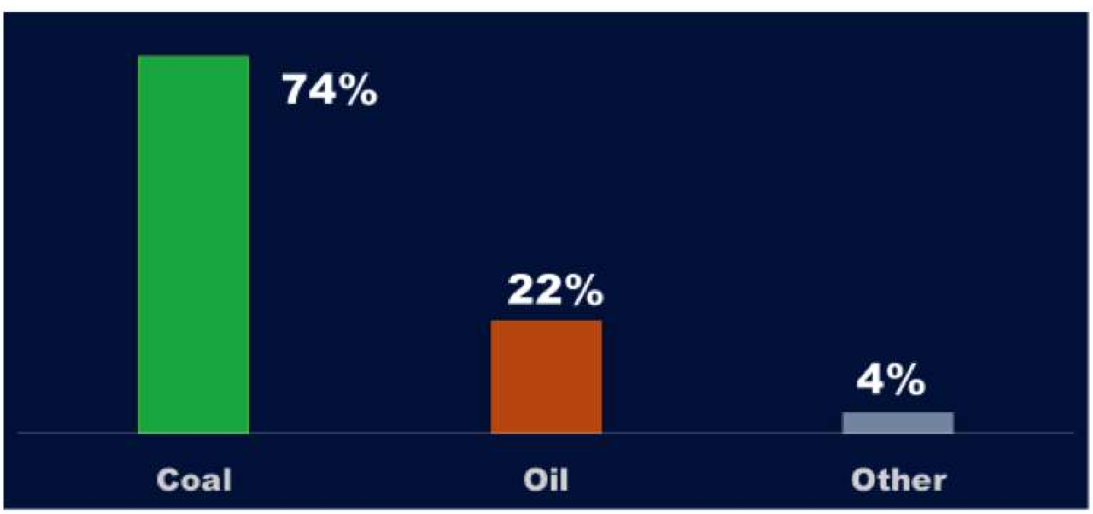


Chart 2: Contribution to Meeting Incremental Electricity Demand in the PJM Region



Two other conclusions of the NETL report also stand out. First, natural gas prices were very high.

- "… in eastern PJM, ISO-NE, and NYISO, gas and electric transmission were severely constrained, leading to all-time high gas prices in New York and elevated natural gas and electricity prices across each region." (p. 6)

- "… spot [gas] prices in New York reached $175/MMBtu …." (p. 8)

- "… natural gas prices in PJM spiked from a normal level near $3/MMBtu to $96/MMBtu at the Texas Eastern M3 interface … on January 5." (p. 14)

- Increases in spot gas prices for ISO-NE, PJM and NYISO were higher during the bomb cyclone than during the Polar Vortex. See Exhibit 1-20, p. 23.

Second, renewables were detrimental to resilience.

- "… cloud cover and wind speeds outside of operational parameters caused a reduction in average daily contribution from intermittent renewables … essentially imparting a resilience penalty to the system. This resulted in a need for dispatchable fossil generation to make up this generation in addition to its resiliency role in meeting the greater demand during the [Bomb Cyclone]." (p. 4)

- "Available wind energy was 12% lower during the Bomb Cyclone than for a typical winter day …." (p. 2)

- "Wind and solar had declines of 19% in MISO, 29% in SPP and 32% in ERCOT." (p. 5)

In testimony before the Senate Energy and Natural Resources Committee on January 23, DOE reiterated its concerns about coal retirements in a hearing entitled "Hearing to Examine the Performance of the Electric Power System under Certain Weather Conditions, Focusing on the Northeast and Mid-Atlantic Regions." Bruce Walker, Assistant Secretary, Office of Electricity Delivery and Energy Reliability at DOE, testified that "[t]he grid's integrity is maintained by an abundant and diverse supply of fuel sources today, especially with onsite fuel capability. However, the real question is whether or not this diversity will be here tomorrow." He went on to say that "[w]hat was apparent during [the recent "bomb cyclone"] weather event was the continued reliance on baseload generation and a diverse energy portfolio. Without action that recognizes the essential reliability services provided by a strategically diversified generation portfolio, we cannot guarantee the resilience of the electric grid." And further: "[w]hen we start relying on natural gas and oil, we increase our exposure … [T]he critical infrastructure is not the coal sitting at a plant or a nuclear facility, now I've got to rely on thousands of miles of pipelines and oil deliveries."

Coal thus remains a critical component in TVA's power mix, as another recent report highlighted:

- ***Coal-fueled generation provides many attributes that are critical for grid reliability and resilience***. A variety of attributes are required to maintain a reliable and resilient grid, and no one technology can do it all. Different resources provide these attributes to varying degrees, and coal provides many critical attributes. As the electric sector becomes increasingly reliant on natural gas and as renewable penetration grows, market structure changes may be required to properly price and value the contribution of all types of generation to ensuring both reliability and resilience.

- ***Resource diversity is critical in maintaining a reliable and resilient electricity system*.** The coal fleet plays an important role in helping to maintain resource diversity. The impact of unpredictable low-probability, high-impact events that challenge grid resilience is magnified as the electricity system evolves. For example, natural gas has historically been prone to supply disruptions and price shocks, while intermittent renewable and demand response resources are generally not dispatchable1 to meet unforeseen fluctuations in electricity demand. The U.S. coal fleet benefits from stable commodity pricing, multiple means of delivery, and an ability to stockpile fuel. Diversity in fuel supply improves the resilience of the grid and mitigates the impact of fuel supply disruptions.

- ***The coal fleet provides stable pricing as a hedge against natural gas price volatility*.** The price of natural gas has an outsized impact on the price of electricity in most markets. Today's natural gas prices are at near-historic lows, which has resulted in natural gas-fired combined-cycle plants being *the* favored technology to replace retiring generation and meet expected load growth. Retaining existing coal-fueled power plants can help insulate ratepayers against rising and possibly volatile natural gas prices.[15]

The essential attributes provided by different resources to grid reliability, resilience and affordability are shown in the table immediately below. The comparison highlights two important facts: (i) all the attributes listed are needed for grid reliability and resilience; and (ii) no single resource by itself exhibits all the attributes needed for reliability and resilience—however, coal-fueled generation provides many of these attributes.

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[15] PA Consulting Group, "The Contribution of the Coal Fleet to America's Electricity Grid" (August 2017) (PA Report) at i, available at http://www.americaspower.org/wp-content/uploads/2017/08/PA-Coal-Fleet-Study.pdf.

Qualitative Comparison of Grid Reliability and Resilience Attributes by Fuel Type[16]

Attribute	Coal	Natural Gas	Wind/Solar	Nuclear	Demand Response
Dispatchability	✓	✓		✓	
Inertia	✓	✓	✓ (wind)	✓	
Frequency Response	✓	✓	✓[17]		
Contingency Reserves	✓	✓			✓
Reactive Power	✓	✓		✓	
Ramp Capability	✓	✓			✓
Black Start		✓			
Resource Availability	✓	✓		✓	
On-Site Fuel Supply	✓			✓	✓
Reduced Exposure to Single Point of Disruption	✓		✓	✓	✓
Price Stability	✓		✓	✓	✓

In sum, in considering the possibility of retiring more coal units, TVA must take into account the impact that action will have in making the TVA grid less diverse, less resilient, and less reliable.

II. TVA Must Adjust Prior Assumptions When Updating the IRP

Major federal policy changes have occurred, and others are underway, since TVA completed the 2015 IRP. These changes and the avoided capital costs must be incorporated into TVA's scenario planning for resource strategies as it accounts for its least-cost planning requirements and priorities for power cost and reliability.

A. Policy Assumptions

1. *EPA Clean Power Plan has been stayed and proposed for repeal*. The United States Supreme Court stayed the implementation of the CPP on February 9, 2016. The stay will remain in effect until the Supreme Court rules on any challenges to the rule. It is very unlikely that the current rule will ever come into effect. The federal implementation plan has been withdrawn. The EPA has proposed to repeal the rule. 82 FR 48035 (Oct. 16, 2017). If EPA issues any

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16 PA Report at ii.

17 Although most wind does not provide frequency response, newer vintage wind resources with integrated storage can do so. Some solar depending on the type of inverter also supports frequency response.

replacement rule it will unlikely resemble the CPP which imposed a hard cap on power sector carbon dioxide emissions. Rather, any rule would more likely incorporate the historic interpretation of Clean Air Act § 111(d) by providing flexible guidelines focused on individual units and accounting for the inherent variability among units in terms of the technology they use, their ages and operational profile. The result will likely be economically achievable emission rates through best operating practices and/or equipment upgrades. See 82 FR 61507 (Dec. 28, 2017).

2. *The Clean Water Act ELGs for power plants have been stayed and under reconsideration*. EPA has postponed for two years the earliest compliance date for BAT and pretreatment standards for flue gas desulfurization wastewater and bottom ash transport water. 82 FR 43494 (Sept. 18, 2017). EPA intends to revise those limitations in a new rulemaking in response to several petitions for reconsideration. Moreover, EPA plans to reset the earliest and latest compliance deadlines for the permitting authority (currently Nov. 1, 2020 and Dec. 31, 2023 respectively) when it finishes the new rulemaking revising the standards. The outcome of this rulemaking and potential changes may well reduce substantially both the total investment and timing for the continued operation of TVA's existing coal units.

3. *EPA proposed revisions to CCR Disposal Rules***.** EPA has proposed to: (1) clarify the type and magnitude of the non-groundwater releases that would require a facility to comply with some or all of the corrective action procedures; (2) the requirement for proper height of woody and grassy vegetation for slope protection; and (3) modify the alternative closure provisions. The agency is also proposing six alternative performance standards that would apply in participating states with an approved CCR permit program under the WIIN Act. The estimated cost savings from these changes is between $32 million and $100 million per year (at an annualized 7 percent discount rate). 83 FR 11584 (March 15, 2018).

4. *EPA decision to retain current NAAQS for NO2*. Based on EPA's review of the air quality criteria addressing health effects of oxides of nitrogen and the primary NAAAQS as measured by nitrogen dioxide (NO2), the Administrator signed a notice on April 6, 2018 that EPA will retain the current standards without revision.

These and other policy changes

B. Going Forward Costs of Existing Resources and Costs of Replacement Assumptions

The notice of intent mentions several "industry-wide" changes necessitating TVA's need to develop a new IRP. The changes, according to the notice, include that "natural gas supplies are abundant and are projected to remain available at lower cost." 83 FR 6668. The notice does not explain "lower' than what or if it simply means lower than the historically high prices experienced from 2000-2008. In any event, the fuel price is just one factor in any analysis to identify the most economic energy resource strategy.

Some observers reflexively conclude that low natural gas prices have made coal and nuclear baseload power plants uncompetitive with natural gas-fired generation. However, a closer look of historical retirements shows that some of these retirements are occurring despite the fact the closed coal plant would have a lower cost to keep operating than the cost of a replacement natural gas plant or other generation resource. According to IHS Markit, the average going-forward cost for coal and nuclear plants currently operating to serve the non-peak load segments of demand are significantly below replacement costs.[18] The existing coal plant cost is 30 percent lower than natural gas combined cycle and 50 percent below renewables integrated by natural gas combined cycle.[19] On average, over the observed age distribution of existing plants, the cost gaps between the going forward costs of existing plants and the replacement costs demonstrates the existing plants will likely remain economic for another decade or more.[20]

C. Natural Gas Price Forecast Assumptions

In updating its IRP, TVA must be very cautious in its forecasts for natural gas prices. Long term natural gas price forecasts have proved problematic over the years because of the volatility and unpredictability of natural gas prices as shown below.

As a result, both the Energy Information Administration (EIA) and other forecasters' long-term natural gas prices have often failed to accurately predict future natural gas

18 IHS Markit, Ensuring Resilient and Efficient Electricity Generation pp 35-36.
19 Id. at 36, Figure 16.
20 Id. at 36.

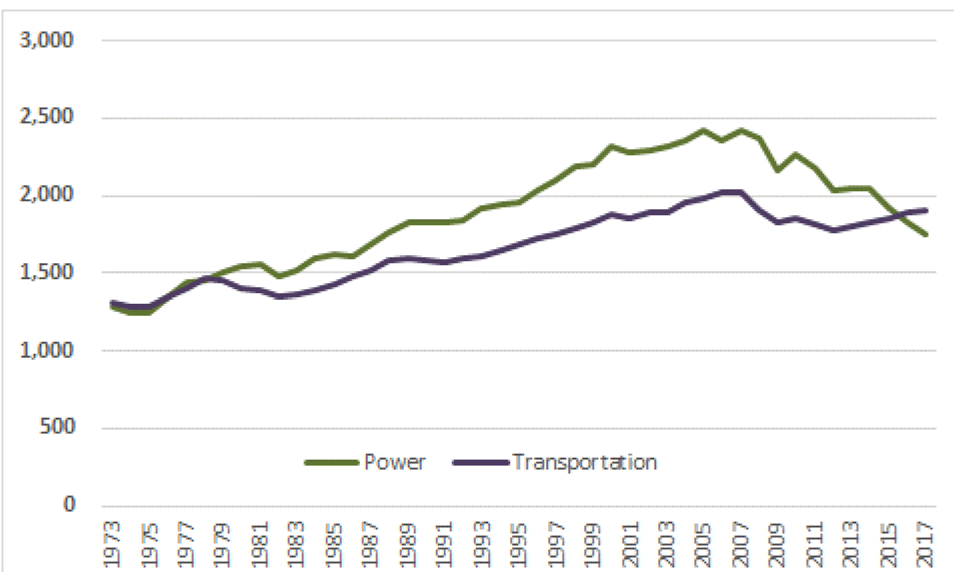
prices. EIA's AEO 2018 Reference case projection for natural gas prices starts from a base of $3.06 per million Btu in 2018 and rises to over $4.26 by 2030. However, under the "High Gas Price" case which incorporates different assumptions on the size of the resource and the cost and efficiency of the drilling technology projects natural gas prices to grow rapidly to $5.07 per million Btu by 2020 and reach $7.00 by 2032.

Full consideration of these scenarios is essential for TVA's analysis of the most effective energy resource strategies including plans to close its existing coal plants. The primary cause of power price volatility is the dependence on natural gas for power generation. As noted above, natural gas prices are highly volatile and heavily dependent upon winter weather. Moreover, increased demand for natural gas in the power sector will also have a direct effect on supply and prices for the residential, commercial and industrial customers within TVA's service territory.

III. Reducing coal generation in the Tennessee Valley Will Have No Material Impact on GHG Emissions

The case for retiring coal-fueled electric generation often is based on a concern about GHG emissions. But U.S. power sector CO_2 emissions have been *declining* since the Great Recession, even as the economy has recovered. According to the Energy Information Administration (EIA), U.S. energy-related CO_2 emissions declined by 1.4 percent between 2005 and 2016.[21] The decline is so pronounced that transportation-sector CO_2 emissions have now surpassed power-sector emissions:

US Carbon Dioxide Emissions from Electric Power and Transportation Sectors (million metric tons)[22]

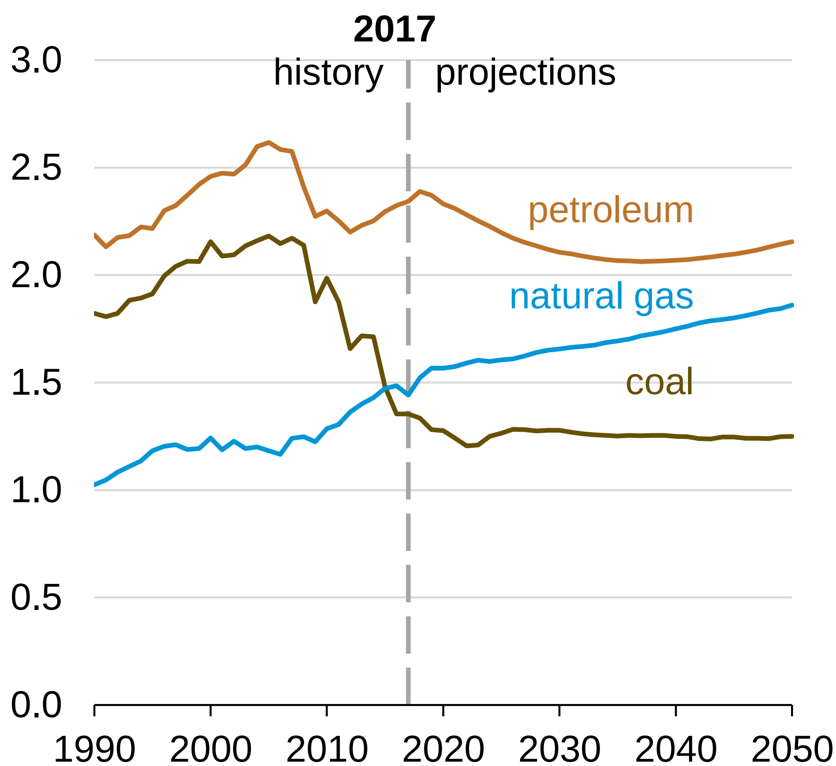


21 AEO 2017 at 22.

22 EIA, Monthly Energy Review, Table 12.6.

Comparing historical and projected CO_2 emissions from coal, natural gas and petroleum demonstrates that coal emissions have been cut dramatically and will continue to be well below the emissions of the other two fuels[23]:

Energy-related carbon dioxide emissions by fuel (Reference case)
billion metric tons of carbon dioxide



In contrast, other-country emissions are escalating rapidly. As the Environmental Protection Agency in defending the Clean Power Plan (CPP) during the Obama Administration recognized, "climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change."[24] The EIA compared the impact the CPP would have on overall global emissions and concluded that the impact would be so small that it can barely be detected, as seen in the chart below. EIA projects that total world emissions of CO_2 in 2030 with the CPP would be 36.4 billion metric tons, 0.56% less than emissions of 36.6 billion metric tons without the CPP. U.S. emissions are now only a small part of total global emissions and almost no part of the increase in global emissions that are

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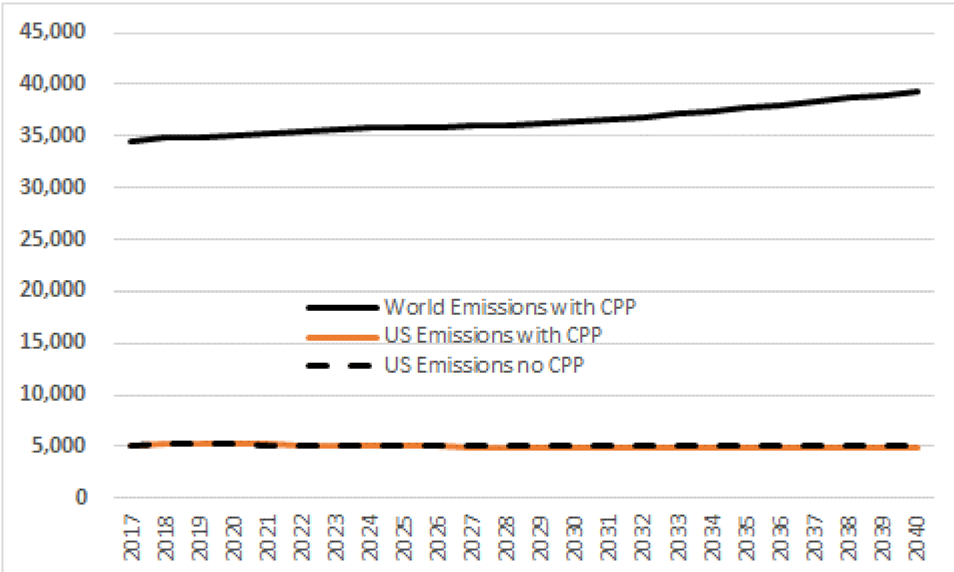
23 EIA Annual Energy Outlook 2018.

24 Interagency Technical Support Document "Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866" (revised 2015) at 14.

projected in the coming years. Obviously, the impact of retiring further TVA coal generation would be even smaller.

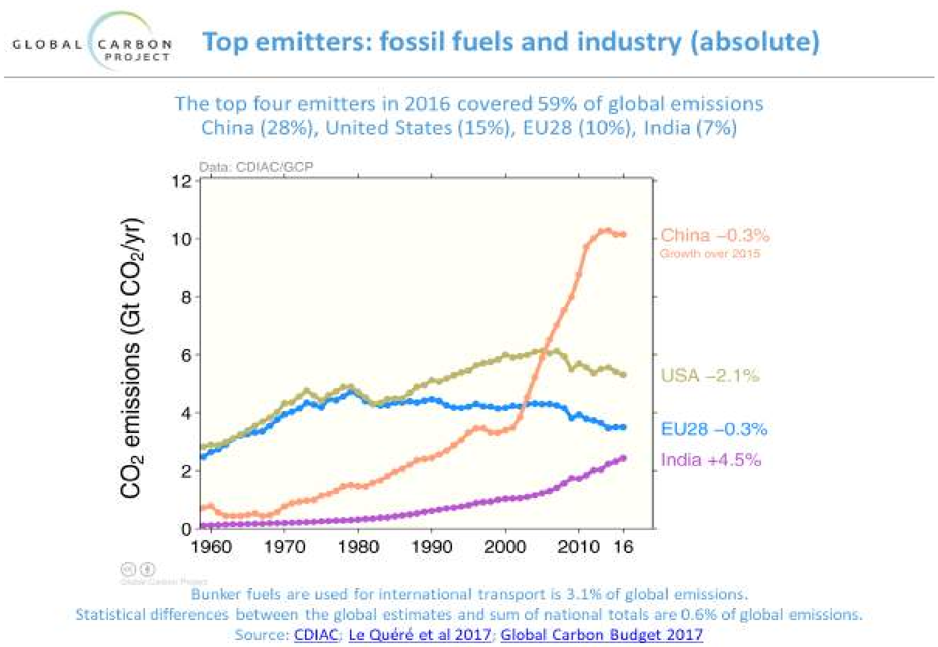
World Carbon Dioxide Emissions from All Sources (million metric tons)[25]



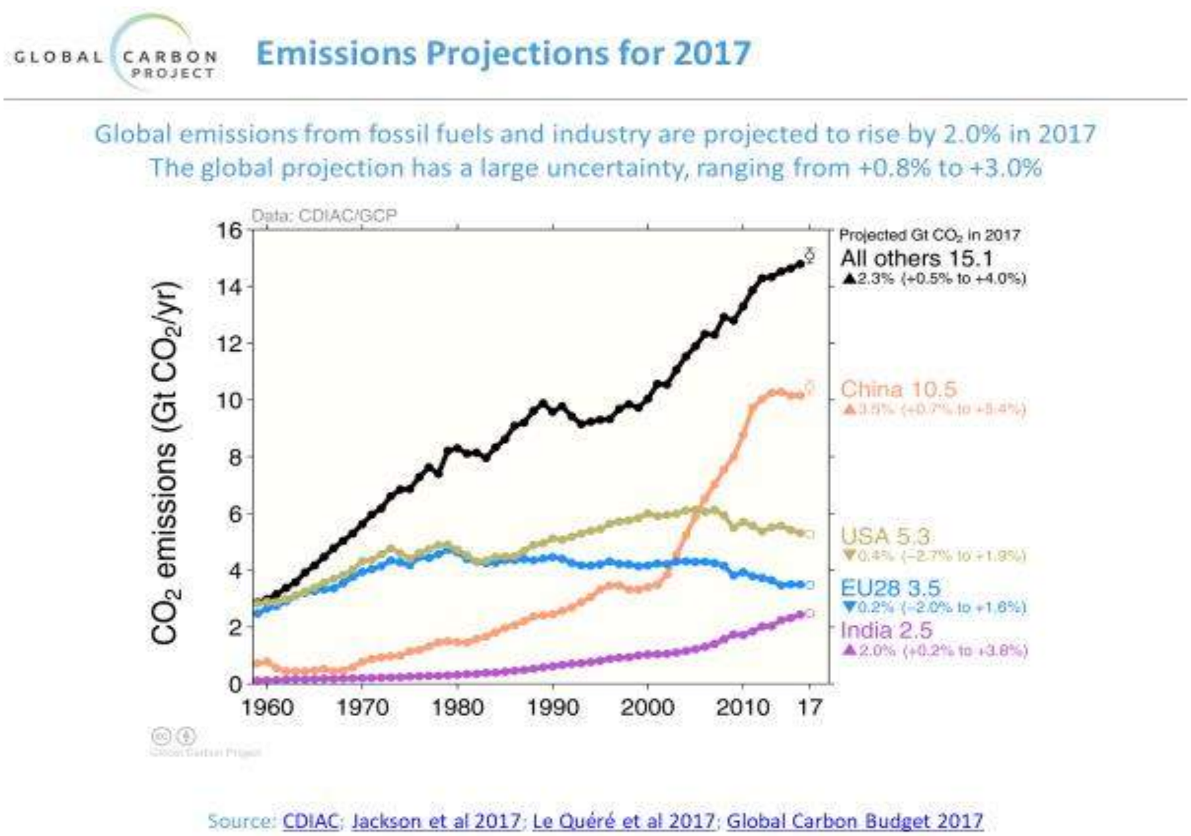
The following charts are from the Global Carbon Project,[26] a group of scientists who track the amount of carbon emitted by human activity, who published their results in three separate scientific journals — *Earth System Science Data*, *Environmental Research Letters* and *Nature Climate Change*. Collectively, they show that the United States is not the problem in terms of growing global CO_2 emissions. The major source of the continuing global increase is China and India.

25 EIA, International Energy Outlook 2017 browser; World Carbon Dioxide Emissions.

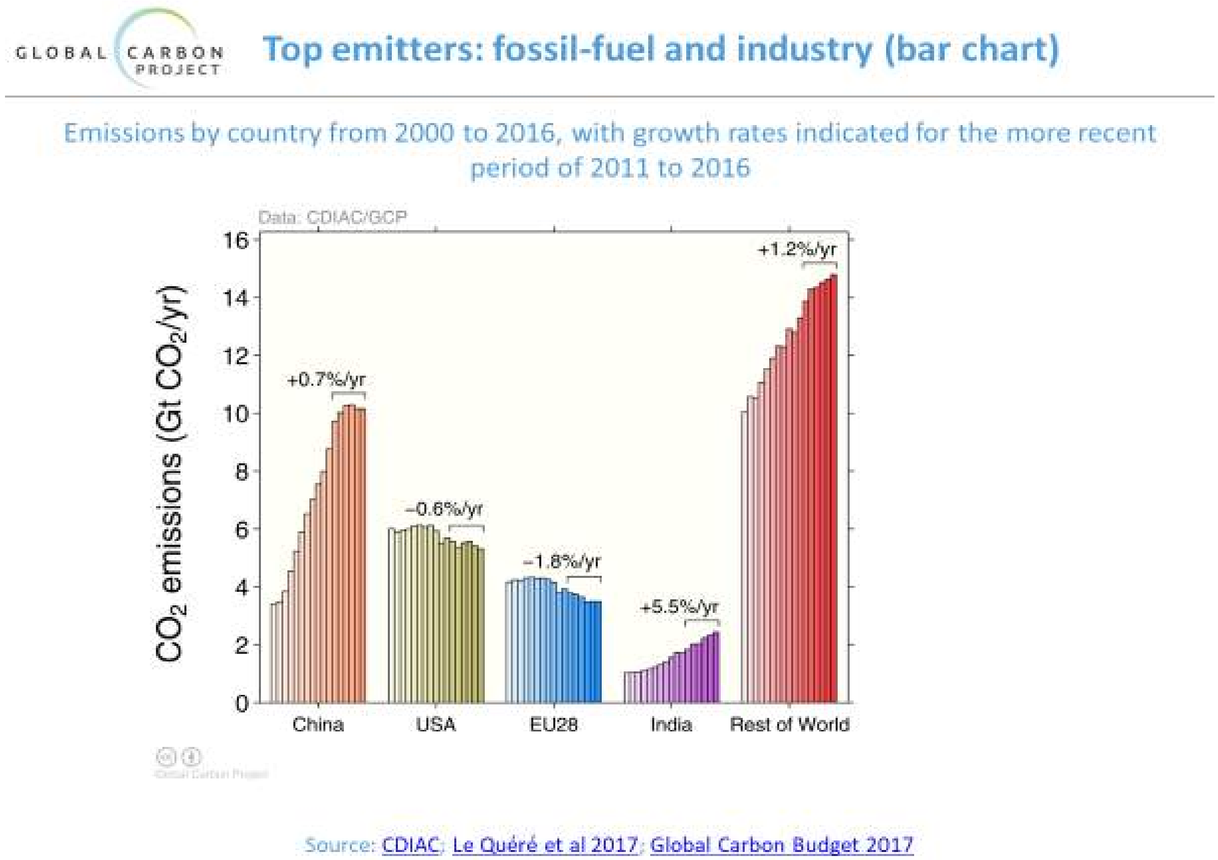
26 *See* http://www.globalcarbonproject.org/index.htm.



This disparity between U.S. and developing country emissions holds true in analyzing emissions from fossil fuels and energy. U.S. coal generation is not the reason why anthropogenic emissions continue to rise.



The following chart further graphically displays the disparity in emission growth rates between the developed world and the developing world.



This disparity is particularly noticeable for 2016, the last year for which data are available.

GLOBAL CARBON PROJECT

Fossil fuel and industry emissions growth

Emissions in the US, Russia and Brazil declined in 2016
Emissions in India and all other countries combined increased

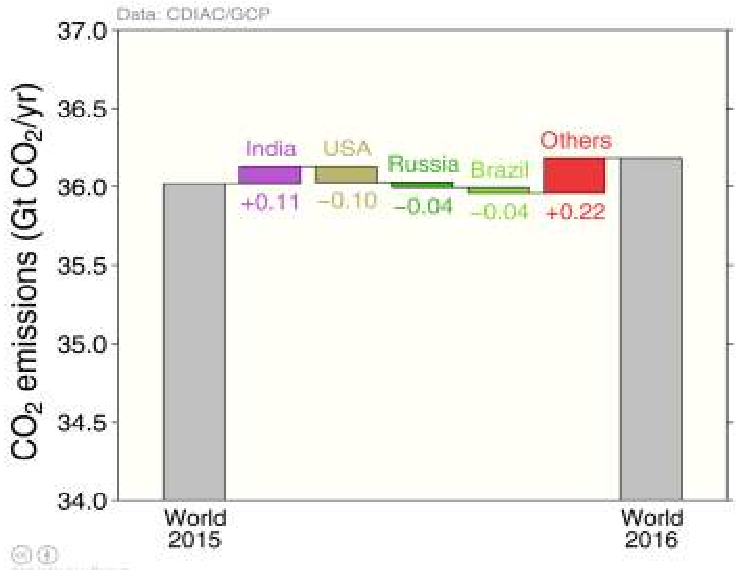
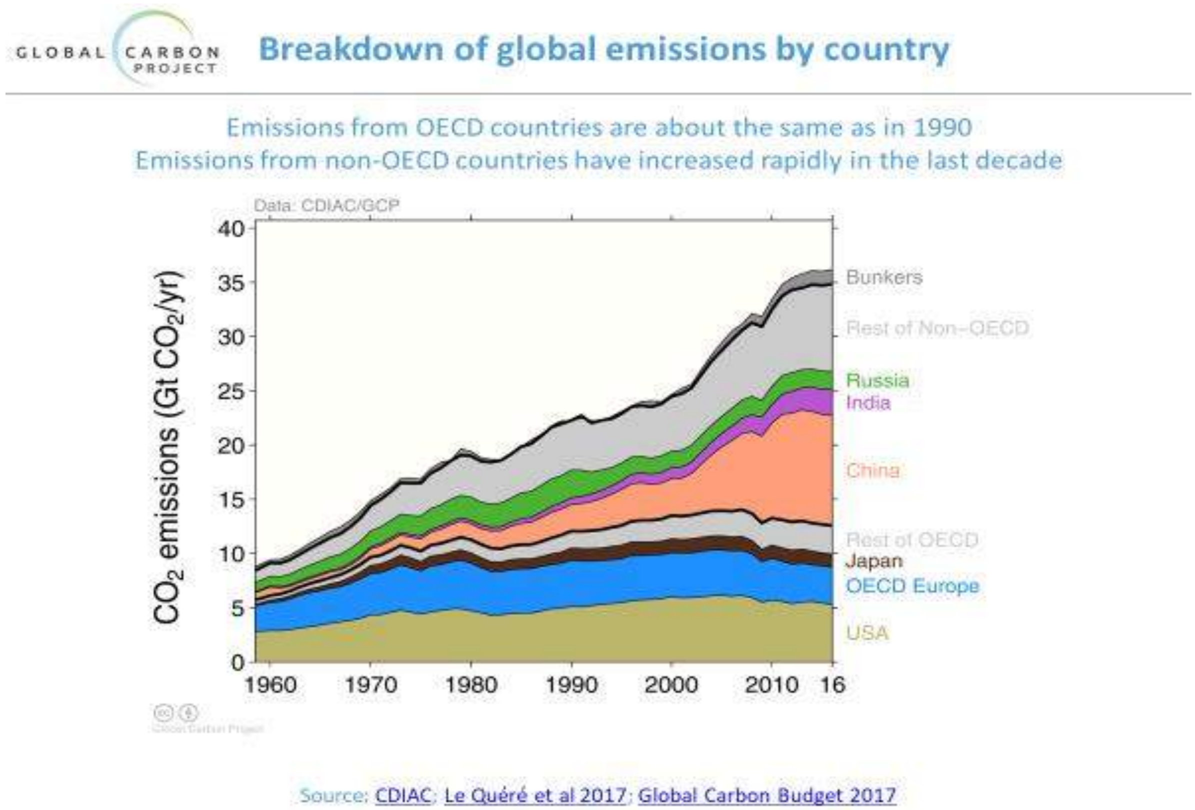


Figure shows the top four countries contributing to emissions changes in 2016
Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

This final chart provides even further evidence that the U.S. is not the problem. As the authors note, emissions from OECD countries are about the same as they were in 1990, whereas developing country emissions have accelerated rapidly.



In sum, any analysis TVA does in determining whether coal generation should be retired must take into consideration that the actual impact those retirements will have only a vanishingly small effect on overall global GHG concentrations.

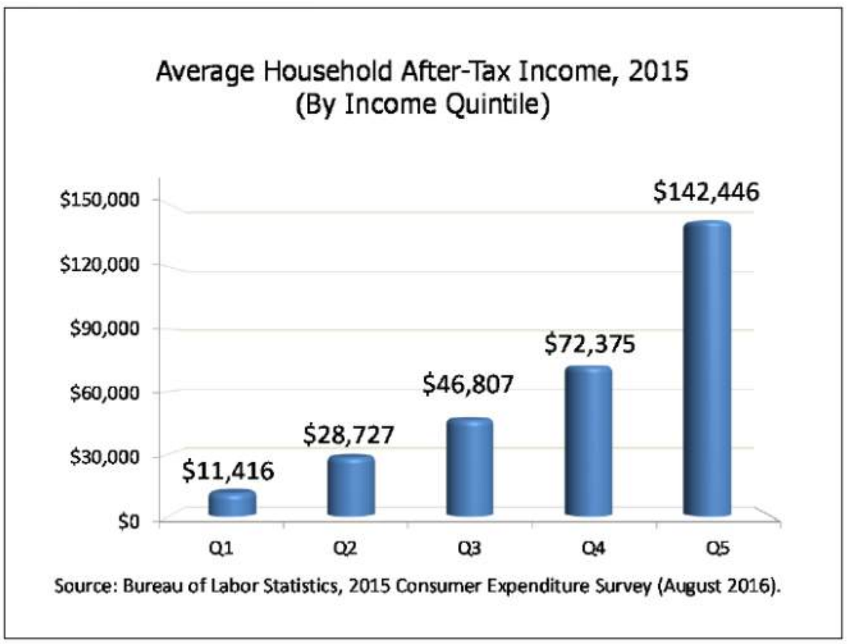
IV. <u>Retiring Coal Generation Will Increase Electric Rates and Lower Employment, and This in Turn Will Harm TVA Region Residents</u>

Because of its abundance, reliability and affordability, about 30 percent of the nation's electricity is generated from coal, resulting in electricity costs that generally are 30 percent lower in states that rely upon coal for more than half of their electricity generation versus states that rely on other fuels. The states in the TVA region benefit in having relatively lower electricity prices given their relatively high use of coal for power generation. In Kentucky, for instance, 84 percent of the state's electricity comes from coal and retail electric rates are 8.3 cents per kilowatt hour. In Tennessee, 39% of power comes from coal, and the state's retail rates are 9.3 cents per kilowatt hour. In contrast, only 4 percent of California's electricity is coal-fired, and its residents pay 15.3 cents per kilowatt hour. Connecticut uses even less coal for electricity, only 1 percent, and its residents pay a whopping 15.3 cents per kilowatt hour.[27] See Coal: America's Power for a complete comparison of coal-fired electricity prices in the TVA service area compared with other service areas using less coal.[28]

Given this relationship between low-cost coal power and low retail electric rates, any decision to retire coal in the TVA region will increase electric rates and force consumers to spend more money on electricity and less on other pressing needs. This should be of paramount importance to TVA as its mission is "to foster the social and economic progress of the people of the Tennessee Valley region."[29]

A. <u>Socioeconomic Impacts</u>

Income inequality remains a serious and growing problem in the United States. In 2016 there were 40.6 million Americans in poverty.[30] In the same year, the average after-tax income of the two lowest income quintiles, representing more than 51 million households, was a mere $20,072.[31] This is equivalent to a take-home income of less than $1,700 per month.[32]



The real pre-tax incomes of American households have *declined* across the three lowest income quintiles since pre-recession 2007 levels, measured in constant 2015

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27 Sources: EIA, *Electric Power Monthly*, March 2017 (2016 data); California Energy Commission (2016 latest available).

28 Source: Coal: America's Power, National Mining Association, nma.org/wp-content/uploads/2016/09/Coal-Americas-Power-2017.pdf

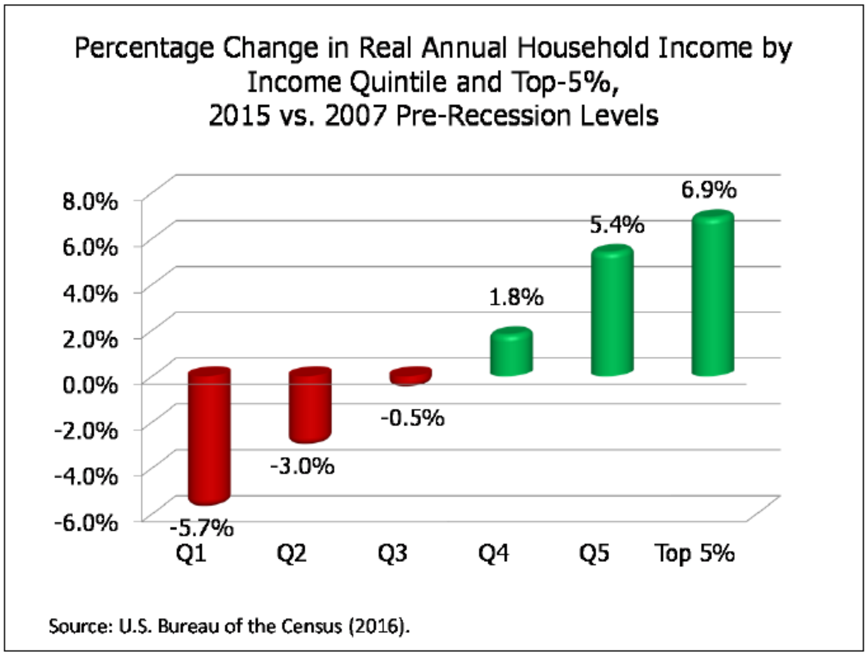
29 As TVA itself says in its scoping notice. 83 Fed. Reg. 6668 (Feb. 14, 2018).

30 U.S. Bureau of the Census, Income and Poverty in the United States: 2016 (Sept. 12, 2017).

31 Eugene Trisko, "Energy Expenditures by American Families" (Nov. 16, 2017) (attachment 2 hereto).

32 *Id.*

dollars.[33] The largest losses of income are in the two lowest income quintiles, representing families with pre-tax incomes below $37,600.[34] In contrast, households in the top 5% of incomes experienced a 7% increase in real median incomes between 2007 and 2015, an average increase per household of $22,570.[35]



Black and Hispanic households are disproportionately represented in the two lowest quintiles, accounting for 32% of households in those quintiles, compared with 14% in the top income quintile.[36] Senior citizens are also overrepresented in the lowest income quintiles.[37]

The electric rate increases that retiring coal generation would cause act as a regressive energy tax, causing the most harm to the tens of millions of Americans least able to afford it. Lower income people pay a large percentage of their incomes on energy. For instance, households in the lowest income quintile, with an average after-tax income of $11,416, spend 20% of their after-tax income on residential utilities and gasoline, while households in the two lowest quintiles spend 16%.[38] This compares with 4% for households in the top income quintile, whose average after-tax income is $142,446.[39]

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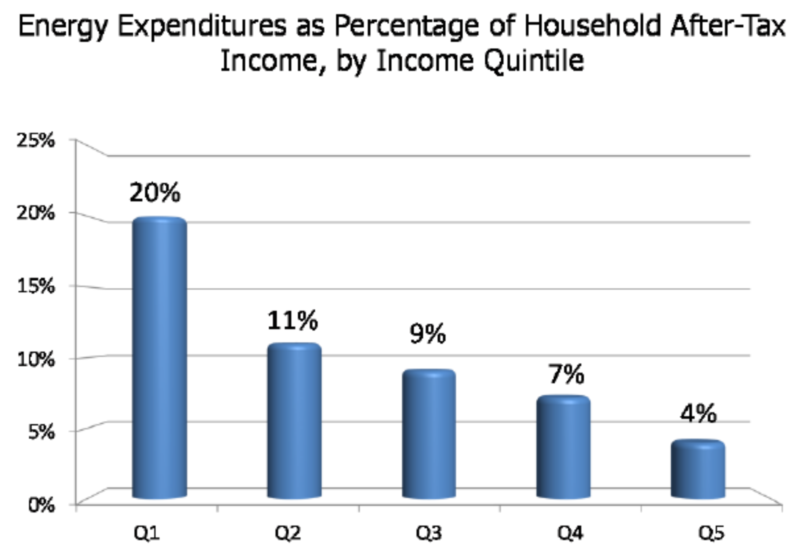
33 *Id.*
34 *Id.*
35 *Id.*
36 *Id.*
37 *Id.*
38 *Id.*
39 *Id.*



Source: Bureau of Labor Statistics, 2015 Consumer Expenditure Survey (August 2016). Includes electricity, natural gas, other household fuels, and motor gasoline.

Many residents of the TVA region are particularly vulnerable to the electric rate increases retiring coal plants would cause because all the states within this region except one have higher rates of poverty than the United States.

3-Year Average Poverty Rate 2014-16 in States in the TVA Region[40]

	U.S.
U.S.	13.7%
AL	16.8%
GA	16.8%
KY	18.3%
MS	20.8%
NC	16.3%
TN	15.6%
VA	10.8%

The impact of retiring more TVA coal generation will also have a particularly strong economic impact on coal communities within the TVA region. Coal generating plants and coal mines tend to be in rural areas that have lower average incomes and higher poverty rates than the United States in general. At the same time, coal jobs tend to be significantly better-paying than many other jobs in these communities. Eliminating

[40] United States Census Bureau, "Income and Poverty in the United States: 2016," September 12, 2017, Report Number: P60-259, https://www.census.gov/library/publications/2017/demo/p60-259.html.

these jobs has direct and material effects on the health and welfare of those who are laid off, as well as on the many other people in these communities whose livelihoods depend on coal mining.

Against this backdrop, coal jobs have been a critical source of income for these distressed communities. For instance, in Kentucky, coal mines paid wages of nearly $1 billion in 2016, resulting in an average annual wage of nearly $100,000 per miner. Coal workers thus are among the highest paid blue-collar workers in the Kentucky economy.[41] Coal mining also produces large economic benefits in coal communities and coal states. Coal mining is directly responsible for nearly $200 million in government revenues in Kentucky and is used to fund a variety of government services, including environmental protection, education and emergency services. In Kentucky, coal produced almost $4.6 billion of revenues for the coal mines, much of which is re-spent in the local economy creating a multiplier effect of other induced and indirect benefits. Kentucky government authorities estimate that an additional $2.16 billion of spending was induced by coal production.[42] Curtailing coal use jeopardizes these vital resources and the services they fund.

B. Health and Welfare Impacts

A well-established body of literature establishes the obvious link between a person's economic well-being and his or her health.[43] Having a good income means a person

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41 Figures for Kentucky are from *Kentucky Coal Facts* (17th ed. 2017), prepared by the Kentucky Energy and Environment Cabinet and the Kentucky Department for Energy Development and Independence in partnership with the Kentucky Mining Association,

42 Information taken from *Kentucky Coal Facts*.

43 *See, e.g.*, Brenner, M.H., Unemployment and heart disease mortality in European countries, Report to the European Commission, Employment, Social Affairs and Inclusion DG: Analysis, Evaluation, External Relations, Social Analysis, December 2013; Brenner MH, Andreeva E, Theorell T, Goldberg M et al. Organizational downsizing and depressive symptoms in the European recession: The experience of workers in France, Hungary, Sweden and the United Kingdom, PLOS ONE, 1-18, May 2014; Brenner MH. Unemployment and heart disease mortality in European countries, Report to the European Commission, Employment, Social Affairs and Inclusion DG: Analysis, Evaluation, External Relations, Social Analysis, December 2013; Brenner MH. Influence of health care expenditures, GDP, employment and globalization on cardiovascular disease mortality: potential implications for the current recession. *International Journal of Business and Social Science*, 3 (20), 1-10, 2012; Brenner MH, Andreeva E. eds. *Development of Macro Level Indicators of Restructuring and Workers' Health*, Berlin: Berlin University of Technology, 2011; Brenner MH. *Explaining aggregate health status (mortality). Insights to the possible impact of the economic crisis*. Report to the European Commission, Directorate General, Employment, Industrial Relations, Social Affairs and Social Protection, 2009; Brenner MH. Commentary: economic growth is the basis of mortality rate decline in the 20th century – experience of the United States 1901-2000. *International Journal of Epidemiology* 34, 1214–1221, July 2005; Brenner, MH. *Unemployment and Public Health in Countries of the European Union*, Report to the European Commission, Directorate General, Employment, Industrial Relations and Social Affairs, 2002; Brenner, MH. *Estimating the Social Cost of Unemployment and Employment Policies in the European Union and the United States*, Report to the European Commission, Directorate General, Employment, Industrial Relations and Social Affairs, 2000; Brenner MH. Heart disease mortality and economic changes; including unemployment in Western Germany 1951-1989. *Acta Physiologica Scandinavica* 161(Suppl. 640), 149-52, November 1997; Brenner MH. Economic instability, unemployment rates, behavioral risks, and mortality rates in Scotland, 1952-1983. *International Journal of Health Services* 17(3), 475-484, 1987a; Brenner MH. Economic change, alcohol consumption and heart disease mortality in nine industrialized countries. Social Science and Medicine 25(2), 119-131, 1987b; Brenner MH and Mooney A. Economic change and sex-specific cardiovascular

can pay for a good diet, for heating and air-conditioning, and for adequate health care. Having a lower income makes it more difficult for people to pay for these necessities and, as important, job loss, economic dislocation and the resulting stress leads to heart and other diseases, personal depression, addiction and suicide.

The Appalachian Regional Commission reports on Appalachian statistics such as poverty, income, and employment. It has produced two recent reports demonstrating the link between lower incomes in Appalachia and poor public health. Because much of

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mortality in Britain 1955-1976. *Social Science and Medicine* 16,431-442, Spring 1982; Brenner MH. Mortality and the national economy: a review and the experience of England and Wales, 1936-1976. *The Lancet* 568-573, September 15, 1979; Brenner MH. Economic Changes and Heart Disease Mortality. *American Journal of Public Health* 61,606-61, March, 1971; Crombie IK, Kenicer MB, Smith WCS and Tunstall-Pedoe HD. Unemployment, socio-environmental factors, and coronary heart disease in Scotland. *Br Heart J* 61,172-7, 1989; Dave DM and Kelly IR. *How does the business cycle affect eating habits*? NBER Working Paper No. 16638, December, 2010; Dupre, M., George, L.K., Liu, G., Peterson, E. The Cumulative Effect of Unemployment on Risks for Acute Myocardial Infarction, *Archives of Internal Medicine*, 172(22):1731-7, 201; Frankel S, Smith GD, and Gunnell D. Childhood socioeconomic position and adult cardiovascular mortality: the Boyd orr cohort. *American Journal of Epidemiology* 150(10):1081-84, 1999; Gallo, W.T., Bradley, E.H., Falba, T., Dubin, J., Cramer, L., Bogardus Jr., S.T., Kasl, S.V. Involuntary Job Loss as a Risk Factor for Subsequent Myocardial Infarction and Stroke: Findings from the Health and Retirement Survey, *Am J Ind Med*, 45 (5):408-416, 2004; Gallo WT, Teng HM, Falba TA, Kasl SV, Krumholz HM and Bradley EH. The impact of late career job loss on myocardial infarction and stroke: a 10 year follow up using the health and retirement survey. *Occup Environ Med* 63:683-687, 2006; Galobardes B, Smith GD and Lynch JW. Systematic review of the influence of childhood socioeconomic circumstances on risk for cardiovascular disease in adulthood. *Ann Epidemiol* 16:91-104, 2006; Goldston K and Baillie AJ. Depression and coronary heart disease: A review of the epidemiological evidence, explanatory mechanisms and management approaches. *Clinical Psychology Review* 28, 288–306, 2008; Hallsten, L., Grossi, G., & Westerlund, H. Unemployment, labour market policy and health in Sweden during years of crisis in the 1990's. *International Archives of Occupational and Environmental Health*, 72 (Suppl), S28-30, 1999; Hammarstrom A and Janlert U. Unemployment and change of tobacco habits: a study of young people from 16 to 21 years of age. *Addiction* 89, 1691-1696, 1994; Henriksson KM, Lindblad U, Agren B, Nilsson-Ehle P and Rastam L. Associations between unemployment and cardiovascular risk factors varies with the unemployment rate: the cardiovascular risk factor study in Southern Sweden (CRISS). *Scand J Public Health* 31, 305-311, 2003; Hulme, D, Moore, K and Shepherd, A, Chronic Poverty: Meanings and Analytical Frameworks. Chronic Poverty Research Centre Working Paper No. 2, 2001 Available at SSRN: http://ssrn.com/abstract=1754546 or http://dx.doi.org/10.2139/ssrn.1754546; Kaplan GA and Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 88(4), 1973-1998, 1993; Kasl, SV and Jones, BA. The impact of job loss and retirement on health. In L.F. Berkman & I. Kawachi (Eds.), *Social Epidemiology* (pp. 118-136). New York: Oxford UP, 2000; McKee-Ryan FM, Song Z, Wanberg CR and Kinicki AJ. Psychological and physical well-being during unemployment: a meta-analytic study. *Journal of Applied Psychology* 90(1), 53–76, 2005; Morris JK, Cook DG, Shaper AG. Loss of employment and mortality. *BMJ* 308, 1135-9, 1994; Moser KA, Fox AJ, Goldblatt PO and Jones DR. Stress and heart disease: evidence of associations between unemployment and heart disease from the OPCS longitudinal study. *Postgraduate Medical Journal* 62, 797-799, 1986; Noelke, C, Beckfield J. Recessions, Job Loss and Mortality Among Older US Adults, *American Journal of Public Health*, Sep 11: e1-e9, 2014; Peterson C and Kim ES. Psychological interventions and coronary heart disease. *International Journal of Clinical and Health Psychology* 11(3), 563-575, 2011; Reeves, A., McKee, M., & Stuckler, D. Economic suicides in the Great Recession in Europe and North America. *British Journal of Psychiatry*. doi: 10.1192/bjp.bp.114.144766, 2014; Sorlie PD and Rogot E. Mortality by employment status in the national longitudinal mortality study. *American Journal of Epidemiology* 132(6), 983-992, 1990; Tausky, C. & Piedmont, E.B. The meaning of work and unemployment: Implications for mental health. *International Journal of Social Psychiatry*, 14(1), 44-9, 1967/8; The American Dietetic Association. Position of the American Dietetic Association: food insecurity in the United States. *J Am Diet Assoc* 110, 1368-1377, 2010; Whooley MA and Wong JM. Depression and cardiovascular disorders. *Annu Rev Clin Psychol* 9:327–54, 2013.

Appalachia overlaps the TVA region, its findings are instructive.[44] In its August 2017 report "Health Disparities in Appalachia,"[45] the Commission concluded that the region compares unfavorably to the rest of the nation on a large number of health measures. In a subsequent report, the Commission noted that the region also suffers from a disproportionate share of what it called "deaths of despair" or "diseases of despair" resulting from three main causes—alcohol, prescription drug and illegal drug overdose; suicide; and alcoholic liver disease/cirrhosis of the liver.[46] The Commission cautioned that its findings predate the emergence of the opioid crisis in 2015 and that the reality today in Appalachia is likely worse.[47]

In sum, retiring coal generation will increase electric rates, and this in turn will create both socioeconomic and health and welfare impacts on the poorest of TVA's customers. As an agency formed to "foster the social and economic welfare of the people of the Tennessee Valley region," TVA must take this into account as it considers whether to retire more coal generation and increase electric rates.

NMA appreciates the opportunity to submit these comments.

Sincerely,

Bruce Watzman
Senior Vice President, Regulatory Affairs

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44 Appalachia consists of all of West Virginia and parts of 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia.

45 Available at https://arc.gov/research/researchreportdetails.asp?REPORT_ID=138.

46 Appalachian Regional Commission, "Appalachian Diseases of Despair" (August 2017), available at https://arc.gov/assets/research_reports/AppalachianDiseasesofDespairAugust2017.pdf.

47 *Id*. at 19.

Appendix A

THE IMPACT OF EARLY COAL RETIREMENTS ON KEY POWER MARKETS

Prepared for:

National Mining Association
Washington, DC

May 2014

Energy Ventures Analysis
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OUTLINE

- Problem Statement
- Introduction
- Impact of Early Coal Retirements in Winter
- Impact of Early Coal Retirements in Summer
- Methodology
- Detailed Gas Analysis
- Detailed Power Analysis
- Appendix

OUTLINE

- Problem Statement

Problem

- Introduction
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PROBLEM STATEMENT

The winter of 2013-14 posed a large challenge to the power and natural gas markets. The U.S. had its 11th coldest winter in history, record high natural gas demand and average peak power prices that were more than double than what has been observed in the past 5-years. Additionally, the market witnessed record high gas storage withdrawals, and short term gas price spikes reaching as high as $135/MMBtu at some Northeast trading points.

Across the Eastern U.S there was simultaneously strong demand for electricity and natural gas to heat homes and businesses. Every bit of natural gas in storage and every electricity generation asset was needed to meet demand. However, there were gas supply constraints in particular areas and some generation assets were unable to perform as expected because of the frigid temperatures. Because of these situations, coal-fired assets were relied upon heavily to provide dependable electricity across the region.

EPA's Mercury and Air Toxics standards will force 26 gigawatts of coal capacity to exit the power markets between the latter half of 2014 and 2016. The majority of the these coal-fired retirements will occur in the regions where they were relied upon to provide electricity this past winter (New England, East North Central, Middle Atlantic, South Atlantic, East South Central).

If these coal-fired plants were not available during the winter of 2014, there would have been severe reliability issues within key electric power markets, because of the constraints in natural gas supply and power generation outages. Additionally, the seasonal spikes in regional natural gas prices that occur, would have been even greater than what was experienced this past winter, causing average peak electricity prices to surge more than 40 percent more than what was observed.

The purpose of this study is to examine the impact to the power and natural gas markets if the coal-fired assets that will retire in the 2014-2016 period had not been available for the winter of 2014. Additionally, if these coal-fired assets were not available during a hot summer, this study analyzes how the power and natural gas markets would be impacted.

OUTLINE

INTRODUCTION

POWER MARKET RESERVE MARGIN SUMMARY PRE and POST COAL RETIREMENTS

Region	Base Capability	Demand	Base Reserve	Retiring Coal Capacity	Post Retire Reserve	Diff.
ISONE	32,631	26,505	23%	1,500	17%	-6%
NYISO	35,000	29,971	17%	75	17%	0%
PJM	180,000	160,000	13%	11,646	5%	-7%
SERC	175,053	135,666	29%	10,614	21%	-8%
FRCC	50,000	43,288	16%	0	16%	0%
MISO	103,945	87,578	19%	4,700	13%	-5%
ERCOT	78,000	67,000	16%	0	16%	0%
SPP	56,326	36,729	53%	1,970	48%	-5%
CAISO	55,000	46,000	20%	101	19%	0%

- EVA identified the power markets having the greatest power reliability risk from the retiring coal units from the change in their reserve margins and fuel delivery constraints.

- Reliability assessment to focus on PJM, MISO and ISO-NE.
  - PJM, because it has the most coal-fired retirements and its reserve margin dropping to only 5%-- well below the 15% target
  - MISO because it has a large amount of coal retirements and reserve margin falls bellow its 15% target
  - ISO-NE because the region is at risk for reliability during periods of constrained gas supply. At critical junctures, only 3,500 MW of ISO-NE's 18,000 MW gas-fired capacity was available this winter because of gas constraints.

- The coal retirements also have an impact on SERC's and SPP's reserve margins, but even after the retirements, these regions have sufficient surplus capacity remaining to remain above reserve margin targets

INTRODUCTION

- In order to systematically and correctly evaluate the issues laid out in the problem statement, EVA designed three sets of scenarios for both the winter and summer reliability assessment (see table below)

- For each scenario, EVA analyzed the PJM, MISO and ISO-NE power markets

- For the ISO-NE winter scenarios, EVA modified its business process from the other two power markets. EVA selectively restricted gas-fired generation assets in ISO-NE that are connected to the Algonquin pipeline, as they were unable to operate during the 2014 winter because of constrained gas supply.

REVIEW OF SCENARIOS PERFORMED	
Winter Assessment	
Base Case - Wint.	Re-Simulation of natural gas and power markets in Winter 2014 (Jan-Feb)
Case #1	Base Case - Wint. *minus* 2014 to 2015 MATS related coal retirements
Case #2	Base Case - Wint. *minus* 2014 to 2016 MATS related coal retirements
Summer Assessment	
Base Case - Sum.	Simulation of natural gas and power markets for extreme summer weather in 2014 (June- Aug)
Case #3	Base Case Sum. minus 2014 to 2015 MATS related coal retirements
Case #4	Base Case Sum. minus 2014 to 2016 MATS related coal retirements

OUTLINE

IMPACT OF COAL RETIREMENTS ON SYSTEM RELIABILITY - WINTER

PJM

- During this past winter, record high electricity demand and generation outages led to several instances in which PJM was low on resources and narrowly avoided load shedding to maintain system reliability
- If the coal plants scheduled to be retired from 2014 to 2016 were not available in PJM during the winter of 2014, there would have been 34 hours where the reserve margin was less than 5% and 4 hours where there would have been a negative reserve margin (insufficient supply) and would have forced power curtailments

NUMBER OF HOURS IN JANUARY 2014 BELOW KEY RESERVE MARGIN LEVELS

		Reserve Margin		
		<10%	<5%	<0%
ISO-NE	Base Case	2	0	0
	2014-15 Retiremen	30	16	16
	2014-16 Retiremen	30	16	16
PJM	Base Case	16	0	0
	2014-15 Retiremen	57	31	3
	2014-16 Retiremen	55	34	4
MISO	Base Case	0	0	0
	2014-15 Retiremen	1	0	0
	2014-16 Retiremen	2	0	0

MISO

- In MISO, despite record high demand due to sustained cold weather, the reserve margin did not become precariously tight
- Under EVA's scenario analysis, no real reliability issues were predicted if the retiring coal plants were not available during the winter of 2014. EVA only estimated 2 hours where there would have been a reserve margin between 5% and 10%

ISO-NE

- In ISO-NE, select gas-fired generators were unable to perform as expected as natural gas pipeline capacity in the Northeast was constrained.
- The reserve margin for ISO-NE would have been negative for 16 hours in January 2014 (without the coal capacity that is expected to retire over the next two years) and would have forced power curtailments.

IMPACT OF COAL RETIREMENTS ON WINTER POWER PRICES (JANUARY-FEBRUARY 2014)

- In addition to threatening system reliability, early coal retirements drove higher wholesale power prices in all three markets, though the impact in PJM in ISO-NE was greater
- The table to right illustrates what the average wholesale power price would have potentially been in January-February 2014, if the coal plants scheduled to retired would not have been available.
- PJM wholesale prices would have been 40% greater without the coal plants, while ISO-NE wholesale prices 50% greater.
- The detailed power analysis section of this report will provide more color on how the power prices would have been effected in the absence of the coal plants

AVG. WHOLESALE POWER PRICE FOR EACH WINTER SCENARIO ($/MWh)

	Base Case	2014-15 Retirements	2014-16 Retirements
ISO-NE	$120	$180	$180
PJM	$102	$143	$145
MISO	$41	$58	$60

IMPACT OF COAL RETIREMENTS ON WINTER POWER PRICES – JANUARY 2014

AVERAGE MONTHLY POWER PRICES – MAJOR U.S. MARKET REGIONS

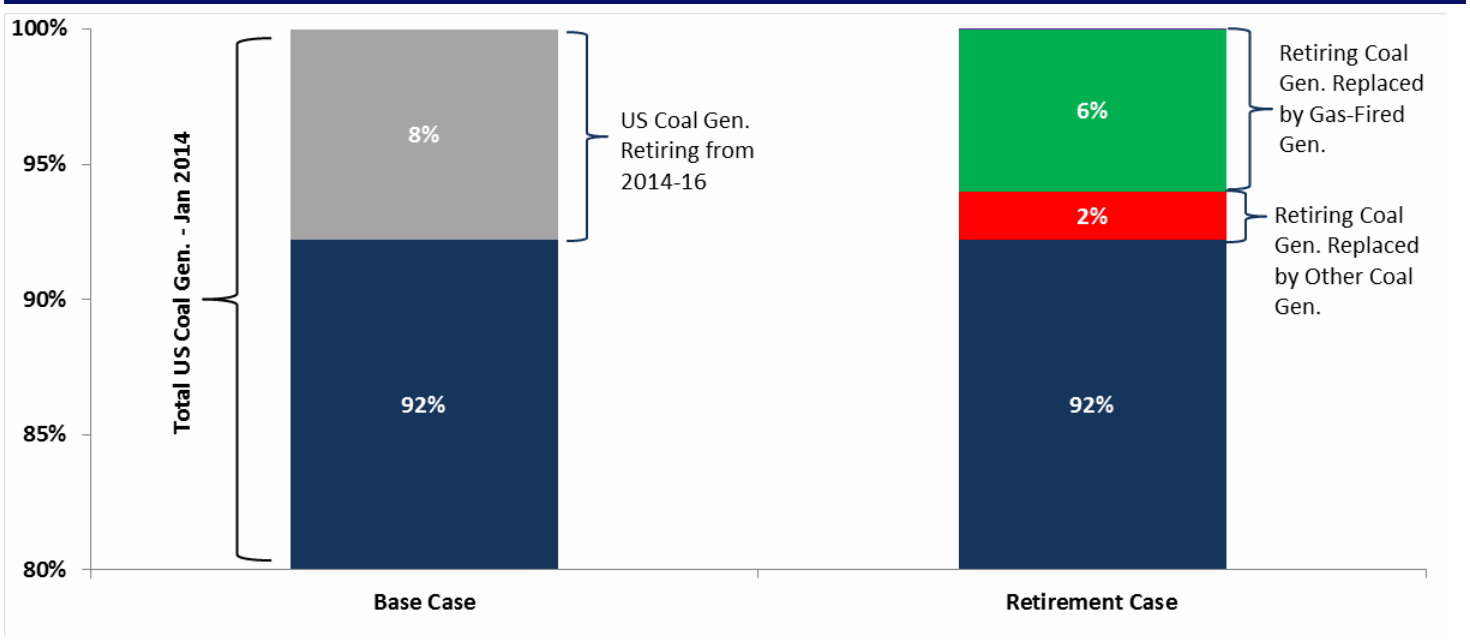
Region	Base Power Prices	Power Prices with Retirements	% Change
ISONE	$130	$190	46.6%
NYISO	$120	$152	27.2%
PJM	$103	$159	55.0%
SERC	$56	$83	47.6%
FRCC	$41	$56	36.8%
MISO	$39	$53	36.8%
ERCOT	$67	$83	23.9%
SPP	$38	$53	37.4%
CAISO	$50	$68	35.3%

- Although the majority of coal retirements affect the Eastern U.S. power markets (PJM, MISO and ISO-NE) the most, the resulting increase in gas demand leads to a rise in the national natural gas prices.
- The table to the left illustrates the effects of the increased price in natural gas on wholesale power prices in other US power markets.
- For example, the California power market, CAISO, would have experienced a 35% power price increase if the coal-fired facilities were retired prior to this past winter.

IMPACT OF COAL RETIREMENTS ON POWER GENERATION

- Of the total Base Case coal generation in January 2014, 92% came from remaining units while 8% came from units slated for retirement.
- With the early retirements, coal's 8% was replaced with three-fourths natural gas and one-fourth incremental coal generation along with a small amount (0.01%) of Demand Side Curtailment.

ESTIMATED REPLACEMENT GENERATION FOR RETIRED COAL GEN. FOR JANUARY 2014



IMPACT OF COAL RETIREMENTS ON GAS INDUSTRY - WINTER

- Even without the projected coal retirements, the gas industry was at a precipice.
  - Record demand, storage withdrawal, prices etc.
  - Pipeline, LDCs and storage operators restrict supplies to non-firm customers.
  - Gas-fired generating capacity lost in several regions due to curtailment of gas supplies.
  - Near record low storage inventories at the end of winter leave industry with a challenge to refill storage to adequate levels.

- With the project coal retirements, the conditions for the gas industry would have been worse
  - Winter Assessment
    - Records for demand, storage withdrawals and prices would have been reset to higher levels.
    - Additional pipeline, LDC and storage operator curtailments likely would have occurred.
    - More power plants likely would have had gas supplies curtailed.
  - In NEPOOL it is unlikely pipeline capacity would have been adequate.
    - As a result NEPOOL would have been faced with selecting from the following alternatives:
      - Increase oil-fired generation (i.e., an additional 1.8 MM barrels).
        - However, NEPOOL outstripped its capability to resupply fuel oil in January in the base case.
      - Increase imported power.
        - Difficult to determine which neighboring regions would have additional power to export.
      - Commence with load shedding.
    - Impact on other regions would not have been as severe as those for NEPOOL.
    - However, curtailment of gas supplies for an additional power plants would be likely.
    - Additional cost to consumers for winter supplies would have been about $35 billion.

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  - Impact of Early Coal Retirements on System Reliability
  - Impact of Early Coal Retirements on Power Prices
  - Impact of Early Coal Retirements on Generation
  - Impact of Early Coal Retirements on Gas Industry
- Methodology
- Detailed Gas Analysis
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IMPACT OF COAL RETIREMENTS ON SYSTEM RELIABILITY – SUMMER- JULY 2014

- To gauge the impact of these coal retirements during a warmer than normal summer period, EVA created a high demand scenario based upon historical data during peak summer months

PJM

- In PJM, EVA found that the early retirement of this coal capacity could lead to 35 hours of reserve margins below 0% based on installed capacity
  - PJM reports having over 10 GW of demand response capability that can mitigate the risk of blackouts, but in some instances the shortage would be greater than 10 GW.
  - Additionally, demand response resources are only required to perform up to 10 times each year.

MISO

- In MISO, 31 hours were found to have e margins below 0% based on installed capacity, while 68 hours had reserve margins below 5%

NUMBER OF HOURS IN JULY 2014 BELOW KEY RESERVE MARGIN LEVELS

		Reserve Margin		
		<10%	<5%	<0%
ISO-NE	Base Case	16	25	25
	2014-15 Retirement	8	17	17
	2014-16 Retirement	11	22	22
PJM	Base Case	27	16	5
	2014-15 Retirement	57	32	34
	2014-16 Retirement	58	34	35
MISO	Base Case	69	34	4
	2014-15 Retirement	60	71	18
	2014-16 Retirement	71	68	31

ISO-NE

- In ISO-NE, capacity shortages exist in all cases due to the high summer demand and the loss of retired coal plants

- With the loss of Salem Harbor and Brayton Point, New England likely would need to rely on either Demand Response, increased imports, or more oil-fired generation to meet peak load

IMPACT OF COAL RETIREMENTS ON POWER PRICES – SUMMER- JUNE-AUGUST

- EVA estimated the effects of extreme summer weather without the coal plants on wholesale power prices during June-August. The results are summarized in the table to the left. A more detailed summary of the effects are presents in the detail power analysis section.

PJM

- Price impacts in PJM are significant during the summer as higher heat rate units and demand response are called upon to meet load
- Wholesale power prices in PJM are estimated to increase 33% in an extreme summer without the coal units

MISO

- In MISO, the price impact is more muted due to fewer retirements and a healthier reserve margin
- EVA estimates that the average whole power price for MISO would increase 8% without the coal plants

AVG. WHOLESALE POWER PRICE FOR EACH SUMMER SCENARIO ($/MWh)

	Base Case	2014-15 Retirements	2014-16 Retirements
ISO-NE	$55	$69	$70
PJM	$49	$64	$65
MISO	$39	$42	$42

ISO-NE

- The prices in the Base case are driven up due to the high demand during the hot summer. With summer peaks approaching the available capacity in New England, the power prices are dictated by the high cost marginal resources in the region
- Without the coal plants and the extreme warm weather, ISO-NE power prices increase 27% compared to the base case.
- EVA did not assume any constrained gas-fired capacity in ISO-NE for the summer scenarios

IMPACT OF COAL RETIREMENTS ON POWER PRICES – JULY 2014

AVERAGE MONTHLY WHOLESALE POWER PRICES – MAJOR U.S. MARKET REGIONS

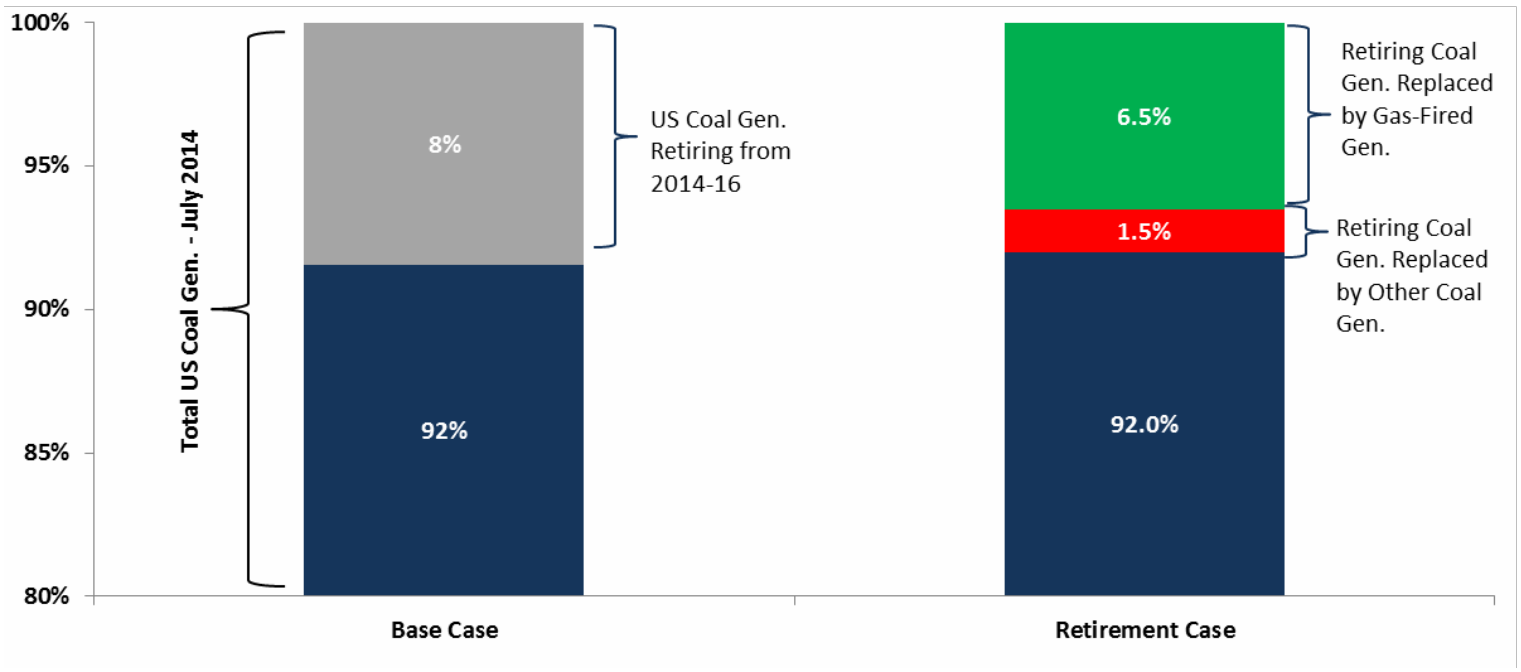
Region	Base Power Prices	Power Prices with Retirements	% Change
ISONE	$74	$106	43.7%
NYISO	$69	$104	49.9%
PJM	$63	$97	54.5%
SERC	$42	$45	8.8%
FRCC	$45	$48	7.0%
MISO	$41	$45	10.4%
ERCOT	$41	$44	6.4%
SPP	$40	$44	10.6%
CAISO	$49	$52	6.3%

- The high withdrawal of natural gas during the winter resulted in storage depletion and lower summer gas storage inventory
- This caused natural gas prices to rise during the summer resulting in higher power prices in EVA's Base Case
- With the coal units not available to provide base load power needs, more gas units are at the margin, which drives up the power prices in PJM, MISO, ISO-NE and SPP
- NYISO is a gas-dominated region that experiences winter basis blowouts which drive much higher prices in the retirement cases

IMPACT OF COAL RETIREMENTS ON POWER GENERATION - SUMMER

- In the summer, the Base Case mix was the same: 92% from remaining units and 8% from retiring units.
- When the early retirements kick in, coal again supplies one-fourth of the replaced generation while gas accounts for roughly 6.5%.
- 10 times the amount of Demand Side Curtailment is required in the summer.

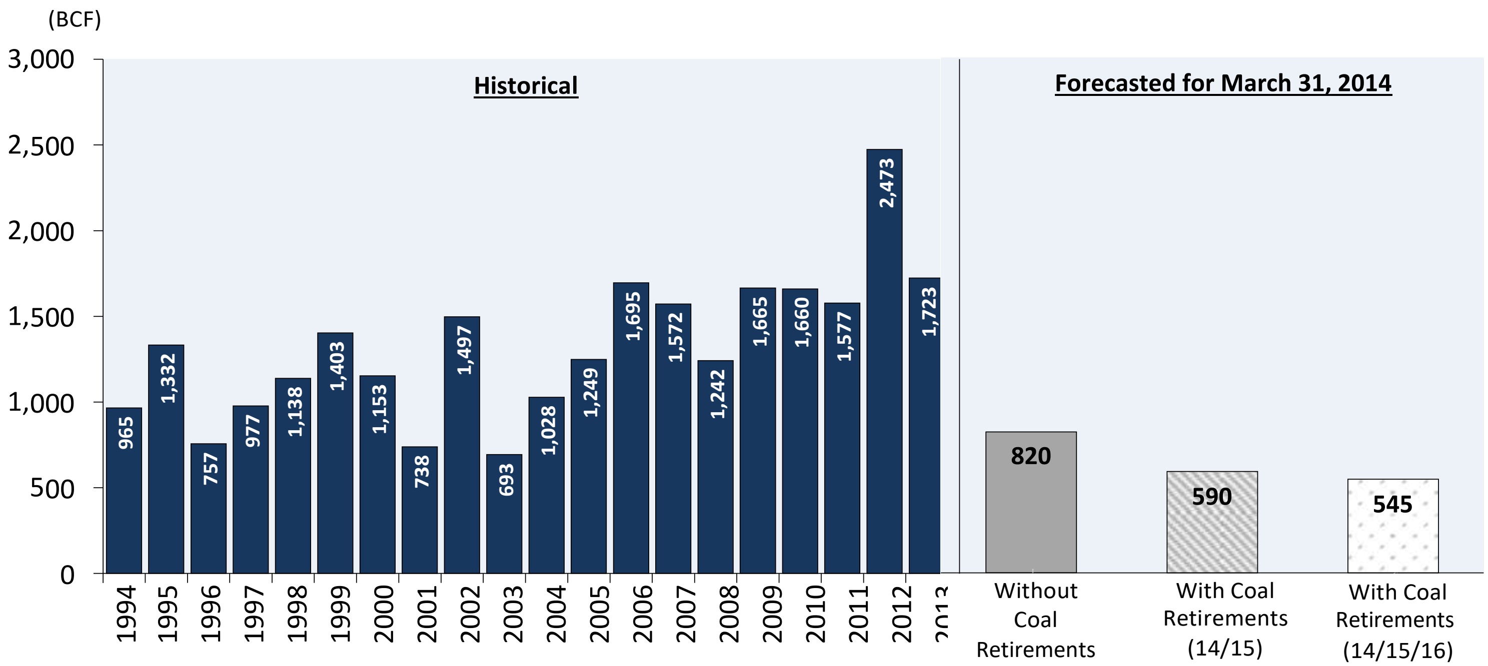
ESTIMATED REPLACEMENT GENERATION FOR RETIRED COAL GENENERATION FORJULY 2014



IMPACT OF COAL RETIREMENTS ON GAS INDUSTRY - SUMMER

- The winter impact would have resulted in record low storage levels at the beginning of spring (April 1, 2014).

STORAGE LEVELS AT THE END OF WINTER (MARCH 31)

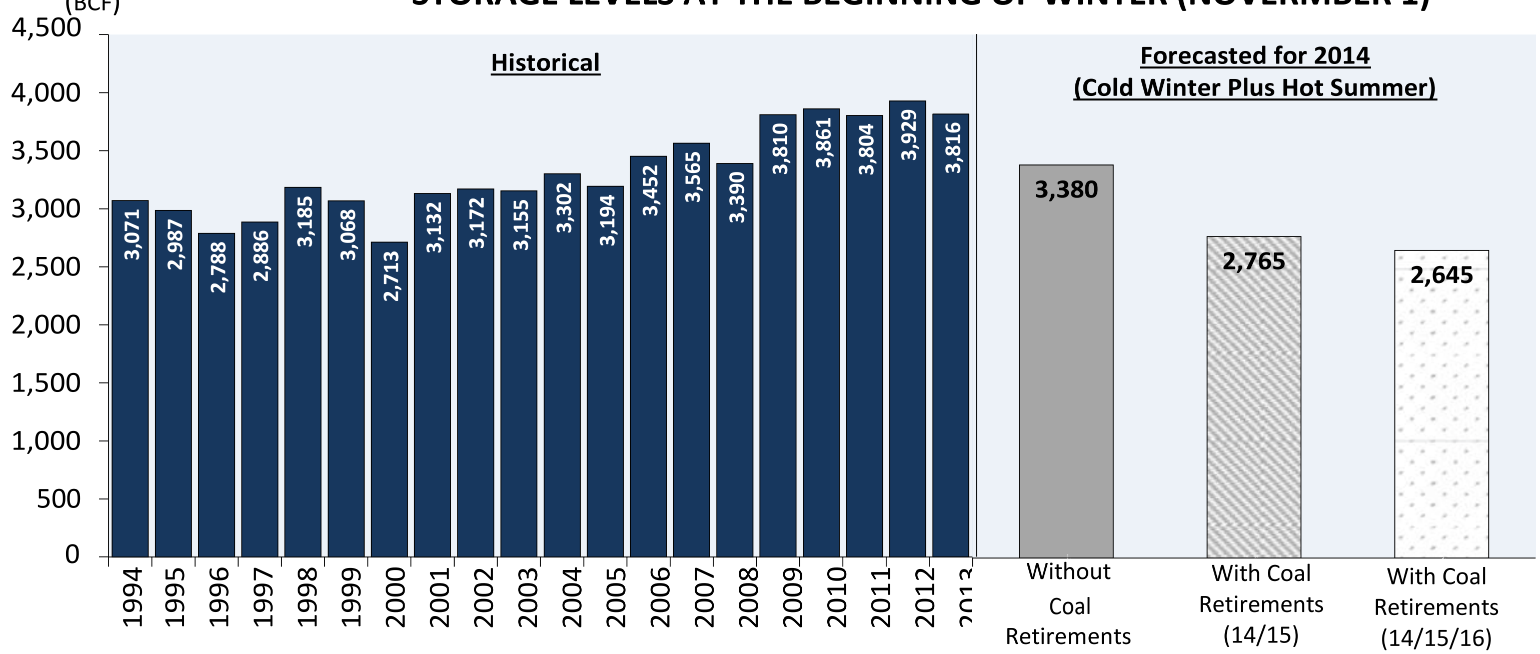


IMPACT OF COAL RETIREMENTS ON GAS INDUSTRY - SUMMER

STORAGE LEVELS AT THE BEGINNING OF WINTER 2014/15

- Storage injections would have been reduced to about 10.4 BCFD because additional summer gas demand.
- Storage refill for next winter likely would have been inadequate unless the winter of 2014/2015 is very mild.
- A supply response likely would occur.
  - However, it would have a minimal impact on 2014 storage injections.
    - Nonetheless, the increased supply would help meet demand during the winter of 2014/2015.
  - Higher gas prices would be required for a supply response.
    - Cost to consumer because of higher gas prices would be in between $11 and $59 billion depending upon timeframe.
  - Total cost to consumers for winter and summer impacts could reach about $90 billion(1).

STORAGE LEVELS AT THE BEGINNING OF WINTER (NOVERMBER 1)



(1) Total cost to all consumers for both gas and power is approximately $100 billion.

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METHODOLOGY

In order to correctly understand the importance of the retiring coal plants to the reliability electric power markets, EVA proceeded with the following methodology.

Natural Gas Market

- National Assessment of the impact of increased demand on:
  - Gas Storage levels, which already at record lows.
  - Natural gas prices for both winter and summer
    - Assessed potential for supply response
    - Assessed potential for demand destruction,
  - Regional assessment of the impact of increased demand on regional pipeline capabilities
    - Pipeline constraints identified

METHODOLOGY

In order to correctly understand the importance of the retiring coal plants to the reliability electric power markets, EVA proceeded with the following methodology.

Power Markets (ISO-NE, PJM, MISO)

- Determined for which power markets that reliability would be affected the most when the coal-fired assets retire.
- For the power markets that will be affected, the list was pared to the markets that had readily available market data from this past winter, so that EVA could calibrate its proprietary models to accurately re-create the situation from the winter of 2014.
- Three scenarios were constructed for the winter assessment
  - *Base Case:* Re-create the performance of the select power markets on an hourly basis for Jan-Feb 2014.
  - *Case 1:* Analyze the performance of the selected power markets without the coal-fired assets retiring in 2014/2015.
  - *Case 2:* Analyze the performance of the selected power markets without the coal-fired assets retiring in 2014-2016.
- Three scenarios were constructed for the summer assessment
  - *Base Case:* Re-create the performance of the select power markets based on extreme historical summer temperatures.
  - *Case 3 :* Analyze the performance of the selected power markets without the coal-fired assets retiring in 2014/2015.
  - *Case 4 :* Analyze the performance of the selected power markets without the coal-fired assets retiring in 2014-2016.
- For each scenario, EVA solved for the following:
  - Estimate the additional gas consumption and the increase in gas prices that would occur without the coal assets.
  - Determine how often the power markets would be at risk for reliability issues without the coal assets.
  - Estimate the impact of power prices with the increased gas prices resulting from the coal plants retiring.

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- Detailed Power Analysis
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IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

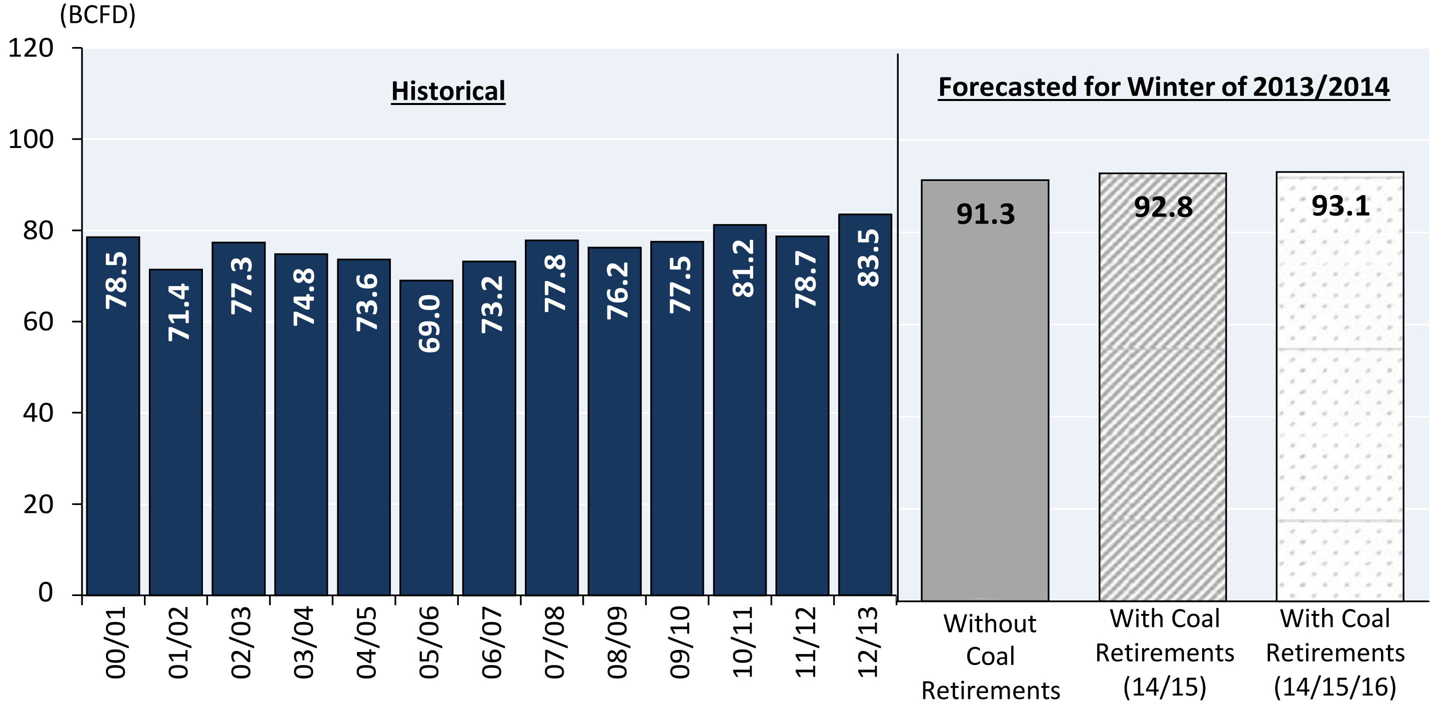
Winter of 2013/14: without projected Retirements

- While the winter weather was cold, it was only the 11th coldest winter on record
  - As a result the outcome could have been worse.
  - Nevertheless, it was an early, long, cold winter.
    - Four distinct cold spells.(1)
- Winter weather resulted in several records
  - Record demand (91.3 BCFD).
    - Due to seasonal and structural demand increases.
  - Record daily demand (125 BCFD).
  - Record storage withdrawals (19.6 BCFD).
  - Record gas prices at key trading hubs ($135/MMBTU).
- Lowest season ending (Mar 31) storage level (820 BCF) since 2003, when demand was 17 percent lower, puts the gas industry at a precipice
- Pipelines, LDC and storage operators issued capacity constraint warnings, OFOs, and withdrawal restrictions
- Well freeze-offs did occur (i.e., at least 1.5. BCFD)

(1) January 6, 7 and 8; January 22, 23 and 24; January 28 and 29; and February 6 and 7.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITHOUT PROJECTED RETIREMENTS



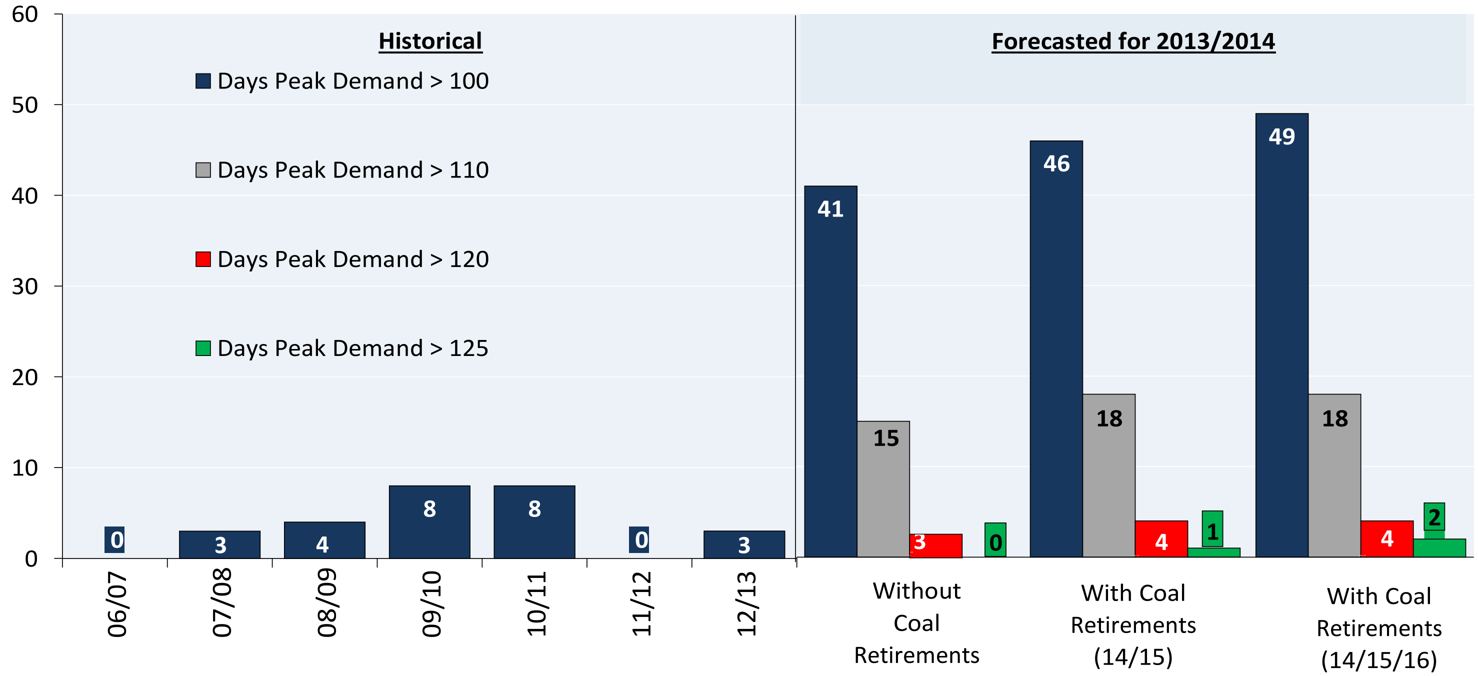
- **Average demand:** Average winter demand increases to 93.1 BCFD

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

- Daily demand: Significant increases in daily demand requirements, which would have further stressed the system
  - Daily demand at 100 BCFD is a significant event for the industry.(1)
  - Daily demand requirements >125 BCFD are a real challenge and can result in significant price spikes, as well as curtailment

COMPARISON OF LOWER-48 PEAK DAY DEMAND REQUIREMENTS DURING WINTER (NOV-MAR)



(1) Average annual daily demand in 2013 was 71.3 BCFD.

IMPACT OF THE WINTER OF 2013/2014 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

- Curtailments: With daily demand at record levels, there was curtailment of gas supplies this winter
  - Examples:
    - UGI (i.e., a Pennsylvania LDC) had its first curtailment of firm supplies in 10 years.(1)
      - Sapa Extrusions temporarily suspended production and casting activity.
      - Virtually all of UGI's 200 large and commercial IT customers were curtailed.
    - A paper mill in Maine that employs 450 had a production outage.
    - Another paper mill in Maine that employs 850 shut down on Jan 11, 2014 for two weeks.(2)
    - NEPOOL, NYPOOL, PJM, MISO and SW Power Pool cited lack of gas availability as reason for gas-fired units being offline.(3)
  - With projected retirements curtailments would have been greater, however specific cases cannot be determined.

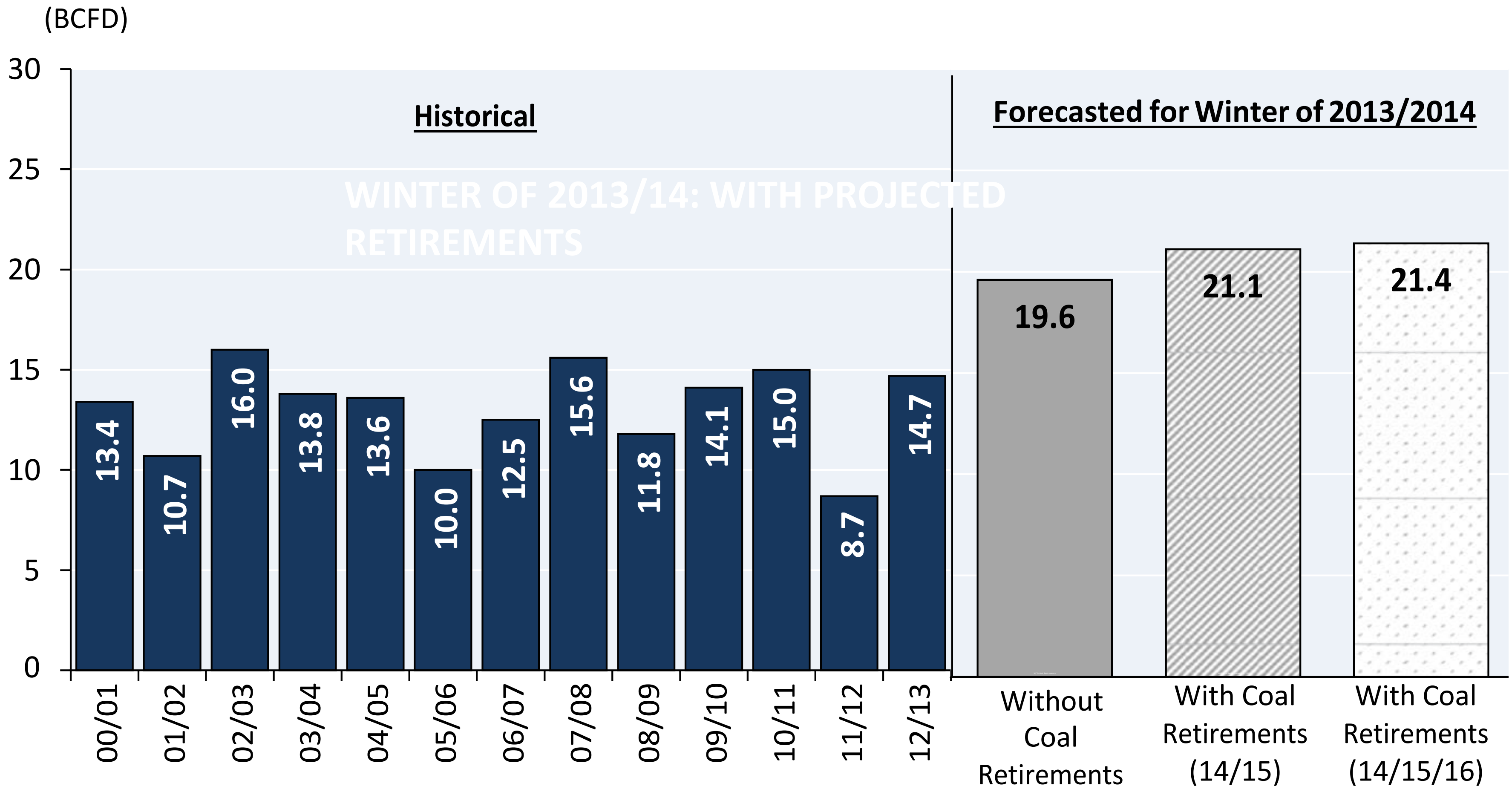
(1) "Although gas services interruptions spike, users take cutoff in stride", *Inside FERC Gas Market Report*, January 31, 2014, pp 1 ff.
(2) "New England Price Volatility as Raising Eyebrows in Senate, DOE", *Natural Gas Week*, February 10, 2014, pp 3-4.
(3) "Power grid operators say cold winter may point to need for more standards", *Inside FERC Gas Market Report*, April 11, 2014, pp 4.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

- Storage withdrawals: Since short-term supply is inelastic, increased demand would cause storage withdrawals to increase to levels that are unprecedented in the industry

STORAGE WITHDRAWALS (NOV-MAR)

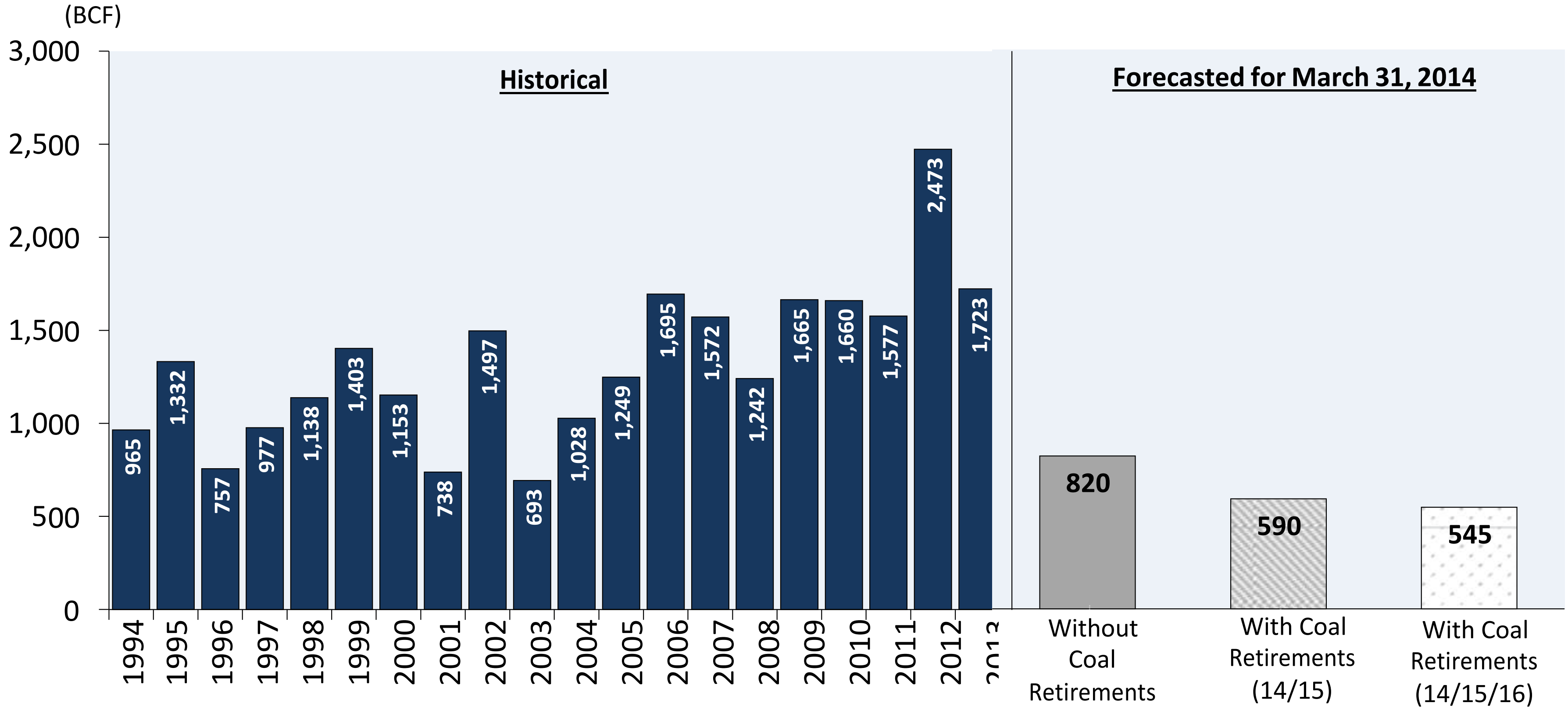


IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

- Season-ending storage: As a result of the above, the March 31 storage level also would have been at an unprecedented level
  - The prior low period for recent times was in 2003, when annual gas demand was 17% lower, which indicates the significant increase in structural demand.

STORAGE LEVELS AT THE END OF WINTER (MAR 31)



IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

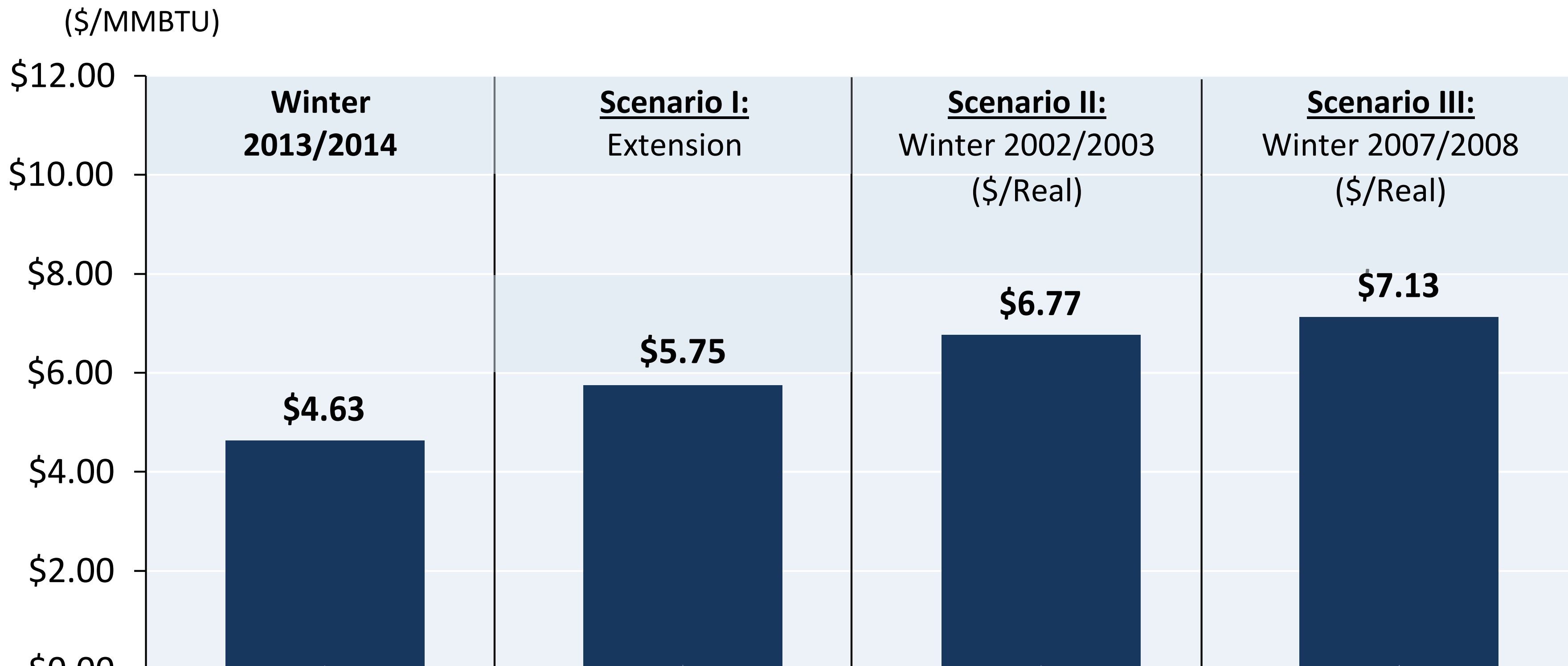
WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

- Gas prices: The combination of (1) higher average winter gas demand; (2) increased stress on the system due to higher daily demand levels; and (3) reduced season-ending storage levels would have caused gas prices to be higher- potentially significantly higher
  - Three potential scenarios examined.
    - Extending the winter 2013/2014 gas prices throughout the remainder of 2014.
    - Use the price trends for 2002/2003 in real terms for the non-winter months for 2014.
    - Use the price trends for 2008 in real terms for the non-winter months of 2014.
  - Analysis is for both Henry Hub and key regional basis differentials.
  - Complete gas price assessment in a separate section.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

WINTER OF 2013/14: WITH PROJECTED RETIREMENTS

SCENARIOS FOR HENRY HUB GAS PRICE ($/MMBTU)



Increased Cost to Consumers for Winter Gas Supplies			
-	$25 Bil.	$31 Bil.	$35 Bil.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

- Post-Winter of 2013/2014 (No Additional Retirements)
  - Low storage level (820 BCF) at the end of winter
  - Refilling storage to adequate levels prior to next winter is the industry's greatest challenge
    - Even with storage injections at projected record levels (12 BCFD).
  - Gas-directed drilling activity remains at record lows, despite gas prices through May being $1.20/MMBTU, or 32% higher
  - There are wild cards on the horizon, but they will not affect this year's storage injections
    - Potential for November 2014 infrastructure event that will bring stranded gas supplies to market.(1)
  - Current NYMEX strip for summer ($4.43/MMBTU) assumes (1) adequate season-ending storage levels; (2) supply growth; and (3) a mild to normal winter

(1) See 2013 FUELCAST Topical Article VII: "Changes in Northeast Infrastructure", November 2013.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

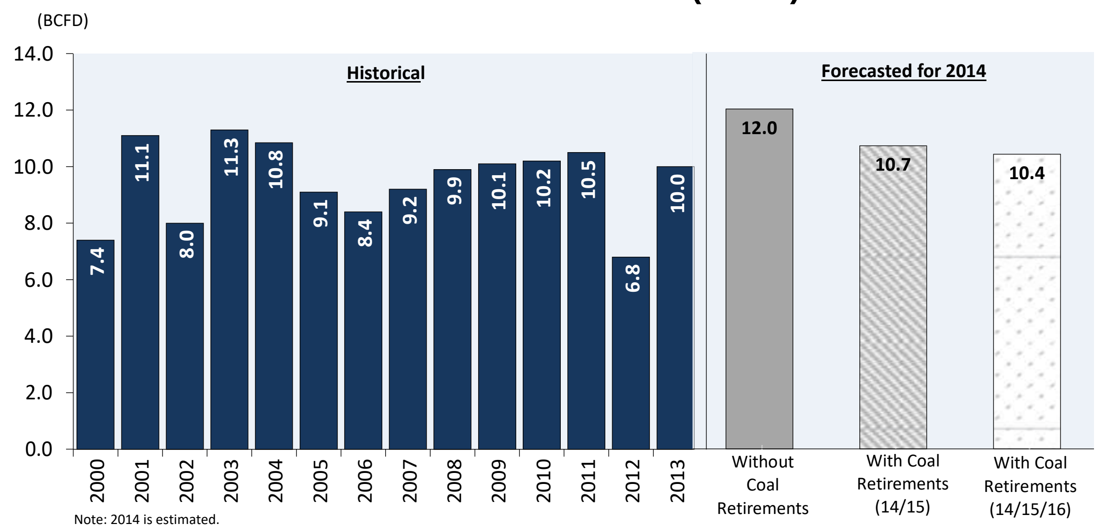
ASSESSMENT OF COLD WINTER AND HOT SUMMER

- Post-Winter of 2013/2014 with Projected Retirements
  - Assumes a hot summer
    - Current forecast is for summer weather to be 6% warmer than normal.
    - The summers of 2010, 2011 and 2012 were 12% to 16% above normal.
  - Gas demand: With gas at the margin increased electricity sales for hot summer results in total summer gas demand increasing from 60.6 to 62.9 BCFD
  - Storage injections: Assuming a negligible short-term supply response, increased gas demand reduces storage injections to only 10.4 BCFD
  - Storage level: Season-ending (Oct 31) storage levels only increase to 2,645 BCF, which is an unprecedented low level entering a winter season and likely not adequate for anything but a mild winter

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

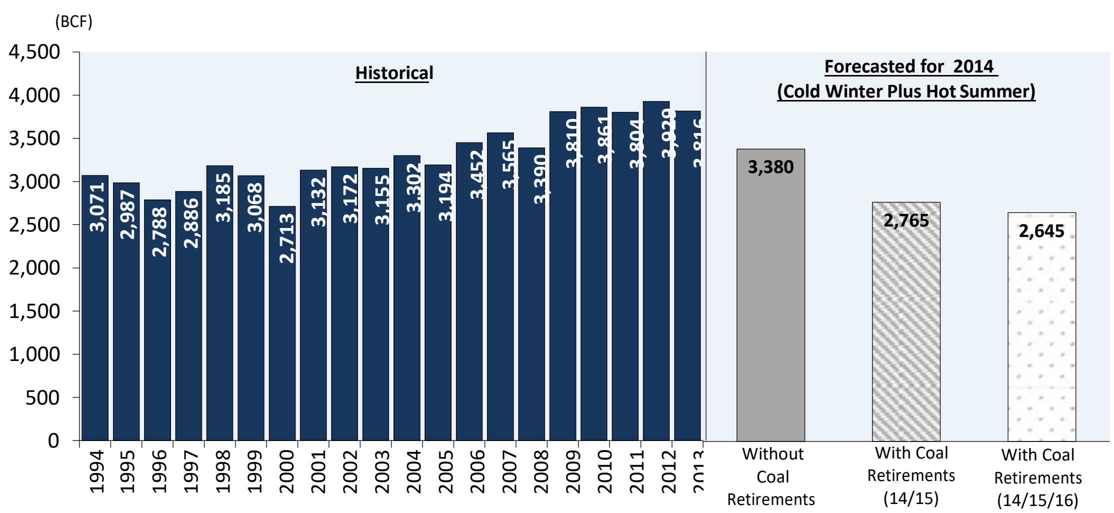
ASSESSMENT OF COLD WINTER AND HOT SUMMER

U.S. STORAGE INJECTIONS (BCFD)



Note: 2014 is estimated.
Source: EIA.

STORAGE LEVELS AT THE BEGINNING OF WINTER (NOVEMBER 1)



IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

- Supply response: Critical issue is what would be the potential supply response
  - Current gas-directed drilling activity at record lows for recent times.
  - With the exception of the November 2013 infrastructure event, domestic production since July 2013 has only increased 1.0%.
    - Drilling activity in the last 10 months has increased supply 1.0%.
  - E&P industry has made it clear no new dry-gas drilling programs without higher gas prices on a sustained basis and competitive prices.[1]
    - Current NYMEX future prices decline to $4.05 per MMBTU by April 2015.
    - While higher gas prices may meet the minimum ROR threshold, gas prices must be high enough to yield a competitive return to that for oil/liquids projects.[2]
    - Required gas price appears to be $5.00/MMBTU on a sustained basis.[3]

[1] "Higher Gas Prices Fail to Tempt ConocoPhillips From Oiler Focus", *Natural Gas Week*, April 14, 2014, pp 4-5; and "Independents Sticking to Liquids Despite Higher Natural Gas Prices", *Natural Gas Week*, March 3, 2014, pp 3-5.

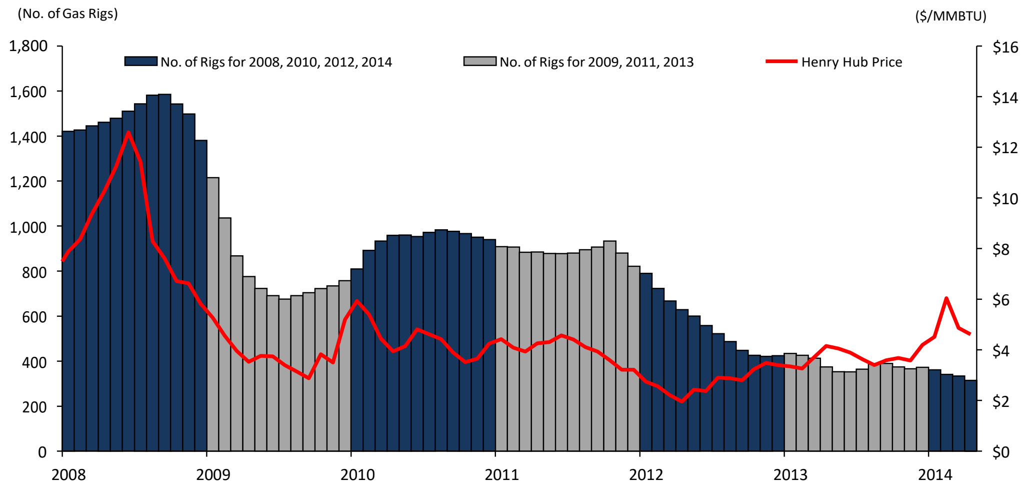
[2] One example of the need for gas prices to be higher in order for gas projects to compete with oil projects is in the Haynesville play. While the core areas for the Haynesville can attain a B/T ROR of 20% with sub- $4.00 per MMBTU gas prices, sustained gas prices just over $5.00 per MMBTU are required to attain a 40% ROR and between $5.50 and $6.00 per MMBTU to attain a 50% ROR. Many oil projects at current oil prices achieve 40 to 50% ROR. For non-core areas of the Haynesville even higher prices are required.

[3] Chesapeake may be an exception.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

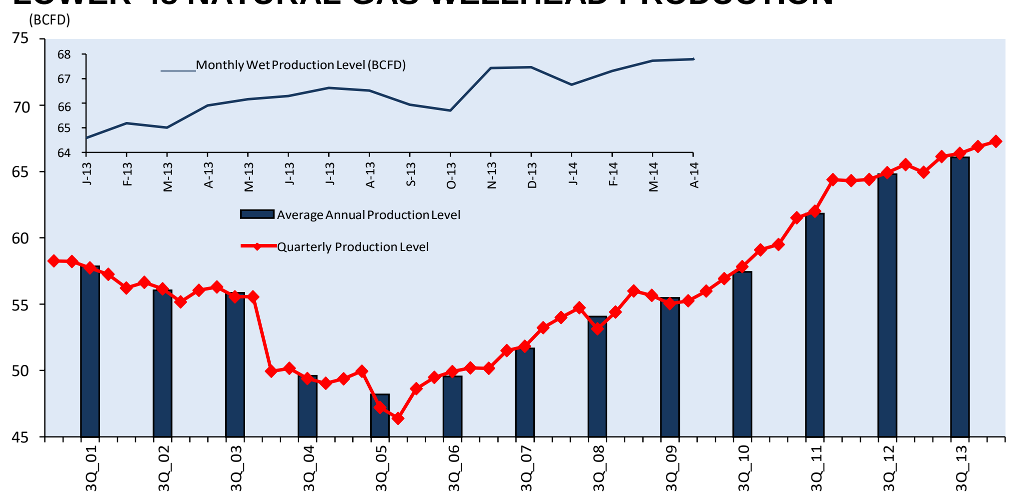
ASSESSMENT OF COLD WINTER AND HOT SUMMER

RIG COUNT FOR GAS WELLS



Source: NGW.

LOWER-48 NATURAL GAS WELLHEAD PRODUCTION



Note: Bars represent average annual production levels, while the dots on the line graphs represent quarterly production levels.
Source: Lippman Consulting, Inc. and EVA.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

- Combination of higher gas demand and reduced storage levels likely will cause gas prices to increase to the $5.00/MMBTU threshold.
  - However, this would need to be on a sustained basis (i.e., three years for the NYMEX future prices).
  - Historically the gas industry has demonstrated the capability to increase the gas-directed rig count quickly.
  - However, this will be more difficult to do at present because of the high oil-directed rig count.[1]
  - Competition for high-horse power rigs is particularly keen.

INCREASE OVER SIX MONTH PERIOD DURING DRILLING BOOM (2008-2011)

	Increase in Rig Count		Increase in Production (BCFD)	
	Max Increase In 6-Month Period	Avg Increase In 6-Month Period	Max Increase In 6-Month Period	Avg Increase In 6-Month Period
For Six Major Shale Plays(1)	114	34	3.6	2.3
For Haynesville Shale	68	33	1.6	0.95

[1] Currently the oil-directed rig count is 1,528, whereas in January 2008 (i.e., the start of the drilling boom) it was only 321.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

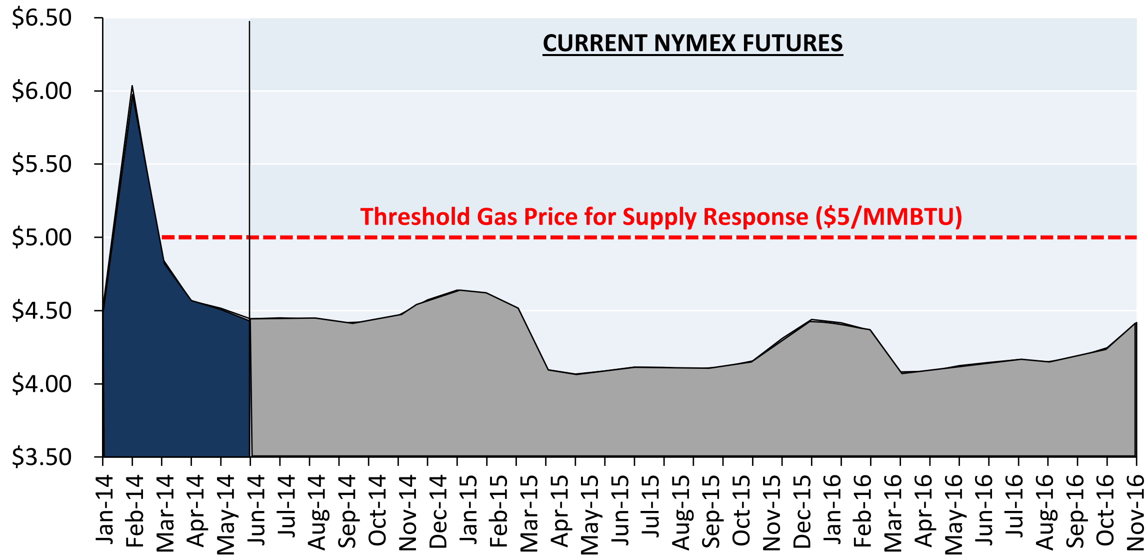
- While increases in the average gas-directed rig count noted in the above table likely are realistic, the increases production levels are not for several reasons.
  - It is very difficult to estimate the time lags between contracting for a rig and the final hook-up of a well to a pipeline (i.e., 3 to 9 months).
  - As a result, supply response would have a small effect on November 1, 2014 storage levels (25 BCF)[1], but would have a significant impact for 2015 and 2016 production levels.
- There is a cost to the consumers for this potential supply response.

[1] Based upon 30 rigs coming online over a 6-month period for the very prolific Haynesville shale play.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

COMPARISON OF THRESHOLD PRICES TO CURRENT NYMEX ($/MMBTU)



Increased Cost to Consumers for Gas Supplies as a Result of Gas Prices Rising to Threshold Levels From Current NYMEX Future Prices(1)

($/Billions)	2014(2)	2015	2016
Increased Cost to Consumers			
Annual	$11.0	$22.7	$23.8
Cumulative	$11.0	$32.7	$55.4

(1) Based upon case for 2014, 2015 and 2016 projected retirements.

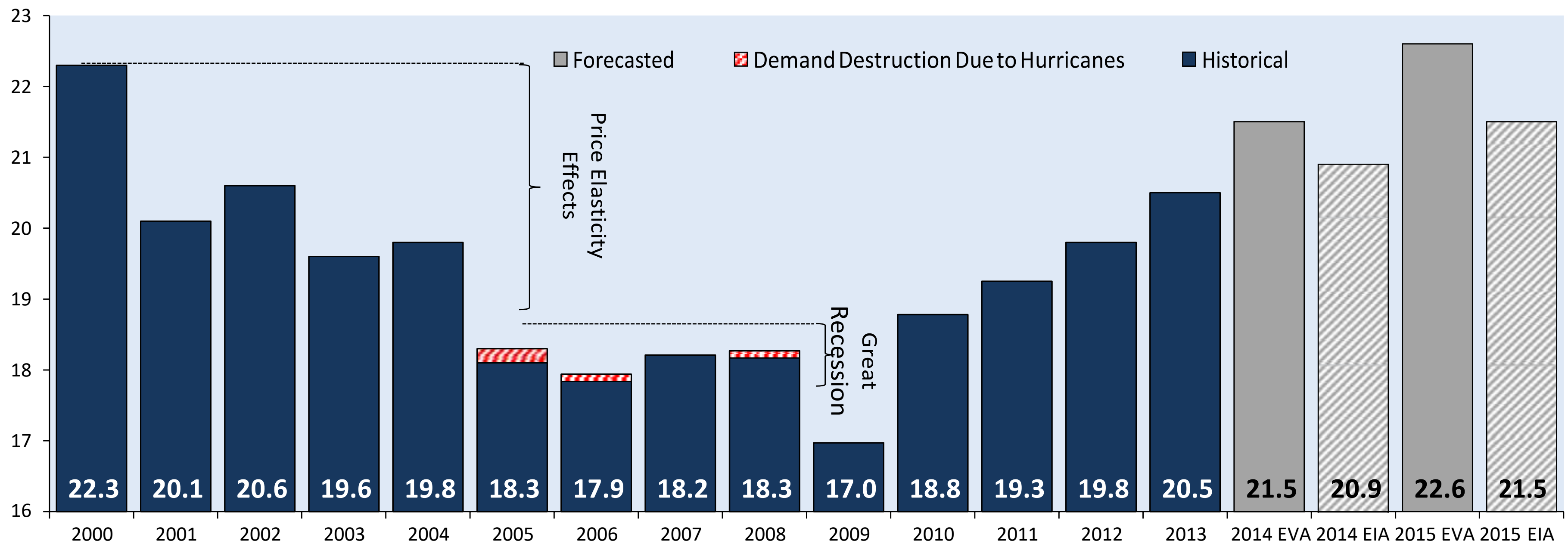
(2) Does not reflect potentially higher gas prices for winter of 2013/2014.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

ASSESSMENT OF COLD WINTER AND HOT SUMMER

- Demand destruction: If market deems supply response inadequate, then prices likely would increase to a level to cause demand destruction
  - Primary candidate for demand destruction is the industrial sector, with the 2000 to 2005 period being the classic example.
    - Gas prices in 2005 reached $13 per MMBTU and averaged $6.76 per MMBTU.
  - However, current conditions are significantly different, particularly oil prices.(1)

INDUSTRIAL SECTOR NATURAL GAS DEMAND (BCFD)



(1) Oil price in the 2000 to 2003 period ranged from $34 to $40.50 per barrel and increased to $67 per barrel in 2005. Current oil prices are in excess of $100 per barrel.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

NATURAL GAS PRICES

- 2014 Gas Prices Without Projected Retirements
  - 2013 average Henry Hub gas prices: $3.70 per MMBTU
  - 2014 average NYMEX prices: $4.64 per MMBTU
    - + $0.94 per MMBTU, or 25%, above 2013 prices.
  - Winter basis differentials at record levels

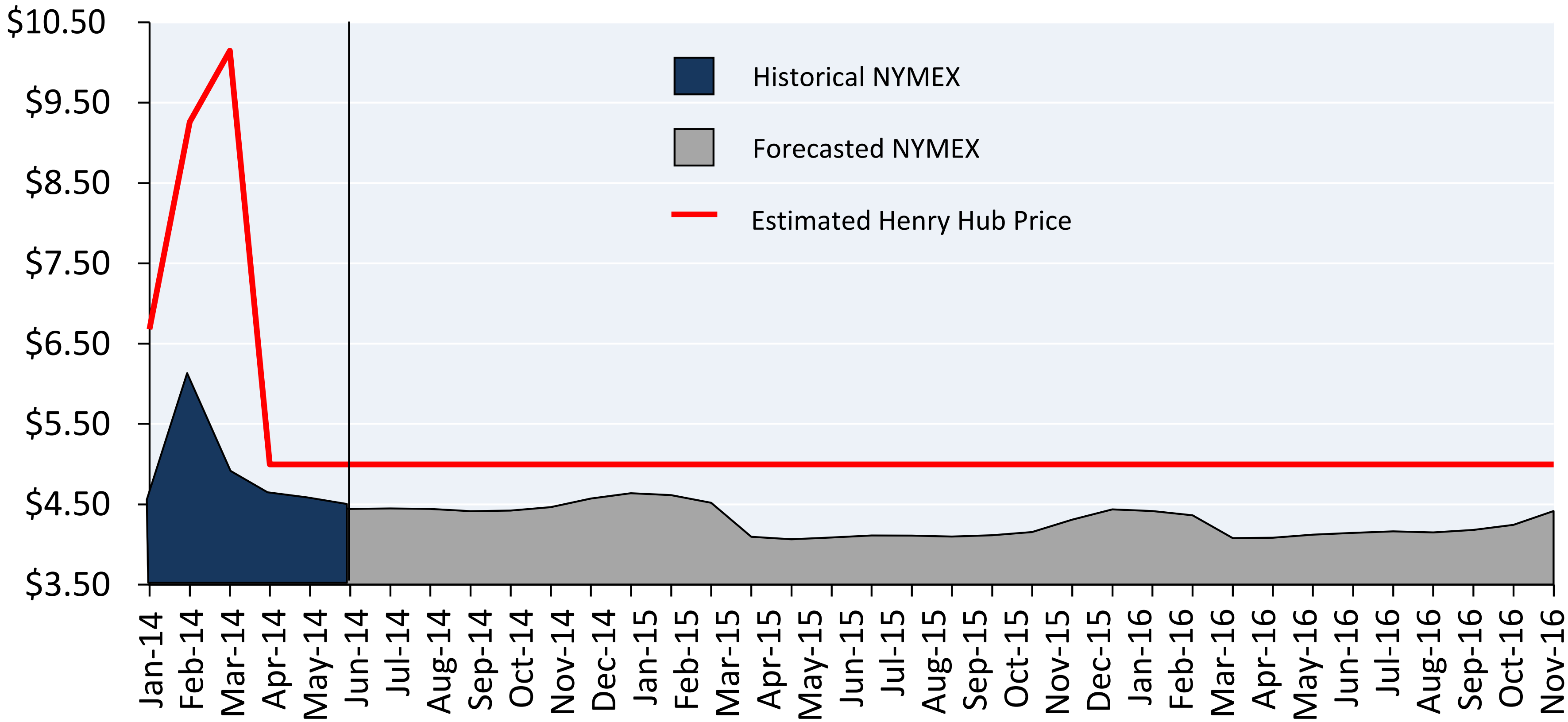
- 2014 Gas Prices With Projected Retirements
  - Focus is on a cold winter plus hot summer with projected retirements for 2014
    - Two distinct price impacts:
      - Increase in Henry Hub gas prices.
      - Increase in winter basis differentials.
  - Unlikely gas prices for the first two months of the winter would have been affected (i.e., Nov. and Dec. 2013)
    - Thus, focus is on 2014 impact.
  - Average annual 2014 Henry Hub gas prices estimated to increase to be $5.92 per MMBTU
    - + $1.28 per MMBTU, or 28%, above current NYMEX.
    - + $2.22 per MMBTU, or 60%, above 2013 gas prices.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

NATURAL GAS PRICES

- Net additional cost in 2014 to consumers approximately $35 billion
  - Understates true cost to consumers because increased prices would have to be on a sustained basis.

COMPARISON OF CURRENT NYMEX TO ESTIMATED HENRY HUB PRICES WITH PROJECTED COAL RETIRMENTS



Note: Assumes cold winter and hot summer with projected retirements for 2014, 2015 and 2016.

IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

NATURAL GAS PRICES

- Second major price impact would be increased basis differentials in the Northeast - approximately $3 to $4 billion
  - Algonquin Citygates.
  - Transco Z6-NY.
  - Transco Z6-Non-NY.
  - TETCO M3.
- Total increase cost to consumers for all sectors about $90 billion

Increased Cost To Consumers

	I. Supply			II. Basis	III. Total
Period	Volume (BCF)	Increased Price ($/MMBTU)	Increased Cost to Consumers(1) ($ Billions)	Increased Cost to Consumers(1) ($ Billions)	Increased Cost to Consumers(1) ($ Billions)
Nov-Dec 2013	5,257	$0.00	$0	$0	$0
Jan-Mar 2014	8,852	$3.44	$31	$4	$35
Apr-Oct 2014	13,594	$0.57	$8	$0	$8
Nov-Dec 2014	5,145	$0.51	$3	$0	$3
Subtotal 2014	27,591	$1.48	$42	$4	$46
2015	27,336	$0.80	$23	$0	$23
2016	28,360	$0.77	$22	$0	$22
Grand Total			**$87**	**$4**	**$91**

(1) For all sectors.

OUTLINE

- Problem Statement
- Methodology
- Impact of Early Coal Retirements in Winter
- Impact of Early Coal Retirements in Summer
- Detailed Gas Analysis
- Detailed [illegible] Analysis
- Conclusions
- Appendix

DETAILED POWER ANALYSIS OUTLINE

- PJM Winter Analysis
- MISO Winter Analysis
- ISO-NE Winter Analysis
- PJM Summer Analysis
- MISO Summer Analysis
- ISO-NE Summer Analysis

PJM WINTER ANALYSIS: IMPACT OF THE WINTER OF 2013/14 ON THE NATURAL GAS MARKET

NATIONAL OVERVIEW

- Winter of 2013/2014 Without Projected Retirements
  - Gas-generation was curtailed in the following regions because of lack of access to gas supplies[1]
    - Likely each case represents a curtailment of interruptible pipeline capacity, as regional pipelines lack the capacity to fully meet both firm (e.g., residential) and interruptible loads.

Region	Total Capacity Offline	Percent With Fuel Issues	Estimated Gas-Fired Capacity Offline
PJM	41,336 MW	24%	9,920 MW
MISO	32,813 MW	20%	6,666 MW
NYPOOL	Lower	Higher	Unknown
Southwest Power Pool	Lower	Higher	Unknown
NEPOOL	14000 MW	100%	14,000 MW(*)

(*) Use Oil-Fired Generation (12.5 GWh).

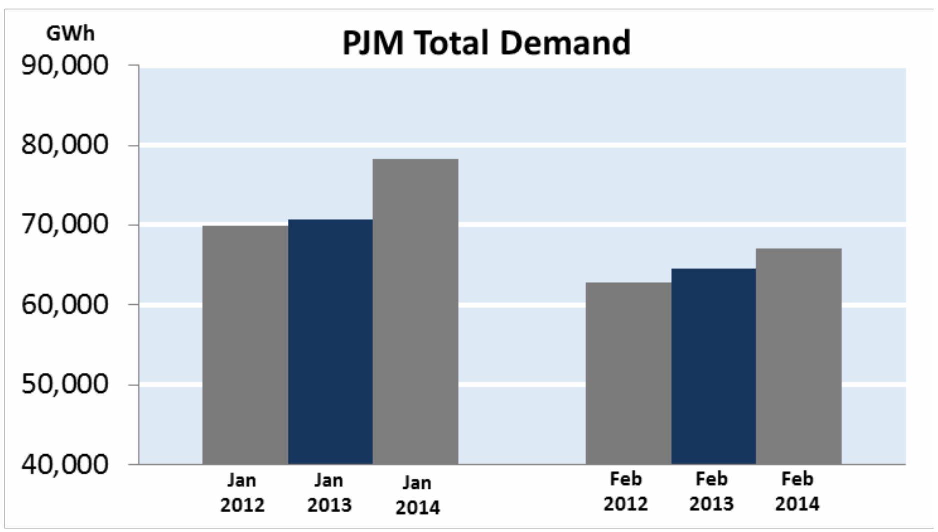
    - In addition, ERCOT had every available unit online on Jan 6 and 7.[2]
      - Gas demand at record levels and one BCFD above prior record level.
      - Regional well freeze-offs (i.e., 1.1 BCFD estimated) occurred.
      - Pipelines and storage operators issued OFOs and limit supplies to IT customers (i.e., power plants).
    - CAISO affected during February 6 weather event.
      - Curtailment of gas supplies to power units occurred.

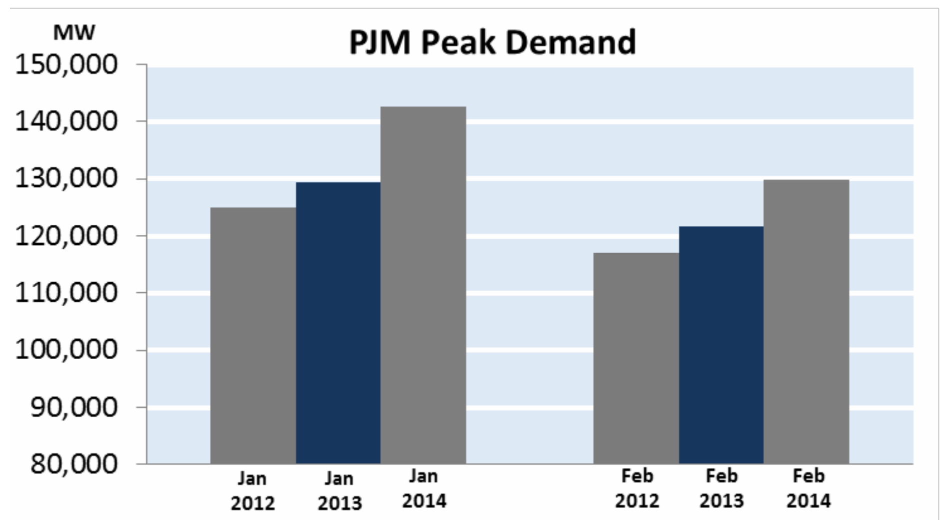
(1) "Power grid operators say cold winter may point to need for new standards", *Inside FERC's Gas Market Report*, April 11, 2014, p. 4; "Northeast Said Too Exposed to Gas Volatility", *Natural Gas Week*, February 10, 2014; and "Oil often trumped gas in Northeast during record-setting winter cold" *Inside FERC's Gas Market Report*, April 22, 2014, p. 3-4.
(2) "Shivering Texas Barely Avoids Rolling Blackouts", *Natural Gas Week*, January 13, 2014, p. 9.

PJM WINTER ANALYSIS: EFFECTS OF POLAR VORTEX ON ELECTRICITY DEMAND

PJM WINTER DEMAND OVER THE PAST THREE YEARS

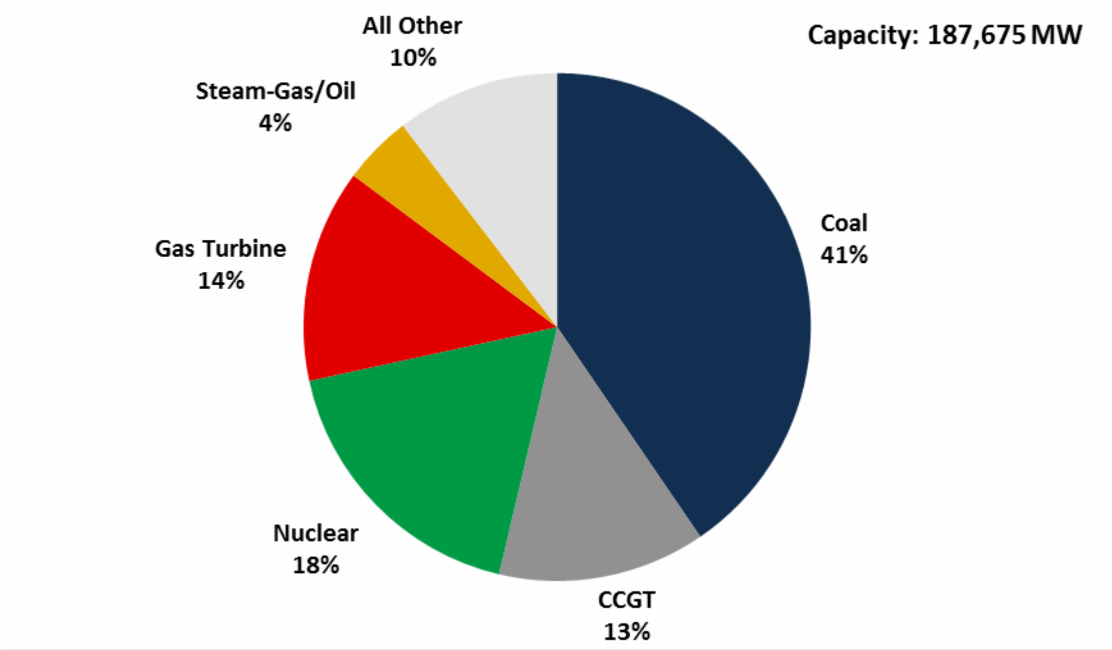
- The polar vortex brought frigid temperatures to most of the Eastern part of the country in January and early February, pushing electricity demand to record levels and forcing generating units out of commission.
- While total January demand grew by 11% YoY, peak demand grew 14% YoY. February total and peak demand growth were 4% and 7%, respectively.
- To simulate the extreme weather conditions in PJM, EVA have used actual hourly load data in its modeling effort.





PJM WINTER ANALYSIS: EXISTING SUPPLY DURING POLAR VORTEX

PJM INSTALLED CAPACITY

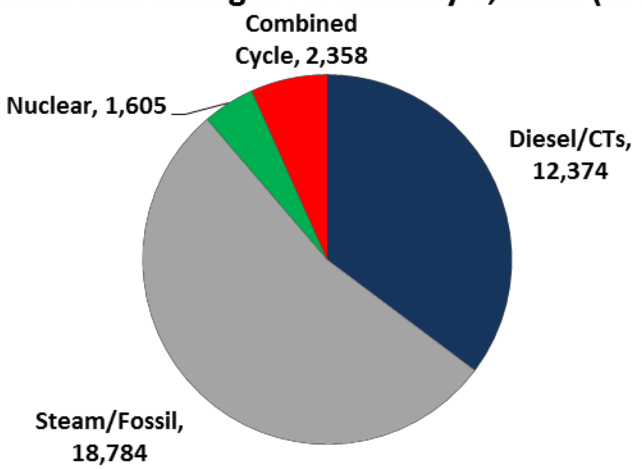


- Because of its proximity to Appalachian coal, PJM is a coal-dominated region – 41% of all existing capacity is coal-fired. This played a very important role during the polar vortex considering the high price of gas as well as its mercurial deliverability.
- CCGTs currently account for 13% of total capacity though this share is expected to grow as coal retirements mount.
- Until these CCGTs begin commercial operations, however, coal units in PJM are the backbone for system reliability.

PJM WINTER ANALYSIS: OUTAGES DROVE VERY TIGHT RESERVE MARGINS ON SOME DAYS

PJM GENERATION OUTAGES FOR JANUARY 2014

Actual PJM Outages for January 7, 2014 (MW)



pjm — Generation Forced Outages for January 6-8, 2014

FORCED OUTAGES (preliminary)	RTO	Diesel/CTs	Steam/Fossil	Nuclear	Combined Cycle	Hydro	Wind	Other	*Confirmed Gas Curtailments**
Monday 1/6/2014 8 p.m. Eastern	30,239	8,120	16,116	2,047	1,665	59	1,200	1,032	*2,160*
Tuesday 1/7/2014									
8 a.m.	35,069	11,238	16,910	1,605	2,299	63	1,313	1,641	*7,489*
7 p.m.	38,033	12,374	18,784	1,605	2,358	61	1,554	1,297	*6,368*

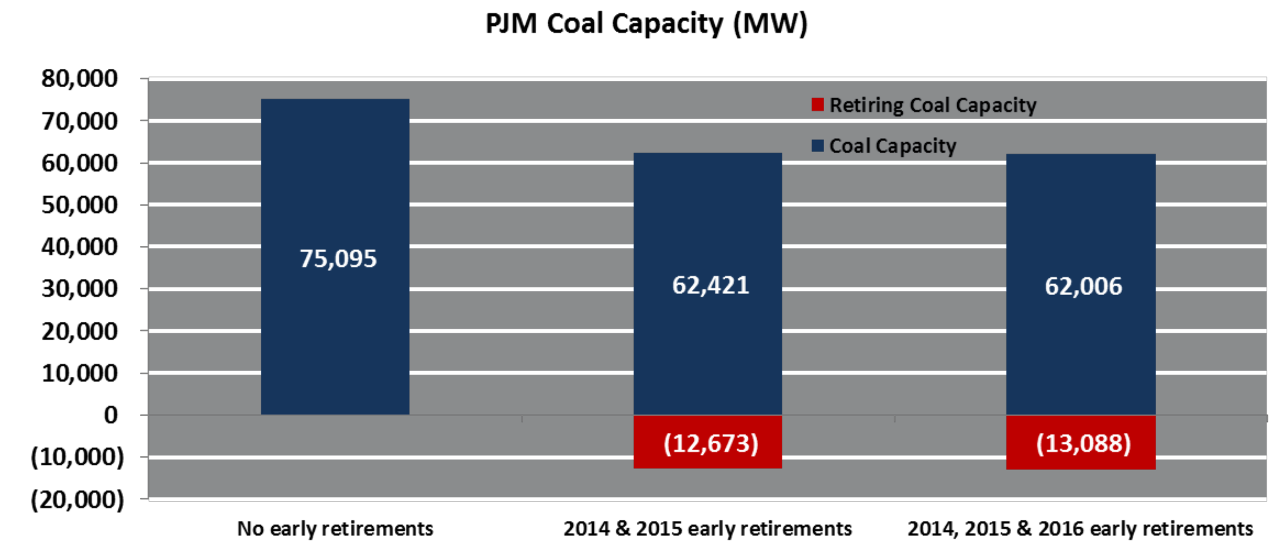
*** PJM revised their Confirmed Gas Curtailment numbers from 6,368 MW to close to 9,000 MW.**

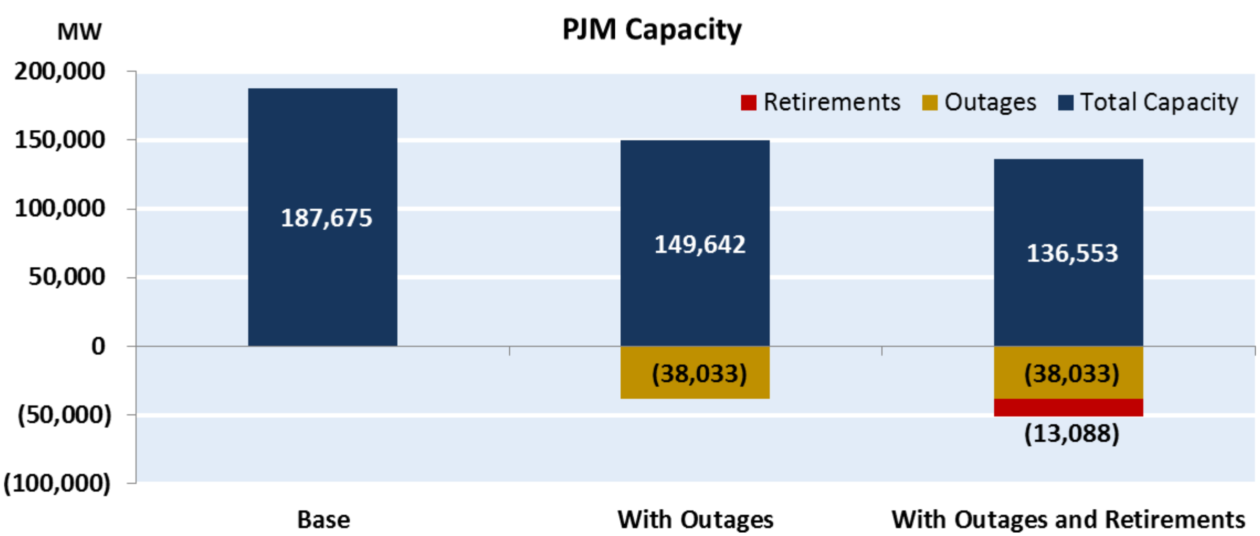
- Despite having sufficient installed capacity to meet the all-time high winter peak of 141,000 MW, PJM faced significant unscheduled outages (nearly 40 GW) and the cold weather resulted in a shortage of gas that left many units unable to run and threatened the grid's reliability.
  - Coal stations dealt with frozen stockpiles, gas pipelines became too constrained to deliver gas, and physical plant parts broke down due to cold temperatures

- For its winter analysis (Case 1 and 2), EVA assumed the above outages for the month of January 2014 as reported by PJM.

PJM WINTER ANALYSIS: TESTING SYSTEM RELIABILITY WITH OUTAGES AND EARLY RETIREMENTS

PJM CAPACITY

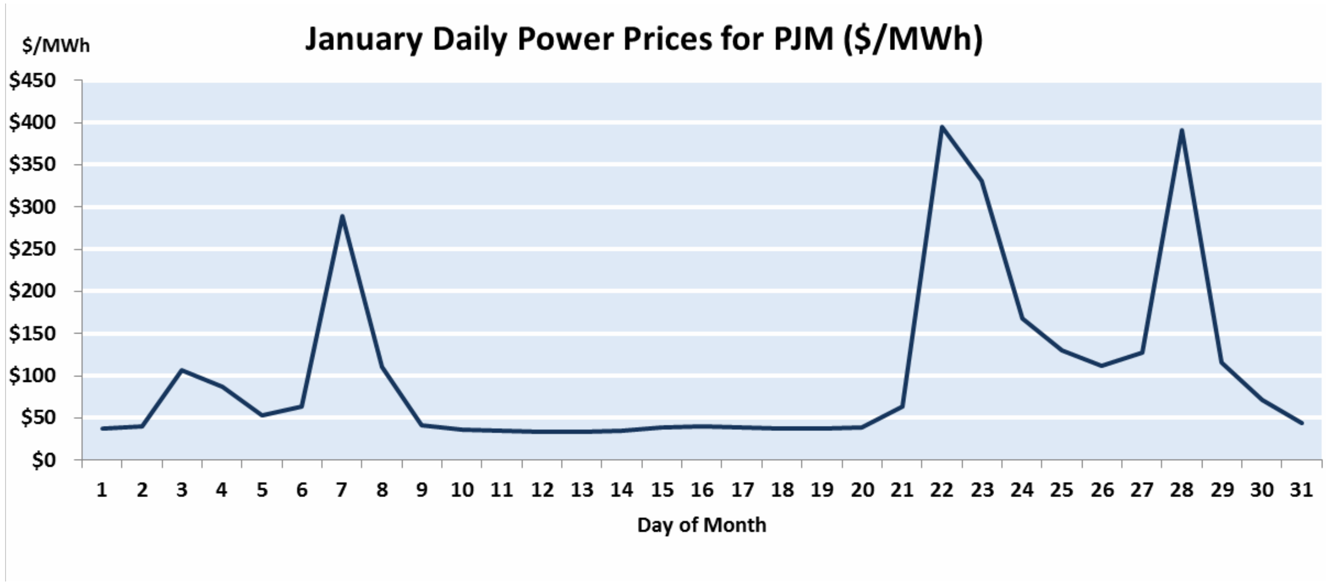




- Of the 75,000 MW of coal capacity in PJM, close to 12,500 MW is scheduled to retire by the end of 2015 and an additional 400 MW by the end of 2016 as a result of environmental regulations and other market drivers.
  - EVA sought to determine the impact of:
  - Extreme weather resulting in high power demand
  - Significant generation outages
  - The loss of coal capacity
- On PJM reliability and prices by simulating an environment where these units were pulled from the market prior to the winter of 2014.

PJM WINTER ANALYSIS: HIGH GAS PRICES AND ELECTRICITY DEMAND DROVE SPIKEY POWER PRICES

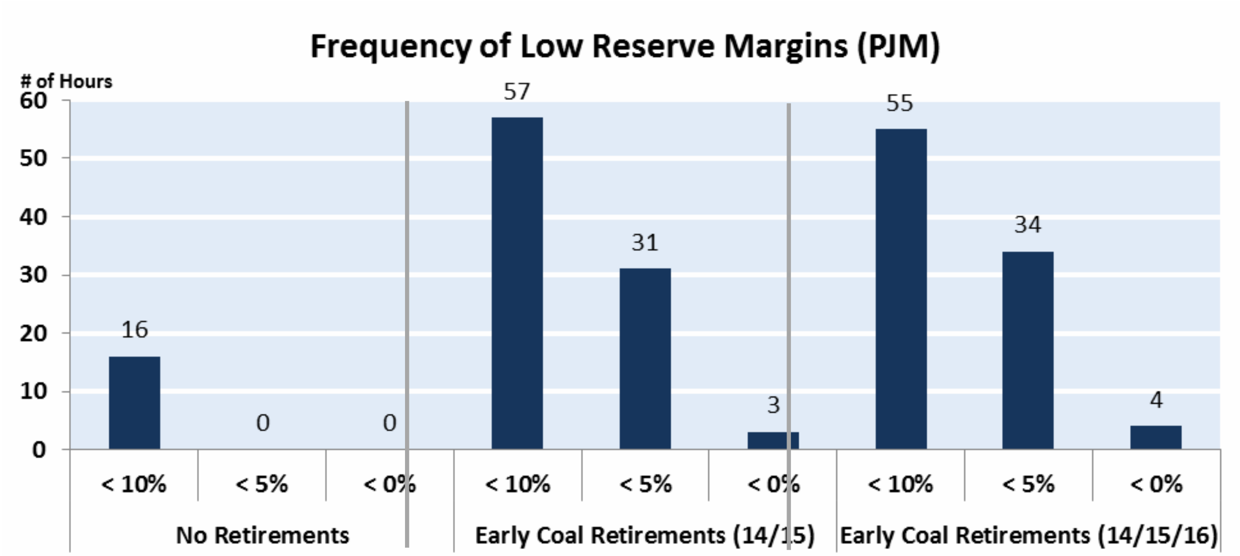
PJM BASE CASE POWER PRICES



- After incorporating the electricity demand and outage information into its modeling, EVA developed the Base Case power prices to the left.
- Though they are close to actual prices, it is impossible to perfectly capture bidding behavior and other market phenomena that drive prices on an hourly basis
- The peaks are consistent with the coldest (and thus highest demand) days of the month.

PJM WINTER ANALYSIS: IMPACT OF COAL RETIREMENTS ON SYSTEM RELIABILITY

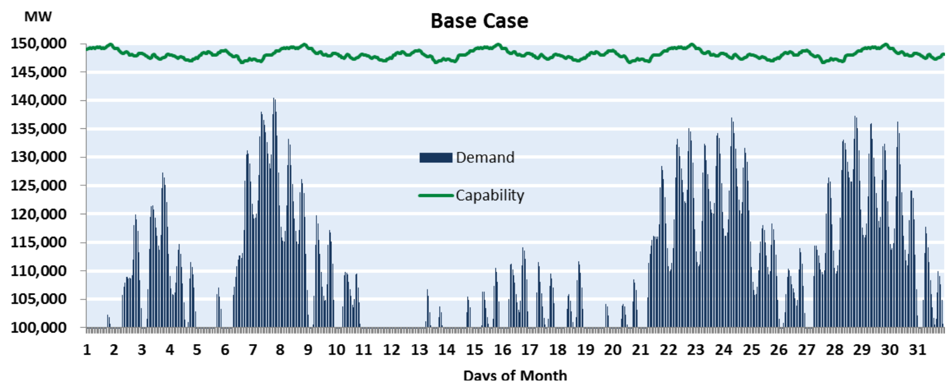
POTENTIAL WINTER BLACKOUTS DUE TO EARLY COAL RETIREMENTS

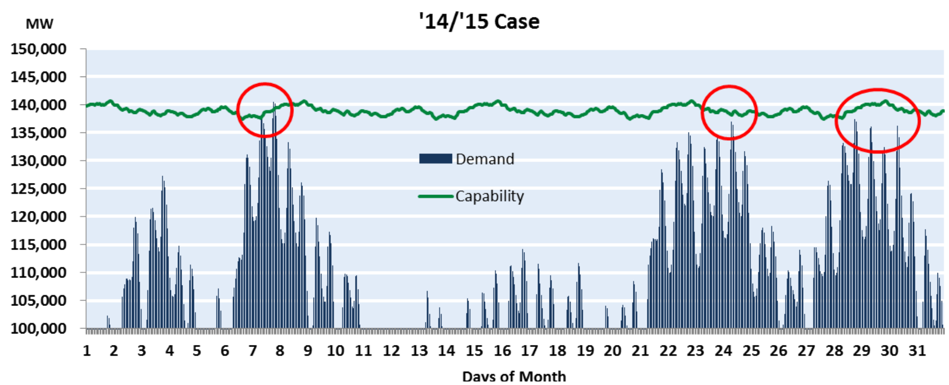


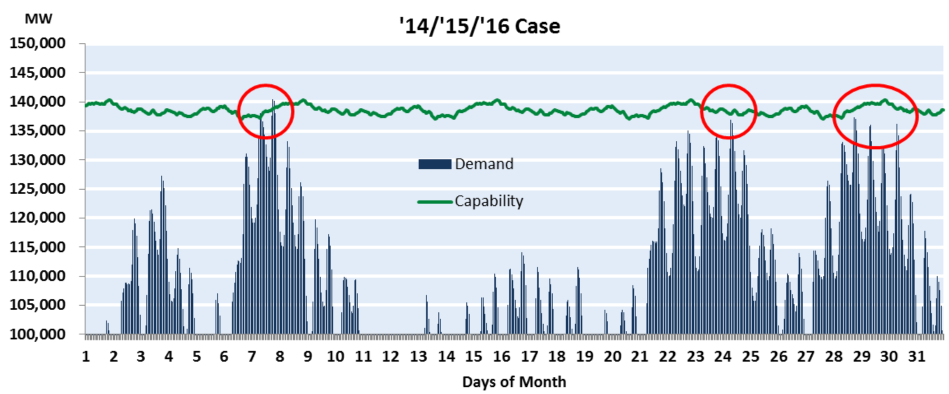
- The results of the three cases in terms of reliability are shown to the left.
- EVA's modeling indicates that during this past winter, record high electricity demand and generation outages led to several instances in which PJM was low on resources and narrowly avoided load shedding to maintain system reliability.
- Under EVA's two scenarios in which MATS-driven coal retirements exited the market prior to this winter, PJM faced an especially high risk of capacity shortages (31 hours and 34 hours with a reserve margin under 5% in the '14/'15 Case and '14/'15/'16 Case, respectively)

PJM WINTER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

PJM RELIABILITY ANALYSIS FOR JANUARY



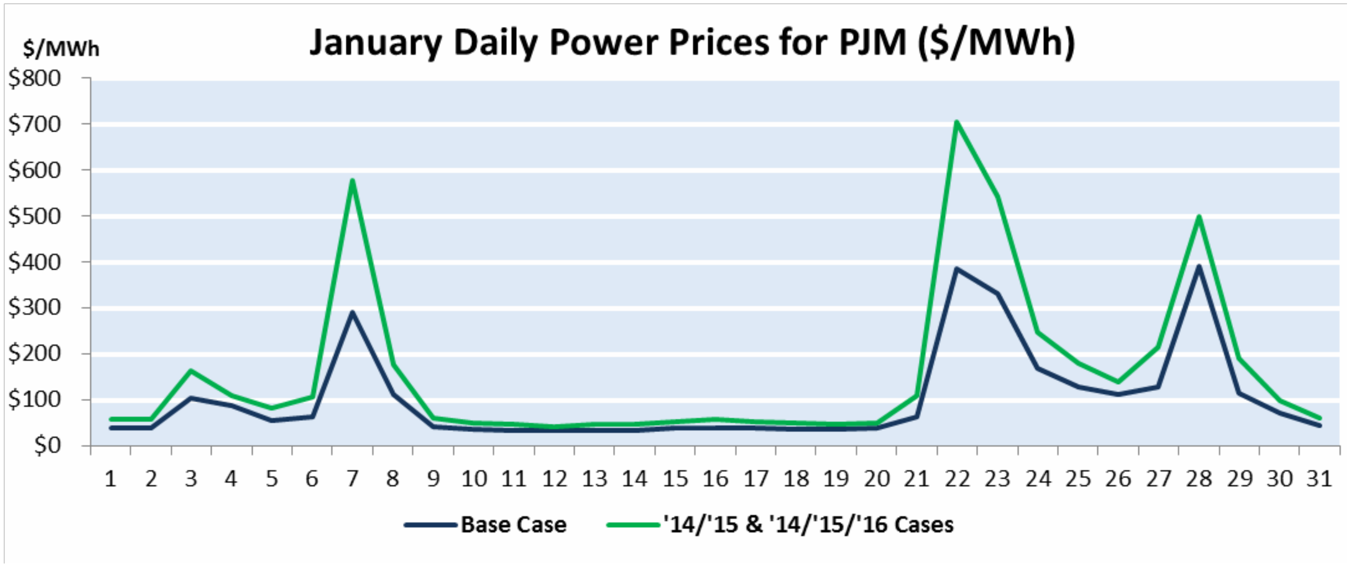


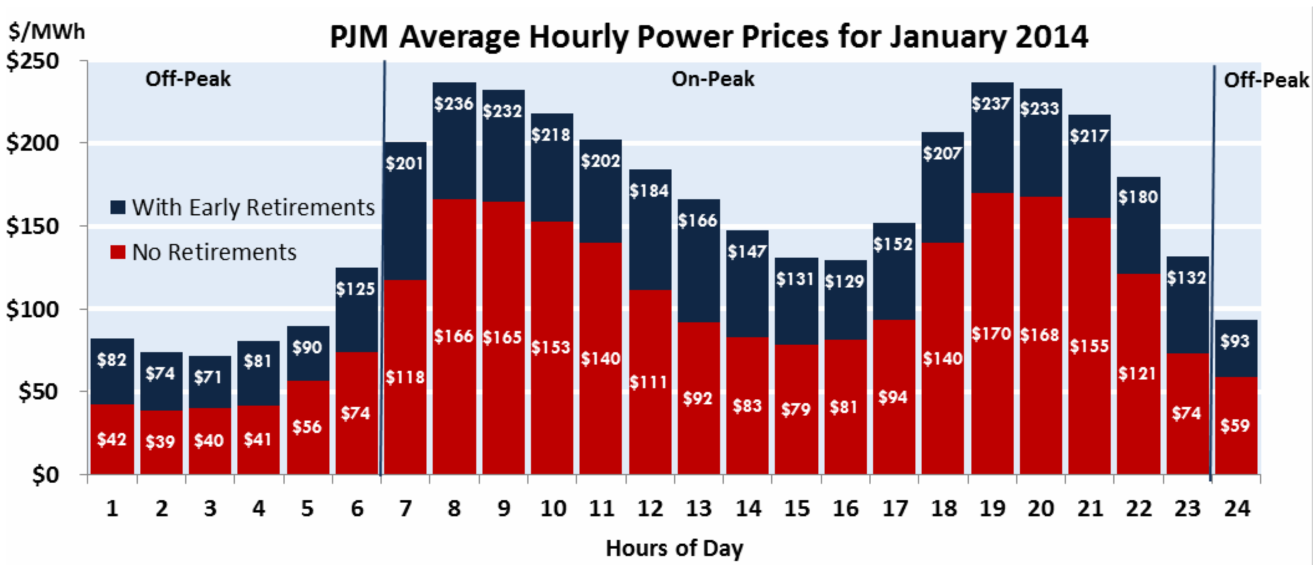


- Over the month of January, there were three major coal weather events that pushed PJM's system to its limits.
  - They occurred in the January 7-8, 22-25, and 28-30 timeframes
- Though the system maintained its integrity during those times in the Base Case, results of the other two cases indicated that multiple shortages would have occurred.
- In the '14/'15 Case, three hours during the January 7-8 cold spell had reserve margins below 0%
- In the '14/'15/'16 Case, four hours during that timeframe had reserve margins below 0%.
  - The later cold spells came perilously close to having negative reserve margins in this case

PJM WINTER ANALYSIS: POWER PRICES DRIVEN EVEN HIGHER DURING COLD SPELLS

PJM POWER PRICES





- As a result of the early retirements, January wholesale prices increased significantly from the Base Case.
- The price impact was almost identical between the '14/'15 Case and '14/'15/'16 Case, where power price spikes in January would have averaged 55% higher, but the majority of the impact would have been seen during those three major cold spells.
- As the retiring units are pulled from the market, generation that historically came from coal is now shifted to gas and higher heat rate peaking units, placing upward pressure on prices.
- The effect is more pronounced during the peak hours when demand is highest, though off-peak prices still increased significantly in the analysis.

PJM WINTER ANALYSIS

PJM GAS MARKET ASSESSMENT

- Additional Curtailments of Gas Units Could Have Occurred in a Few Other Regions
  - Pipeline situation is very different than in New England
    - In general, there are not any major pipeline constraints in these regions.
  - Site specific situations could result in some further curtailments of gas supplies, particularly in the 3 to 6 days where peak demand for the nation would have been >120 BCFD

Region	Pipeline Constraints	Approximate Incremental Gas Burn	Observations
SERC	No	0.5 BCFD	Site specific situations could exist.
RFC	No	0.4 BCFD	Site specific situations; higher basis differentials.
SPP	No	0.2 BCFD	Site specific situations could exist.
WECC	Some	0.2 BCFD	In general West was not affected like the East.

DETAILED POWER ANALYSIS OUTLINE

- PJM Winter Analysis
- MISO Winter Analysis
- ISO-NE Winter Analysis
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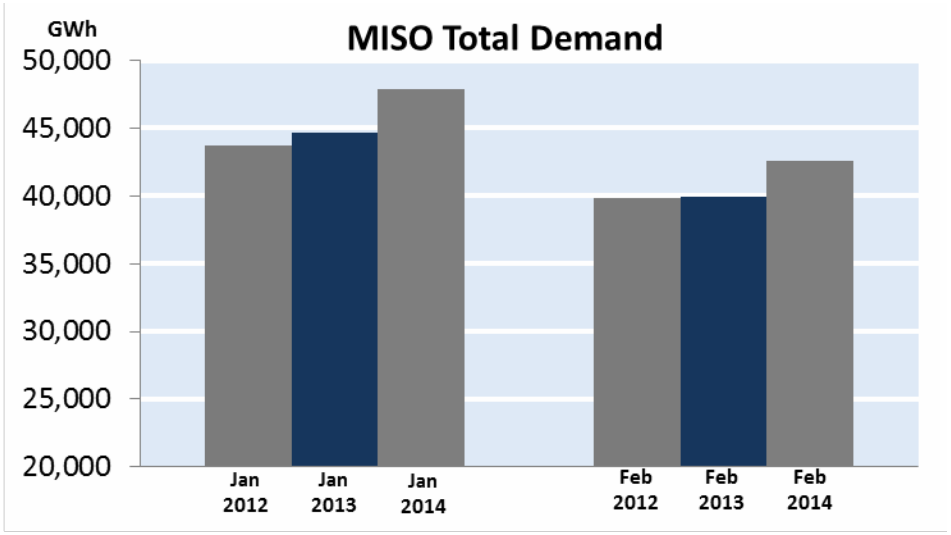
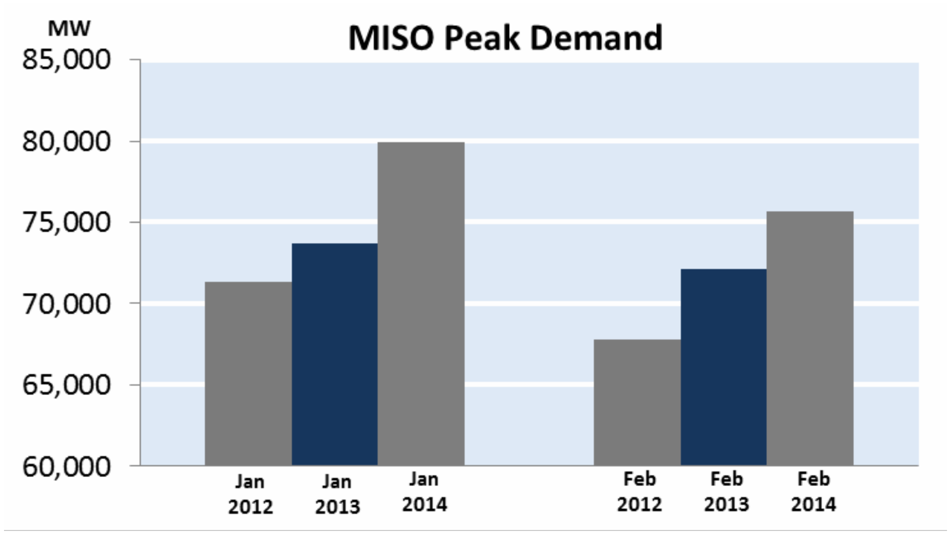
MISO WINTER ANALYSIS: EFFECTS OF POLAR VORTEX ON ELECTRICITY DEMAND

MISO WINTER DEMAND OUTLOOK

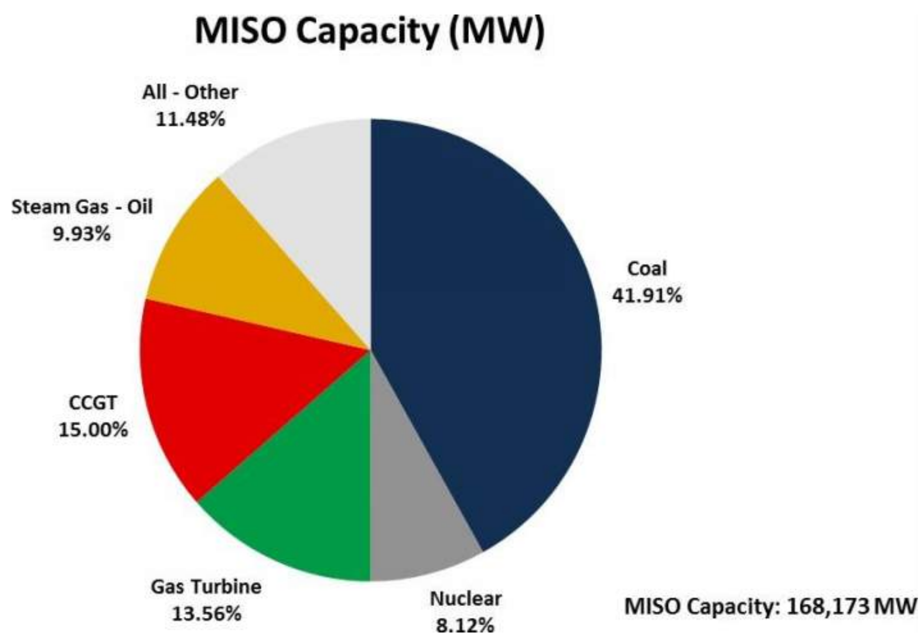
- Extreme weather conditions from the polar vortex in MISO drove peak and total power demand for January up 7% and 5% YoY, respectively.
- The YoY increase seen in February was slightly more tempered.
- To simulate the extreme weather condition in MISO, EVA used actual hourly load data in its modeling effort.





MISO WINTER ANALYSIS: EXISTING SUPPLY DURING POLAR VORTEX

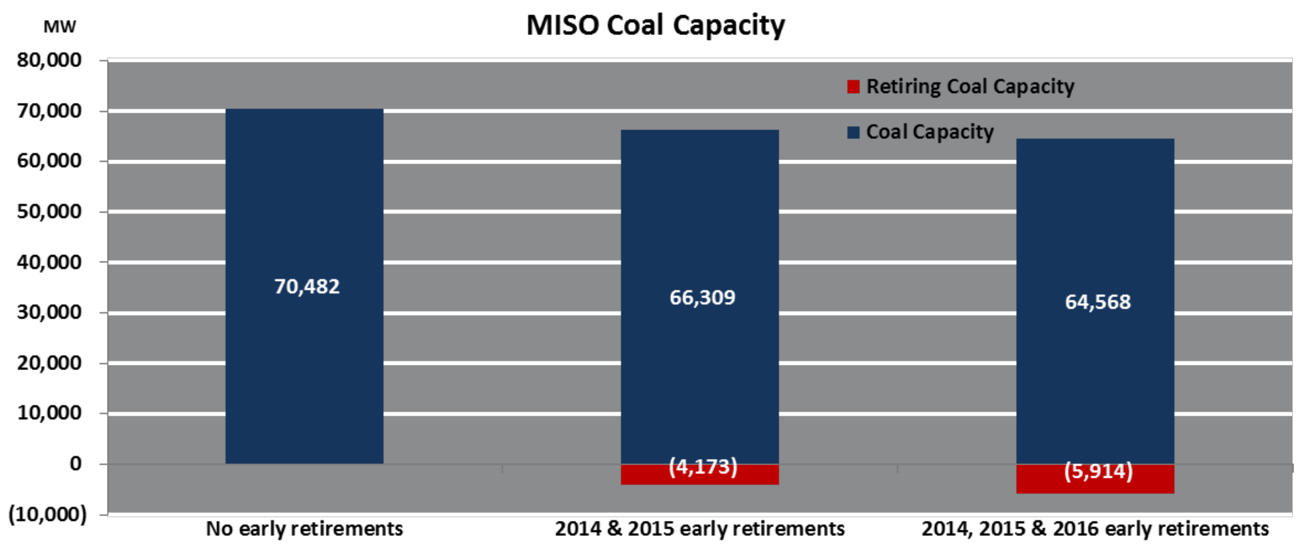
MISO INSTALLED CAPACITY



- MISO also relies heavily on coal to provide system reliability and for producing power – nearly 42% of all MISO capacity is coal-fired.
- CCGTs currently comprise 15% of total capacity though this share is expected to grow as coal retirements mount.
- MISO's reserve margin remained healthy during the polar vortex, meaning reliability did not face a significant threat.

MISO WINTER ANALYSIS: TESTING SYSTEM RELIABILITY WITH EARLY RETIREMENTS

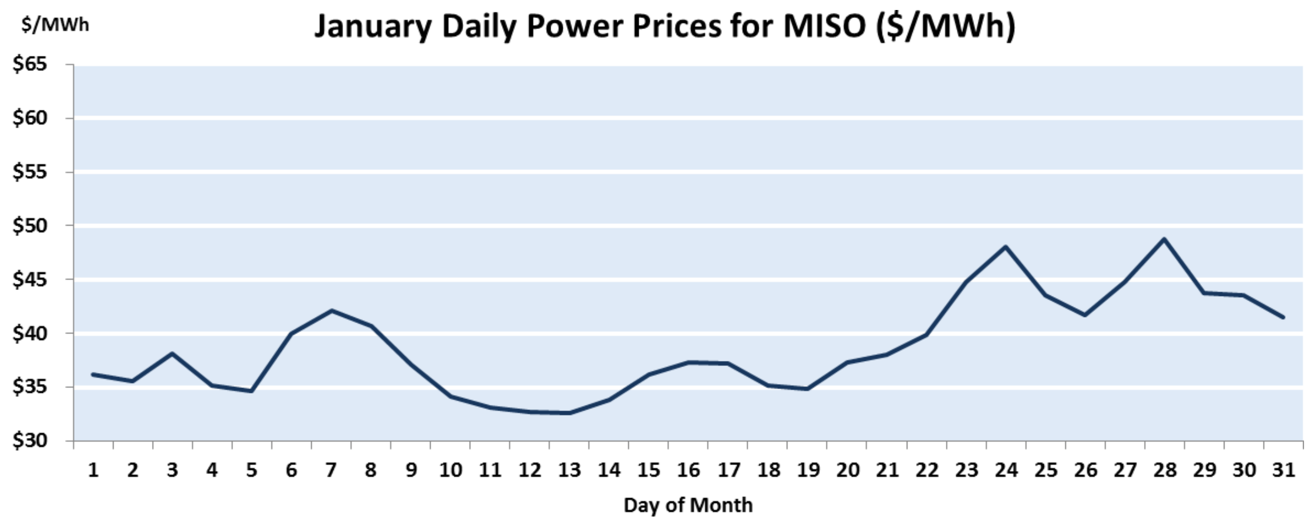
MISO CAPACITY OUTLOOK



- Of the 70,000 MW of coal capacity in MISO, close to 4,000 MW is scheduled to retire by the end of 2015 with an additional 1,800 MW by the end of 2016.
- EVA sought to determine the impact of:
  - Extreme weather resulting in high power demand
  - The loss of coal capacity
- On MISO reliability and prices by simulating an environment where these units were pulled from the market prior to the winter of 2014.
- Fortunately, MISO did not experience the same magnitude of generation outages that PJM did during that time.

MISO WINTER ANALYSIS: PRICE IMPACT WAS TEMPERED DUE TO FEWER OUTAGES

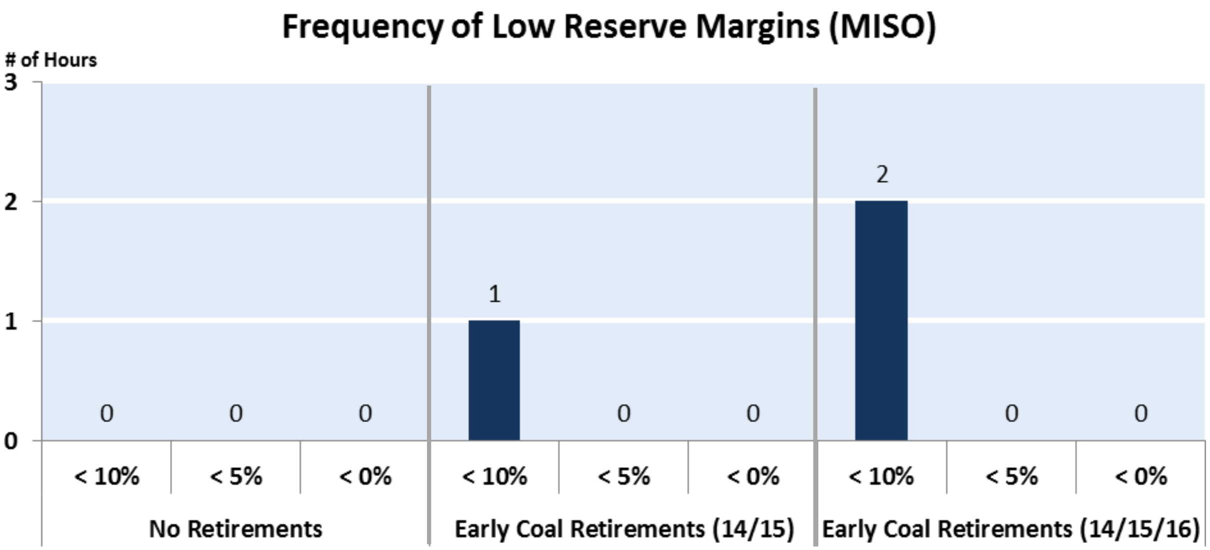
MISO POWER PRICES



- After incorporating the electricity demand and outage information into its modeling, EVA developed the Base Case power prices to the left.
- Though they are close to actual prices, it is impossible to perfectly capture bidding behavior and other market phenomena that drive prices on an hourly basis
- Because coal contributes strongly to the generation mix in MISO, gas-driven power price spikes were not as prevalent.

MISO WINTER ANALYSIS: IMPACT OF COAL RETIREMENTS ON SYSTEM RELIABILITY

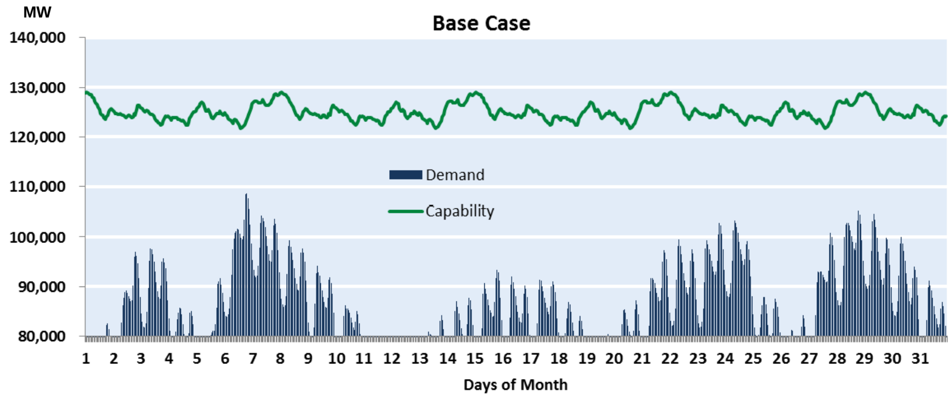
POTENTIAL WINTER BLACKOUTS DUE TO EARLY COAL RETIREMENTS

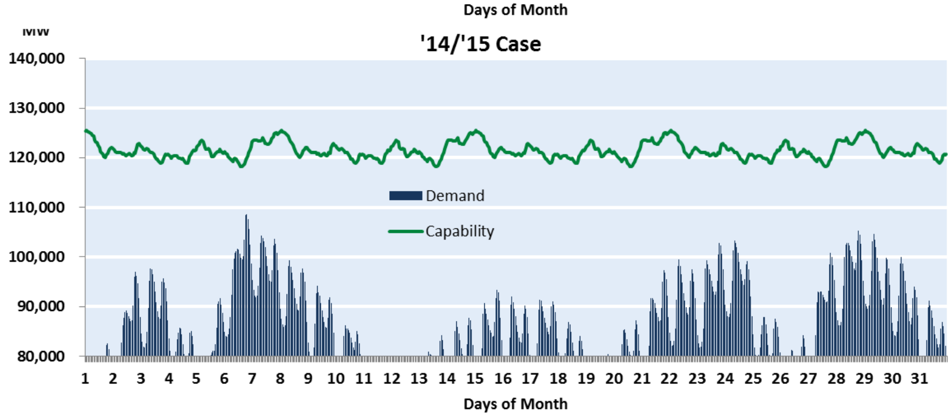


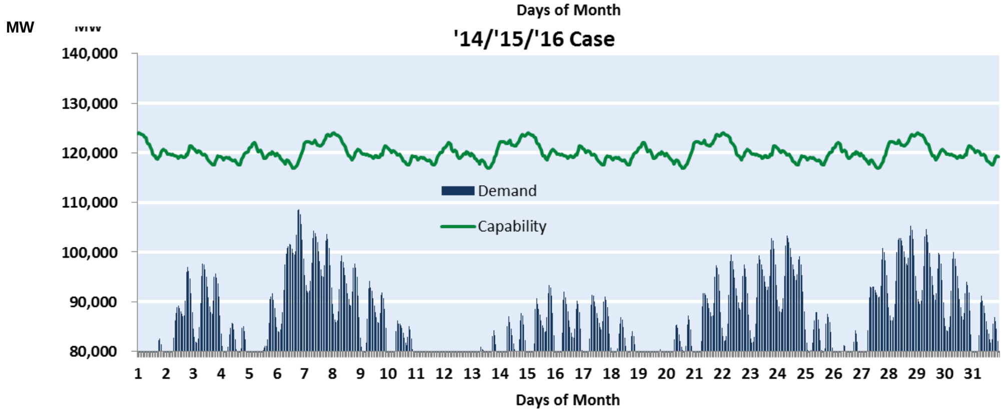
- The results of the three cases in terms of reliability are shown to the left.
- EVA's modeling indicates that despite very high demand due to the sustained cold weather, the reserve margin in MISO did not become precariously tight.
- Under EVA's two scenarios in which MATS-driven coal retirements exited the market prior to this winter (Case 1 and 2), MISO faced only a very small risk of capacity shortages (2 hours with a reserve margin under 10% in the '14/'15/'16 Case).

MISO WINTER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

MISO RELIABILITY ANALYSIS FOR JANUARY





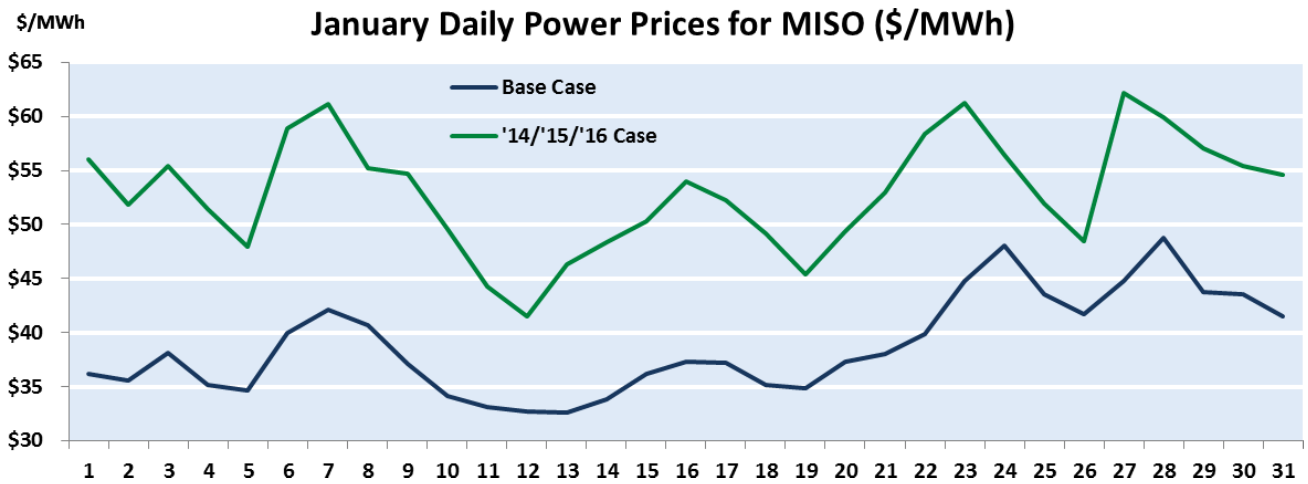


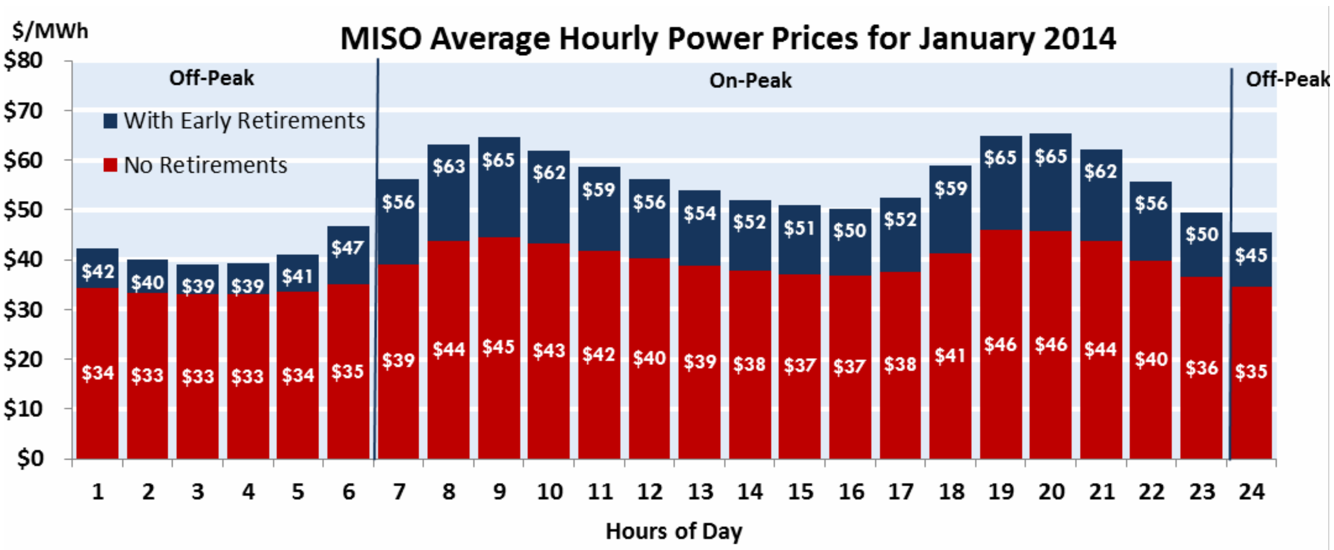
- As shown in the above slide, MISO's supply-demand balance did not become especially tight during the polar vortex because they did not face the same outages that PJM did.

- Even in EVA's retirement cases, MISO had at least a 10,000 MW buffer because the magnitude of coal capacity leaving the market is much lower than that of PJM.

MISO WINTER ANALYSIS

POWER PRICES – MISO





- Despite being a coal-heavy region like PJM, MISO is not expected to be as adversely affected in terms of wholesale power prices by coal retirements as its neighbor to the East.

- In the ’14/’15 Case, January prices climbed an average of 33% as a result of increased gas generation and fuel prices, while July prices climbed just 9%.

- The impact was only slightly greater in the ’14/’15/’16 Case.

MISO WINTER ANALYSIS

MISO GAS MARKET ASSESSMENT

- Impact Minimal for Several Regions

Region	Pipeline Constraints	Approximate Incremental Gas Burn	Observations
NYPOOL			
NYC	Yes		Very constrained pipeline system, but not affected by coal burn; higher basis differentials.
Upstate	No	0.07 BCFD	
MRO	No	0.08 BCFD	Site specific situations could exist.
FRCC	Yes	0.06 BCFD	Site specific situations could exist.
ERCOT	No	0.03 BCFD	Site specific situations could exist.

DETAILED POWER ANALYSIS OUTLINE

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- **ISO-NE Winter Analysis**
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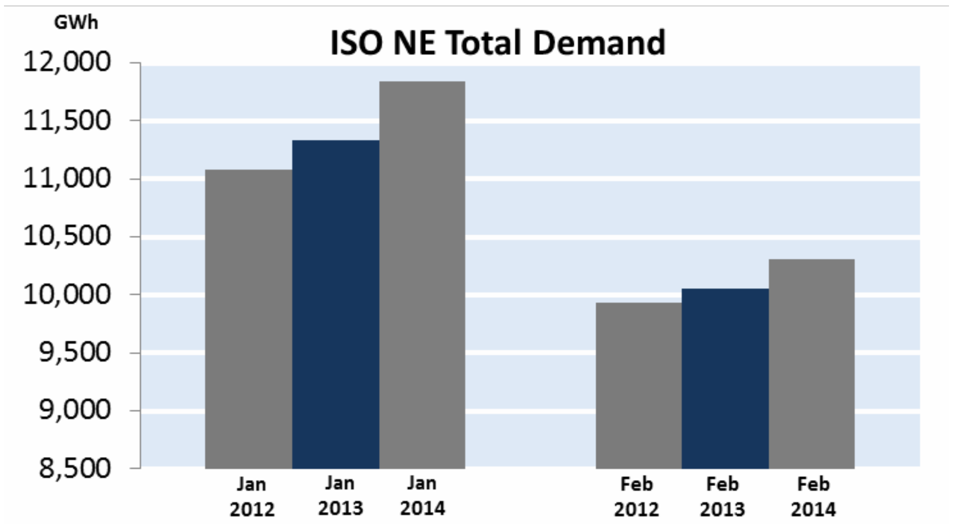
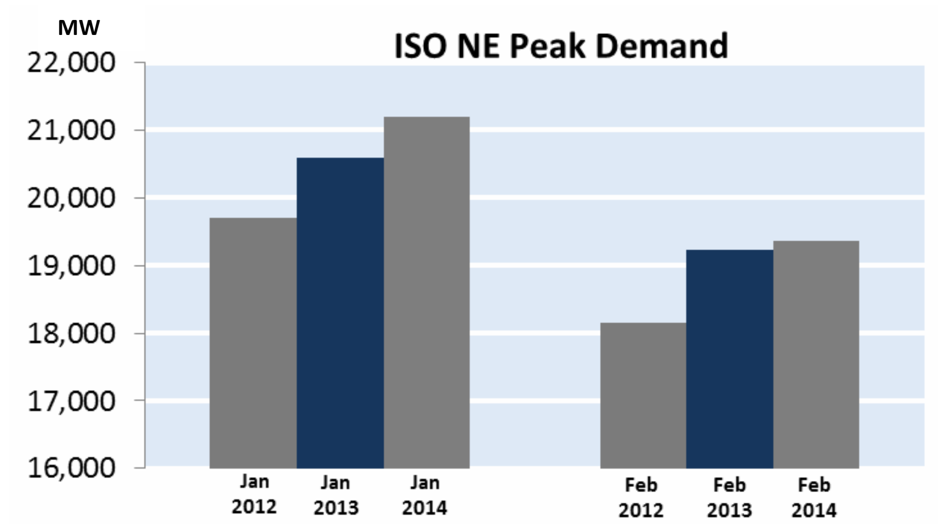
ISO-NE WINTER ANALYSIS: EFFECTS OF POLAR VORTEX ON ELECTRICITY DEMAND

ISO-NE WINTER DEMAND

- ISO-NE total January demand grew 7% YoY where as the peak demand for January grew 8% YoY. February total demand growth was at 7% whereas peak demand growth was at 5% YoY.

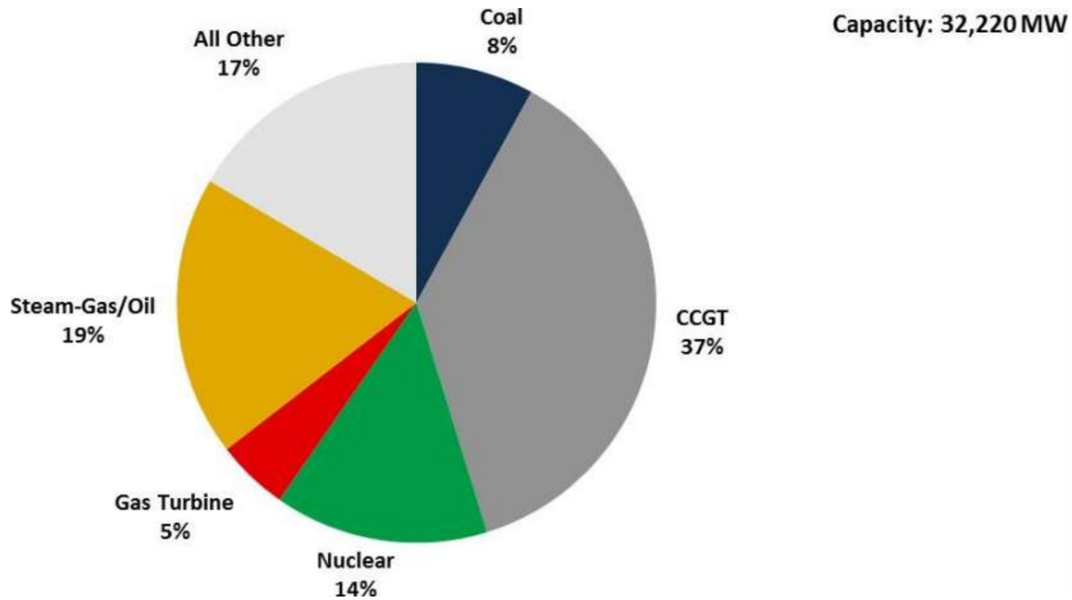
- To simulate the extreme weather condition in ISO-NE, EVA used actual hourly load data in its modeling effort.





ISO-NE WINTER ANALYSIS: EXISTING SUPPLY DURING POLAR VORTEX

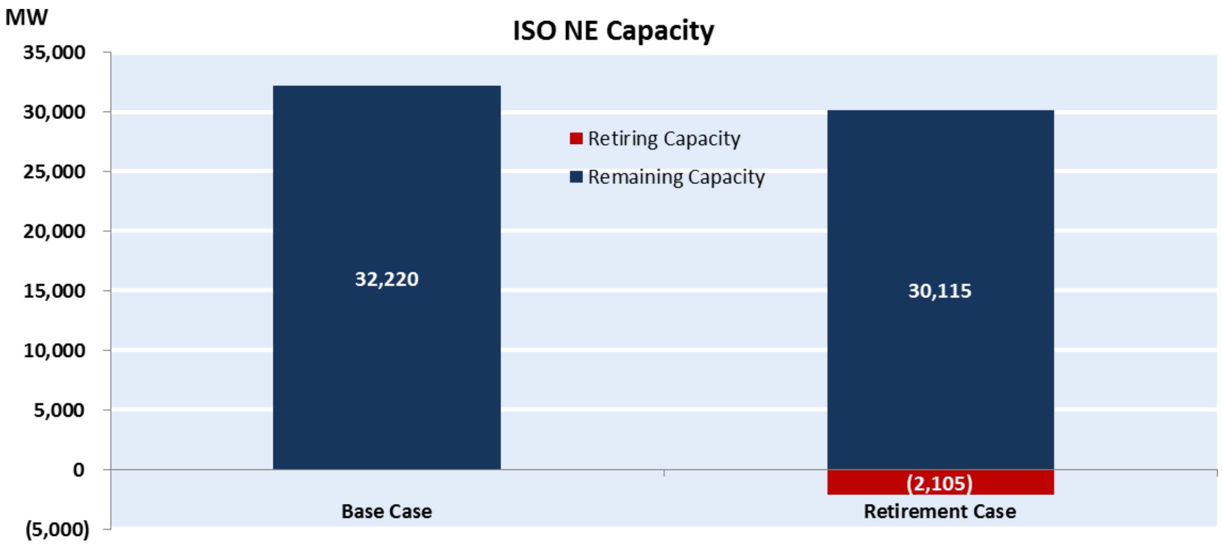
ISO-NE CAPACITY



- Only 8% of ISO-NE's capacity is coal-fired – by far the smallest of the three markets EVA analyzed.
- At first glance, it does not appear that the existing coal capacity is important to reliability, but EVA realized that because of the especially unpredictable nature of gas availability in the region, having a diverse supply is vital to maintaining the system in the winter.
- MATS regulations have a very limited effect on the supply in ISO-NE.

ISO-NE WINTER ANALYSIS: TESTING SYSTEM RELIABILITY WITH EARLY RETIREMENTS

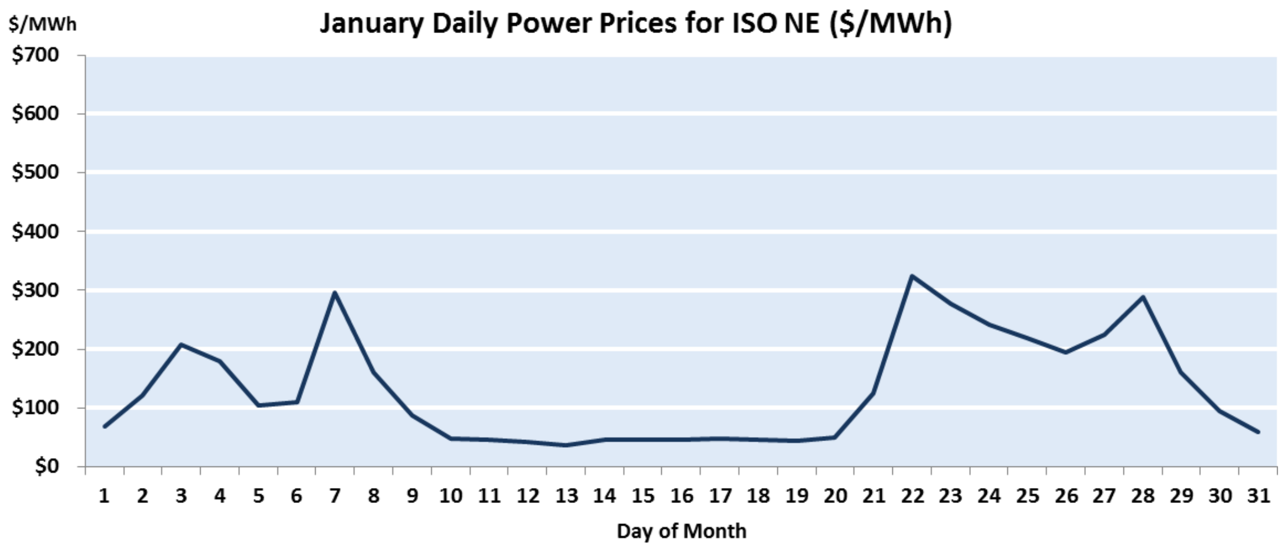
ISO-NE CAPACITY



- Of the 2,600 MW of coal capacity in ISO-NE, EVA assumed that 2,100 MW had left the market prior to the winter of 2014 in Cases 1 and 2.
- Because gas is scarce in New England in the winter, EVA sought to determine the reliability and price impact on the region under the three Cases.

ISO-NE WINTER ANALYSIS

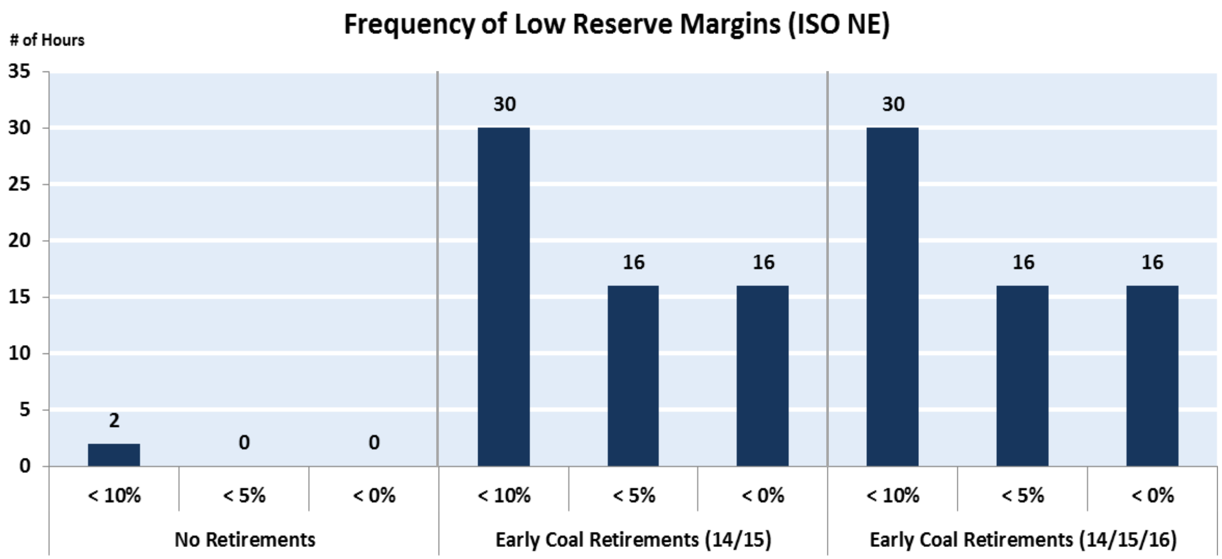
ISO-NE POWER PRICES



- ISO-NE faces a unique situation when it comes to gas availability. Being located at the end of the gas pipelines, ISO-NE has to deal with unavailability of gas due to constraints in the system.
- During the winter of 2014, Oil units in ISO-NE produced 25 times more power than they did last winter as gas prices went through the roof due to the constraints. This resulted in high power prices sustained over a long period of time.
- If the coal units in ISO-NE were to retire last year, the power prices would have seen an even bigger jump during high demand periods crossing the $400/MWh mark.
- Power prices would go through the roof in summer due to the unavailability of the coal units and high temperatures.

ISO-NE WINTER ANALYSIS: IMPACT OF COAL RETIREMENTS ON SYSTEM RELIABILITY

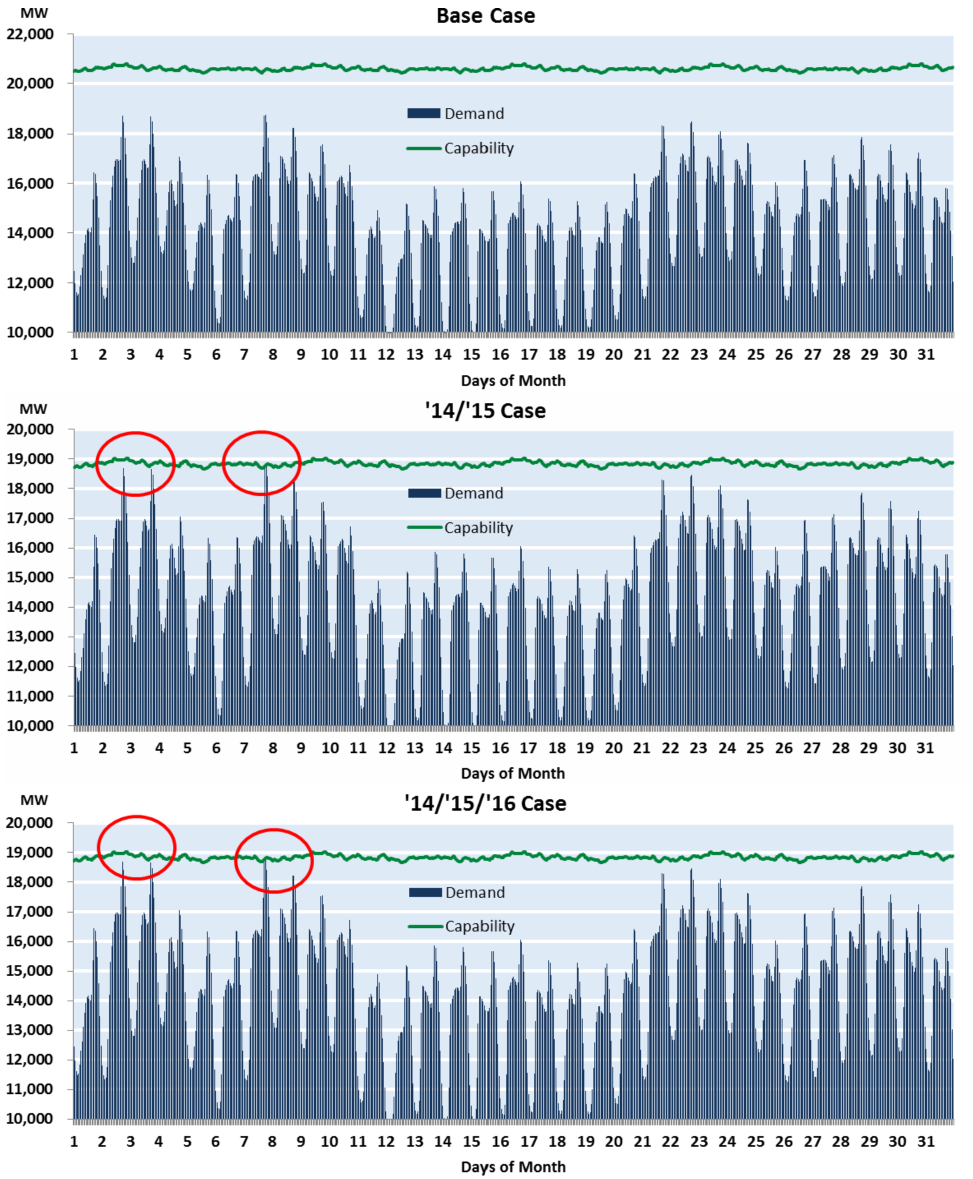
POTENTIAL WINTER BLACKOUTS DUE TO EARLY COAL RETIREMENTS



- During this past winter, record high electricity demand and forced generation outages led to several instances in which PJM was low on resources and narrowly avoided load shedding to maintain the system reliability
- In MISO, despite record high demand due to sustained cold weather, the reserve margin did not become precariously tight
- Under EVA's two scenarios in which MATS-driven coal retirements exited the market early, PJM faced an especially high risk of capacity shortages (31 hours and 34 hours with a reserve margin under 5% in the '14/'15 Case and '14/'15/'16 Case, respectively)
- MISO, with fewer retirements, faced only a very small risk of capacity shortages (2 hours with a reserve margin under 10% in the '14/'15/'16 Case)

ISO-NE WINTER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

ISO-NE RELIABILITY ANALYSIS FOR JANUARY



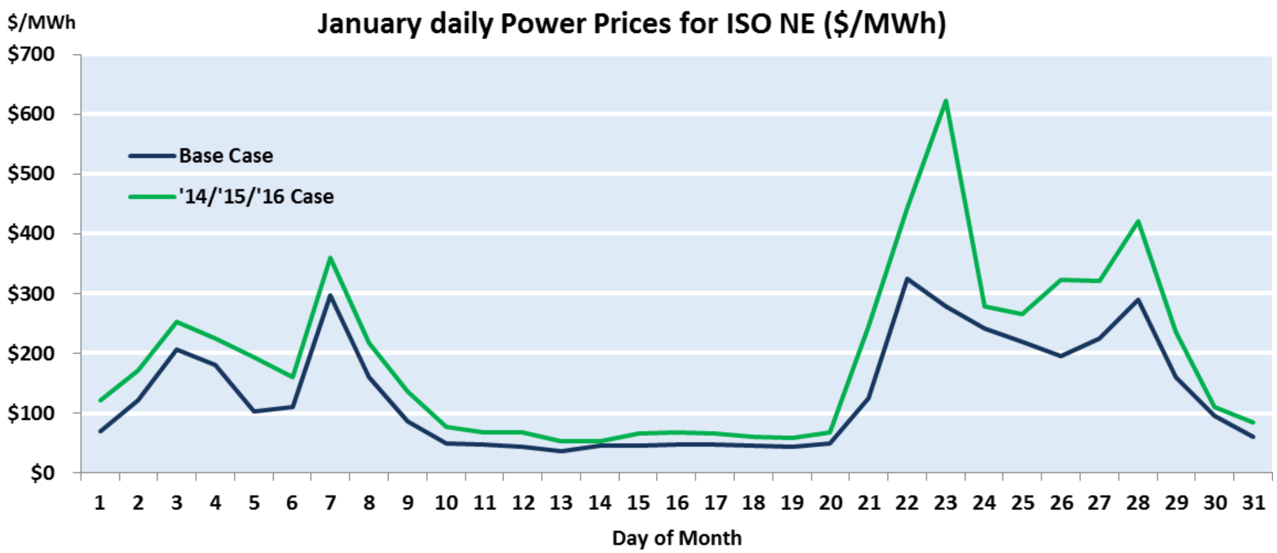
- Over the month of January, there were three major coal weather events that pushed ISO-NE's system to its limits.
  - They occurred in the January 7-8, 22-25, and 28-30 timeframes

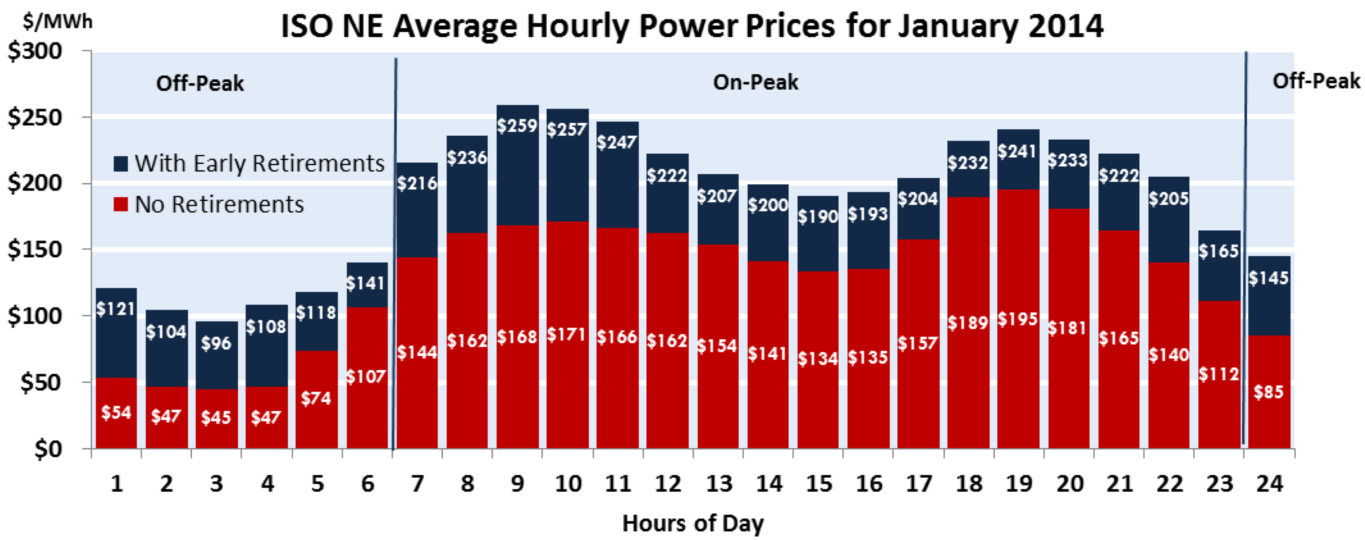
- Though the system maintained its integrity during those times in the Base Case, results of the other two cases indicated that multiple shortages would have occurred.

- In the '14/'15 case as well as the '14/'15/'16 case, 16 hours during that timeframe had reserve margins below 5% and 0% potentially causing reliability issues.

ISO-NE WINTER ANALYSIS

ISO-NE POWER PRICES





- ISO-NE faces a unique situation when it comes to gas availability. Being located at the end of the gas pipelines, ISO-NE has to deal with unavailability of gas due to constraints in the system.

- During the winter of 2014, Oil units in ISO-NE produced 25 times more power than they did last winter as gas prices went through the roof due to the constraints. This resulted in high power prices sustained over a long period of time.

- If the coal units in ISO-NE were to retire last year, the power prices would have seen an even bigger jump during high demand periods crossing the $400/MWh mark.

- Power prices would go through the roof in summer due to the unavailability of the coal units and high temperatures.

ISO-NE WINTER ANALYSIS

ISO-NE GAS MARKET ASSESSMENT

- New England (NEPOOL)
  - New England has gas pipeline capacity constraints and can not meet all of the region's gas load requirements
    - Historical synopsis for the three major regional pipelines.

Pipeline	Percent of Northeast Gas-Fired Generation Served	Percent of Gas/Electric Load FT	Curtailments
Algonquin	40%	10%	● Can not meet entire IT load for several months in each year. ● Winter 2011/2012 restricts gas supplies at Cromwell, CT for >100 days (i.e., 2/3 of winter). ● Winter 2013/2014 restricts IT at Stony Point, NY and Cromwell, CT; no receipt increases at Mendin, MA on Dec 13, 2014.(1)
Tennessee	13 Plants	24%	● Winter restrictions at Station 245 during winter of 2009/2010 (41.7% of winter); 2010/2011 (96.0%); and 2011/2012 (99.3%). ● Summer restriction for 2009 (0); 2010 (22.4%) and 2011 (78.5%).
Iroquois	-	20-25%	

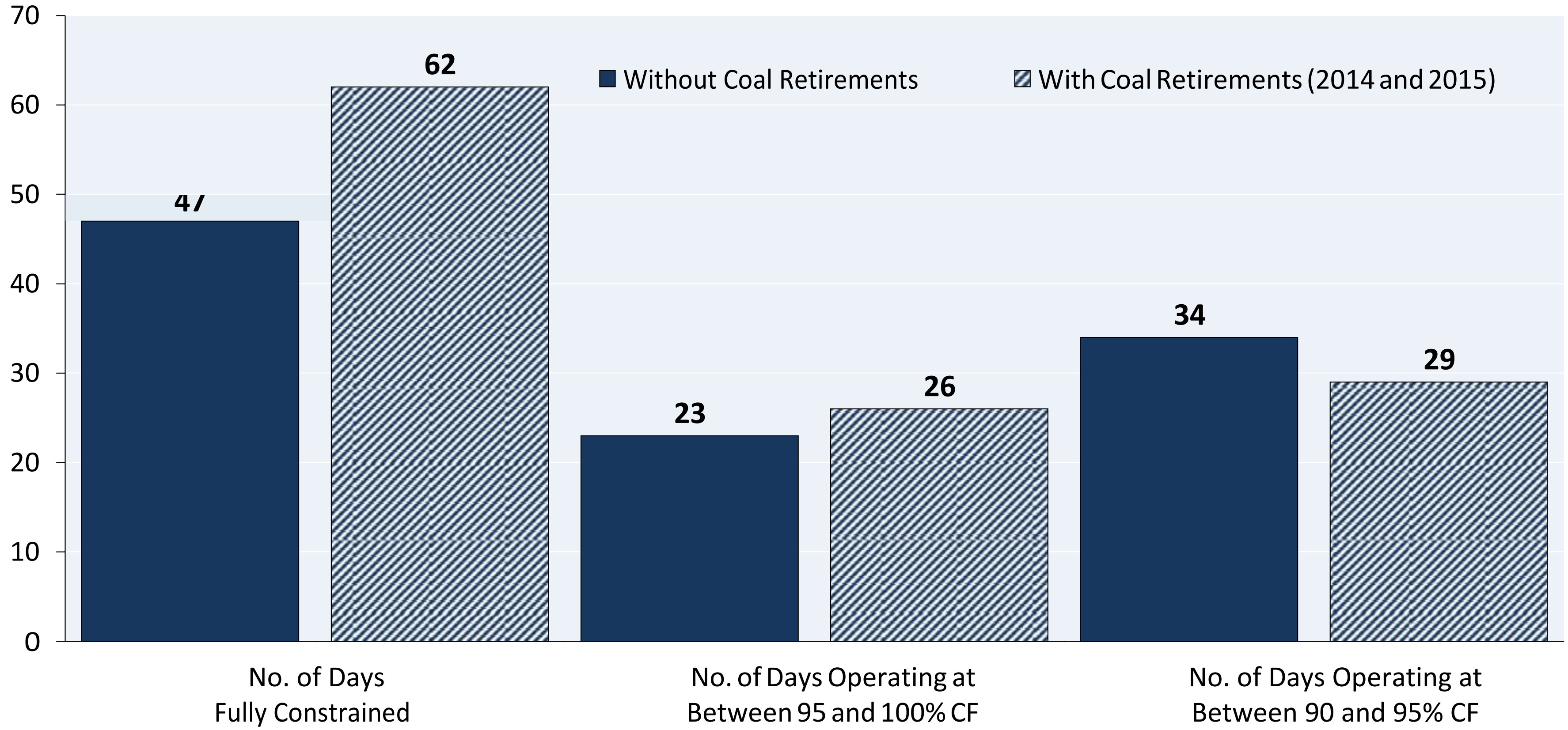
(1) "Power lines replaced gas pipelines during recent Northeast coal snap", *Inside FERC's Gas Market Report*, January 3, 2014, pp 15-16.

ISO-NE WINTER ANALYSIS

ISO-NE GAS MARKET ASSESSMENT

- Case example for Algonquin:
  - Pipeline constraints would increase from about 70 days during the winter to about 88 days.

ALGONQUIN CAPACITY FACTORS FOR WINTER 2013/2014



ISO-NE WINTER ANALYSIS

ISO-NE GAS MARKET ASSESSMENT

- During winter of 2013/2014 used oil-fired generation to meet load requirements (fuel switching).
  - 4% of Dec through Feb load, or 1.13 TWh, was oil-fired.
    - In prior winter only 0.6%, or 167 GWh (i.e., 85% less).
    - A special program for winter 2013/2014 with 90% of 3 MM barrels in tanks consumed.(1)
    - 55-60% of gas units are dual-fuel with 40-45% gas-only.
    - 418 MW of oil-fired generation set to retire by 2017.
- Winter of 2013/2014 with projected retirements
  - Regional gas burn would have increased about 0.1 BCFD.
    - While on the surface this does not seem to be a large amount, already constrained pipelines could not accommodate the increased burn.
    - Key alternatives were:
      - Increased oil-fired generation (i.e., would require additional 1.8 MMB;
        - However, NEPOOL outstripped its capability to resupply fuel oil in January in the base case.(2)
      - Additional imported power, although difficult to determine which neighboring region would be capable of exporting power; and,
      - Load shedding.

(1) "Oil often trumped gas in Northeast during record-setting winter cold", *Inside FERC's Gas Market Report*, April 11, 2014, pp 3-4.
(2) "ISO-NE CEO says New England gas supply issue will get worse before it gets better", *SNL Financial*, March 17, 2014.

DETAILED POWER ANALYSIS OUTLINE

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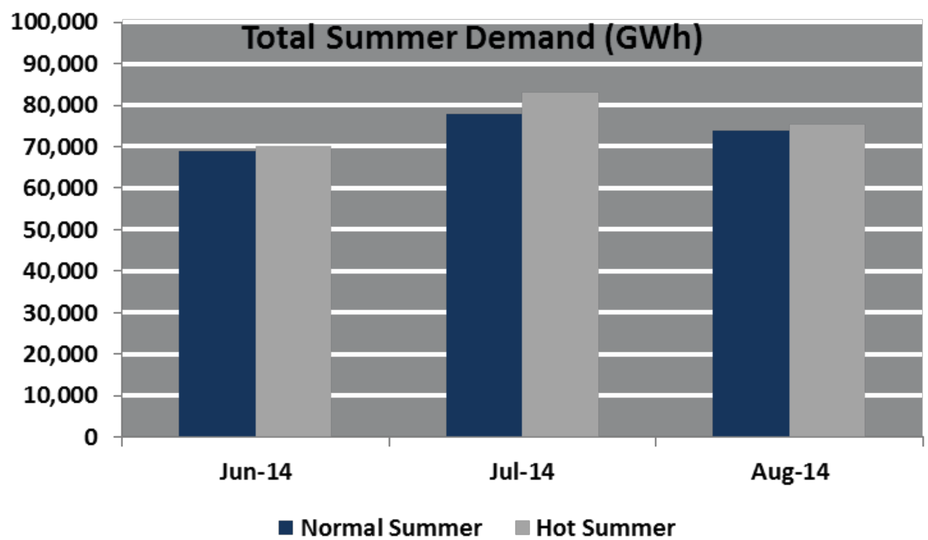
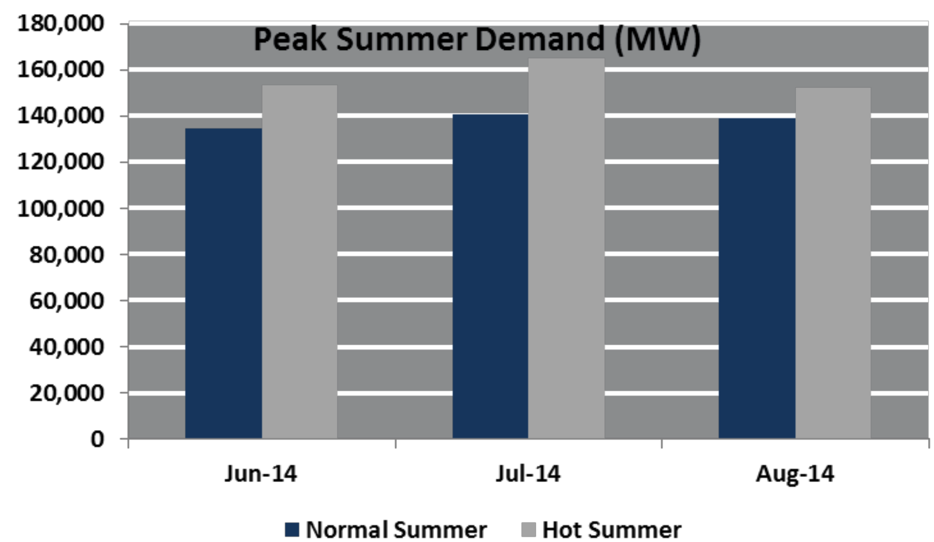
PJM SUMMER ANALYSIS: EFFECTS OF HEAT WAVE ON ELECTRICITY DEMAND

PJM SUMMER DEMAND OUTLOOK

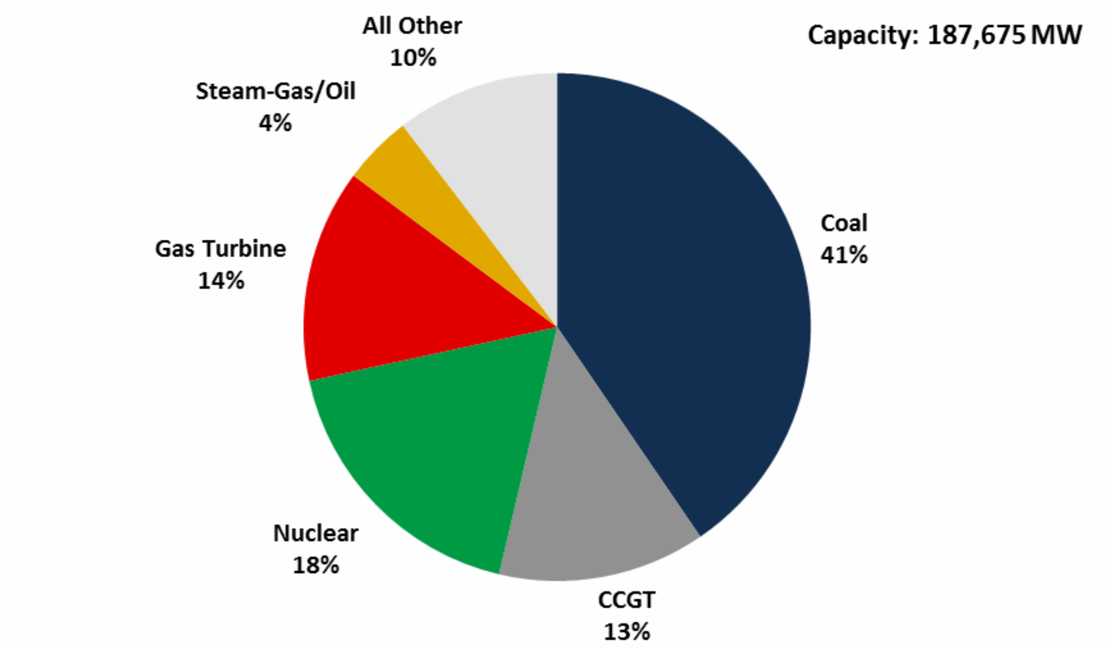
- To simulate a hot summer, EVA used load data from 2011, which had very high peak and total demand due to sustained warm weather.
- Compared to our forecast of a normal summer demand, our hot summer demand was 4% higher on average, whereas the peak demand was higher by 17%, resulting in greater stress on the system.





PJM SUMMER ANALYSIS: EXISTING CAPACITY DURING SUMMER HEAT WAVE

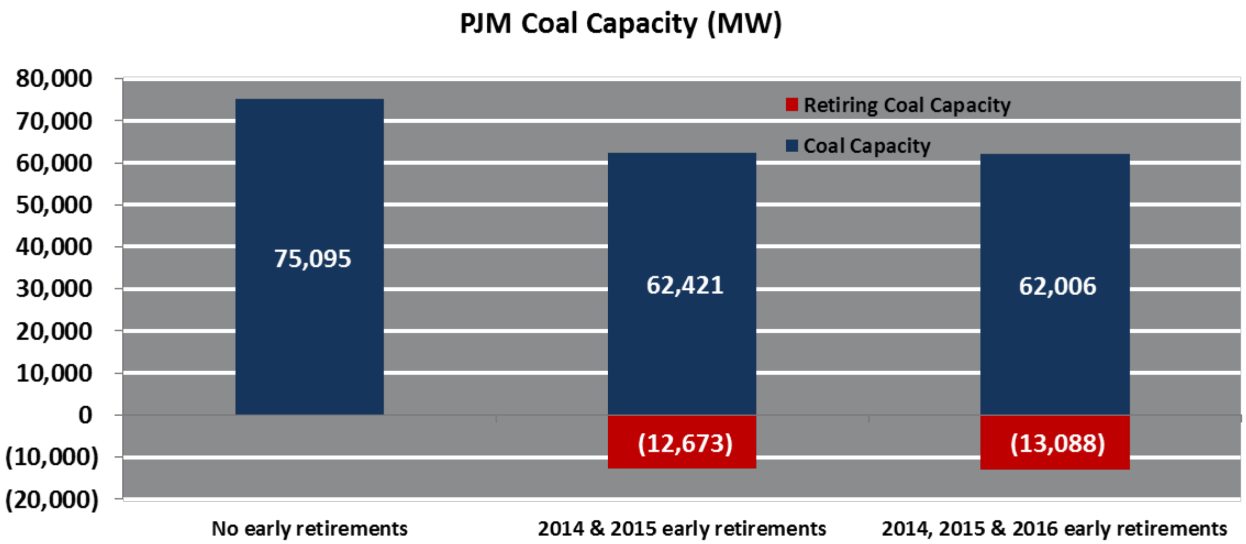
PJM INSTALLED CAPACITY



- Because of its proximity to Appalachian coal, PJM is a coal-dominated region – 41% of all existing capacity is coal-fired. This capacity has played a very important role in meeting summer peak demand, typically running at availability during July and August.
- CCGTs currently account for 13% of total capacity though this share is expected to grow as coal retirements mount.
- Until these CCGTs begin commercial operations, however, coal units in PJM are the backbone for system reliability.

PJM SUMMER ANALYSIS: TESTING SYSTEM RELIABILITY WITH EARLY RETIREMENTS

PJM CAPACITY OUTLOOK

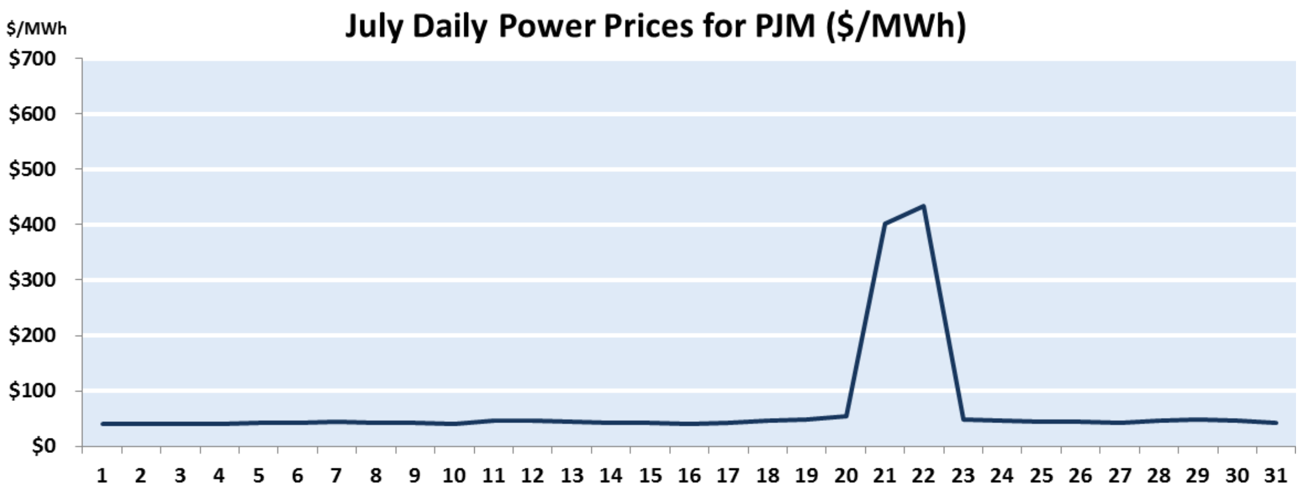


- Of the 75,000 MW of coal capacity in PJM, close to 12,500 MW is scheduled to retire by the end of 2015 and an additional 400 MW by the end of 2016 as a result of environmental regulations and other market drivers.
- EVA sought to determine the impact of:
  - Extreme summer weather resulting in high power demand
  - The loss of coal capacity

On PJM reliability and prices by simulating an environment where these units were pulled from the market prior to the winter of 2014.

PJM SUMMER ANALYSIS: HIGH SUMMER DEMAND MEANT HIGH POWER PRICES ON SOME DAYS

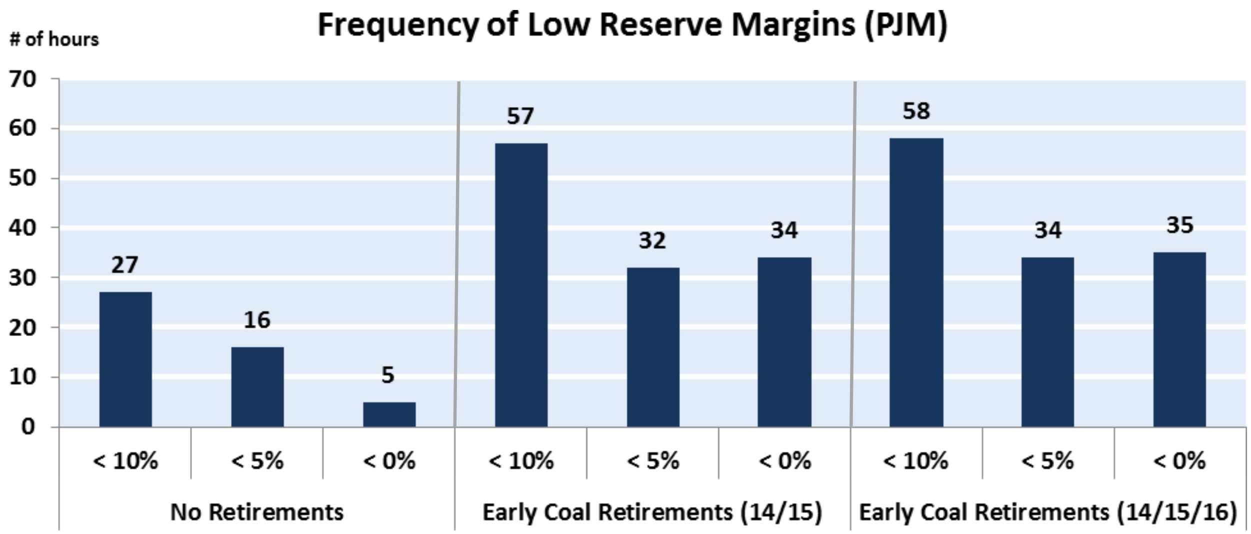
PJM BASE CASE POWER PRICES



- EVA incorporated all of the market data into its modeling and developed the Base Case power prices to the left
- One specific heat wave led to elevated prices around July 20-22, but they remained fairly tempered for the remainder of the month in the Base Case.

PJM SUMMER ANALYSIS: HOT WEATHER DROVE HIGH SUMMER DEMAND AND TIGHT RESERVE MARGINS

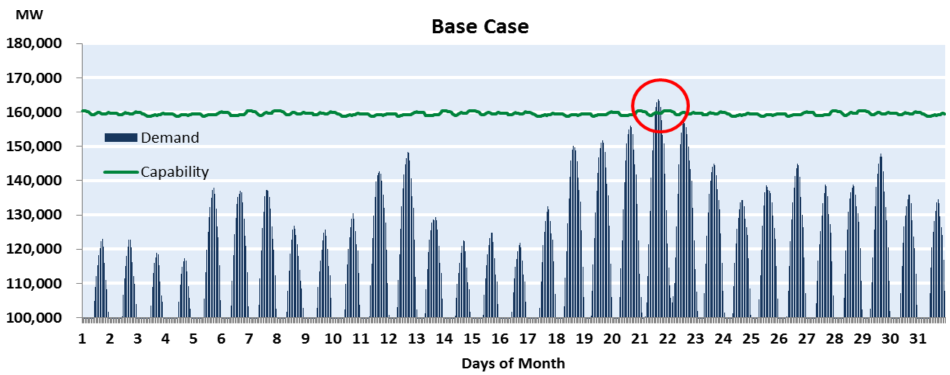
POTENTIAL SUMMER CAPACITY SHORTAGES DUE TO EARLY COAL RETIREMENTS – PJM

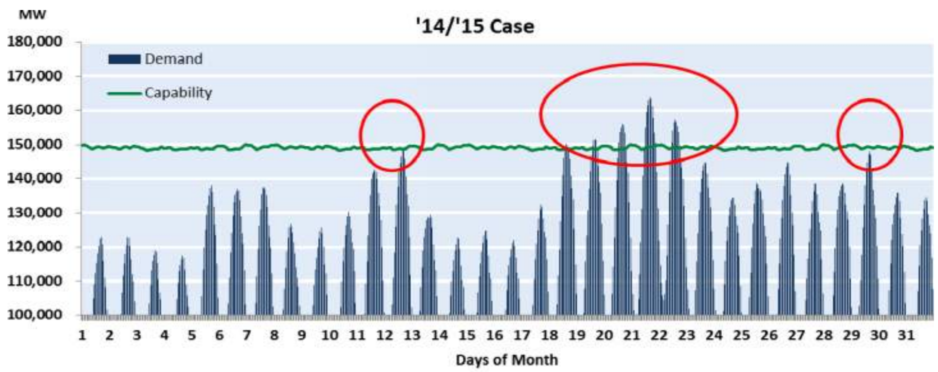


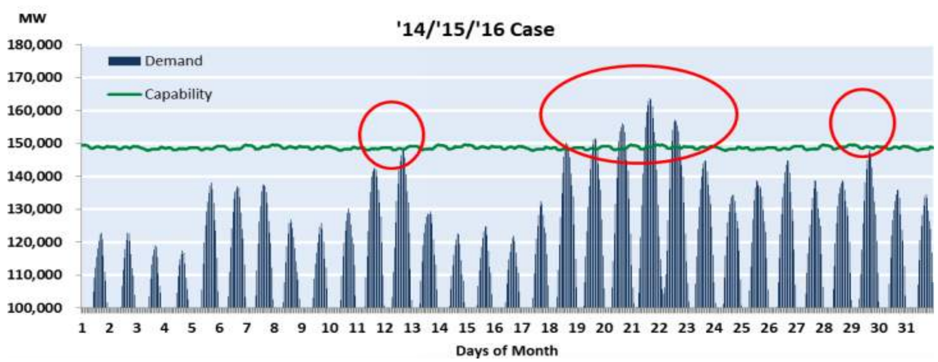
- The results of the PJM analysis suggest that in the Base Case, there would be 5 hours with a negative reserve margin.
  - It is likely that increased imports as well as demand response would be called upon to meet load.
- In Cases 1 and 2, there would be 34 and 35 hours, respectively, of negative reserve margins during the summer.
  - Demand response and increased imports may not be sufficient to make up for this in some hours, resulting in a capacity shortage and potential reliability issues.
- The magnitude of the shortage is detailed in the following slide.

PJM SUMMER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

PJM RELIABILITY ANALYSIS FOR JULY







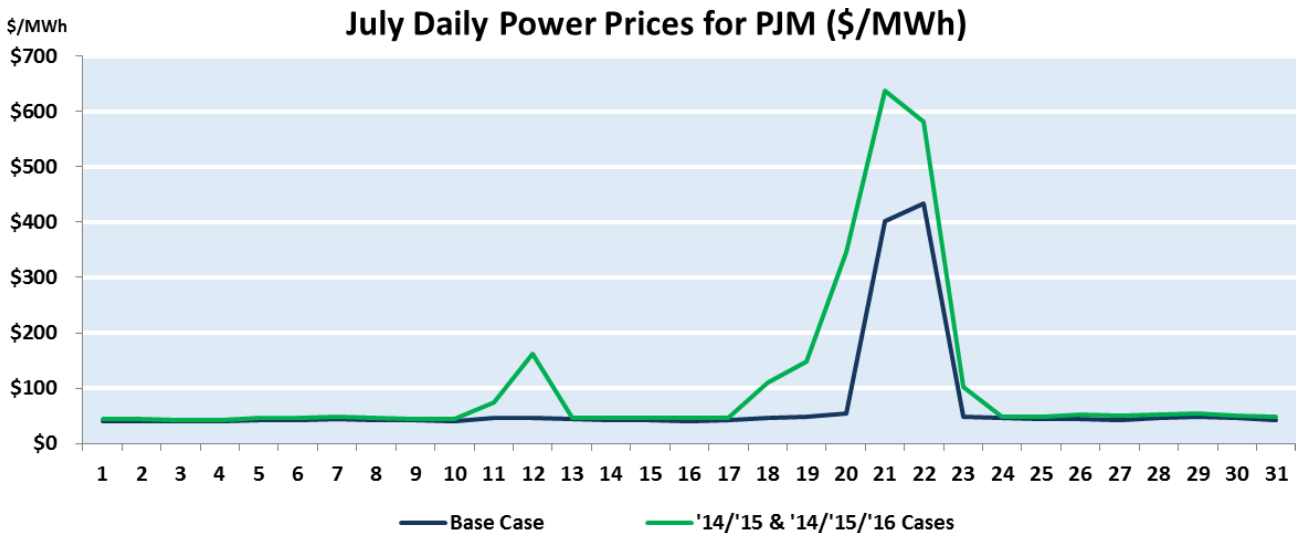
- In the Base Case, the hot summer weather only leads to a capacity shortage on one day in July, but there are several instances where the system gets tight and demand response capacity may be needed.

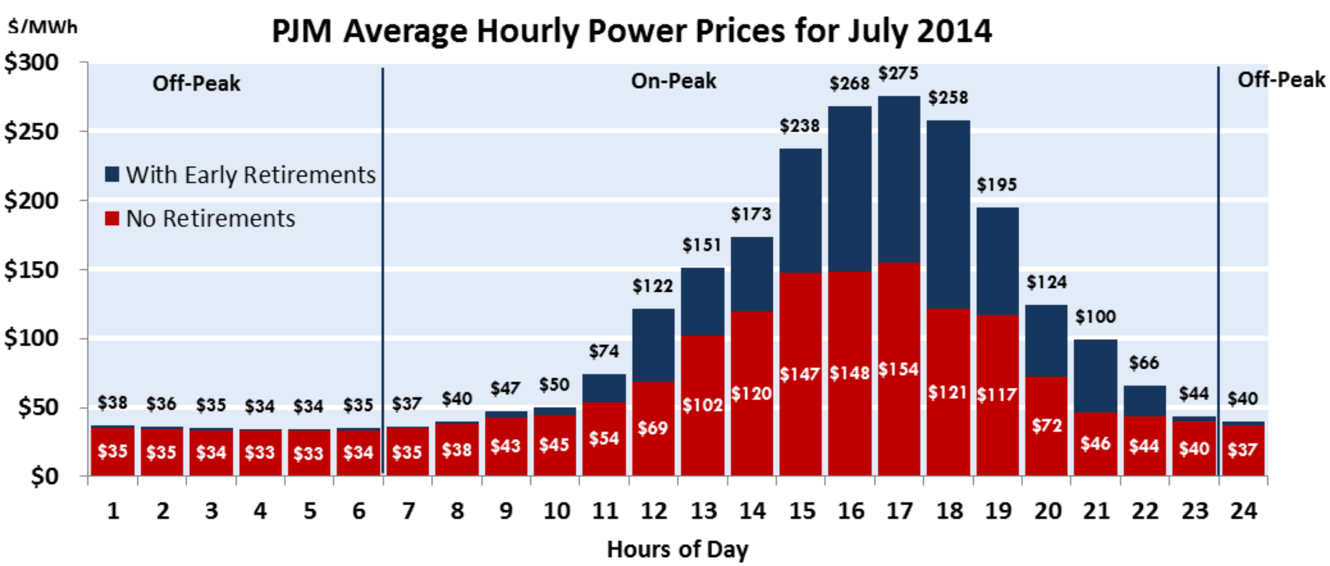
- In Case 1, there are roughly 6 days where demand exceeds capacity, with the bulk of them occurring between July 19 and 22.
  - In one instance, demand exceeds capacity by greater than 10 GW, implying that demand response would likely not be sufficient enough to compensate for the capacity shortage.

- In Case 2, there are roughly 7 days in which demand exceeds capacity and potentially three more where reserves become very tight.

PJM SUMMER ANALYSIS

PJM POWER PRICES





- Tight reserve margins and increased gas generation drove higher power prices in both Case 1 and 2.
  - The price impact was nearly identical between the two cases, so EVA is just showing one line for both of them.
- On an around-the-clock basis, prices increased by an average of 54% in July of 2014 in the retirement cases as higher heat rate units were called upon to meet load in the absence of the retired coal capacity.
- Additional gas demand places upward pressure on gas prices and in turn power prices.
- Peak prices are affected most significantly, where the increase neared 100% in some hours.

DETAILED POWER ANALYSIS OUTLINE

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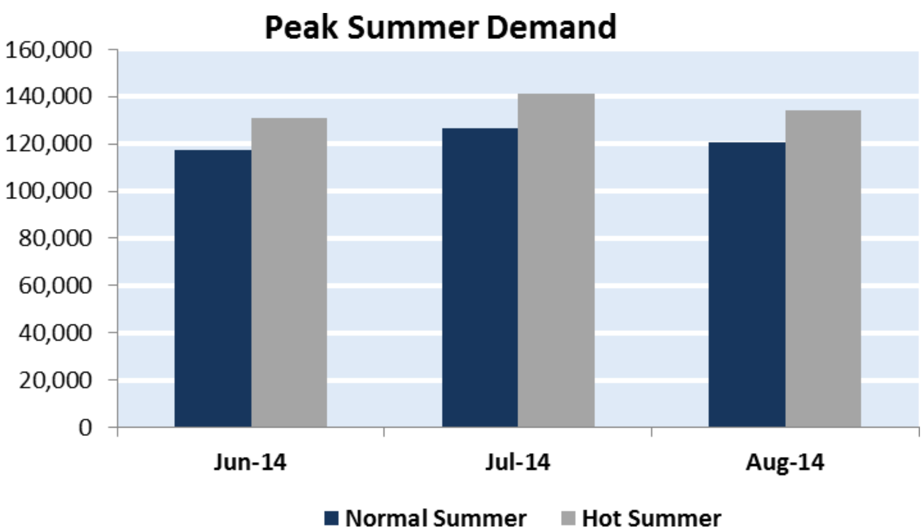
- ISO-NE Summer Analysis

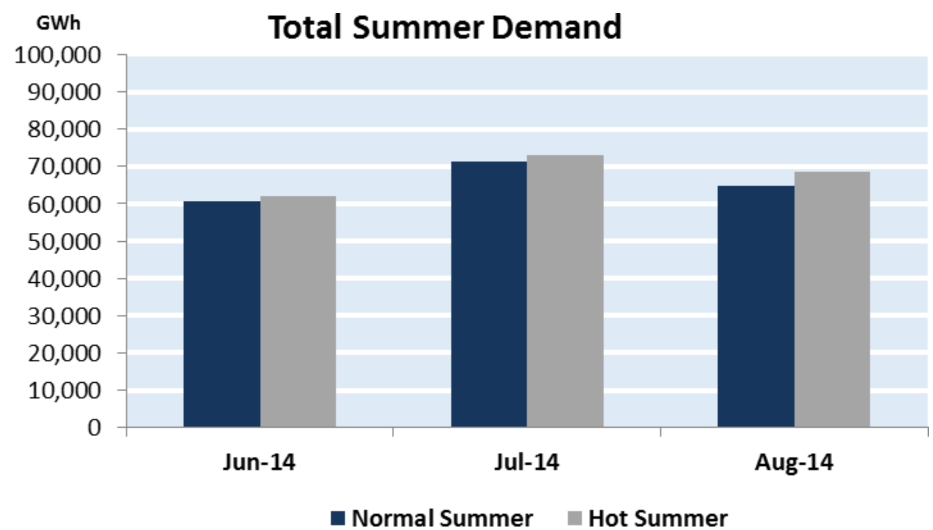
MISO SUMMER ANALYSIS: EFFECTS OF HEAT WAVE ON ELECTRICITY DEMAND

MISO SUMMER DEMAND

- Like the PJM analysis, EVA used 2011 load data to proxy the effects of a hot summer on electricity demand while also adjusting for the absorption of Entergy into the MISO footprint.

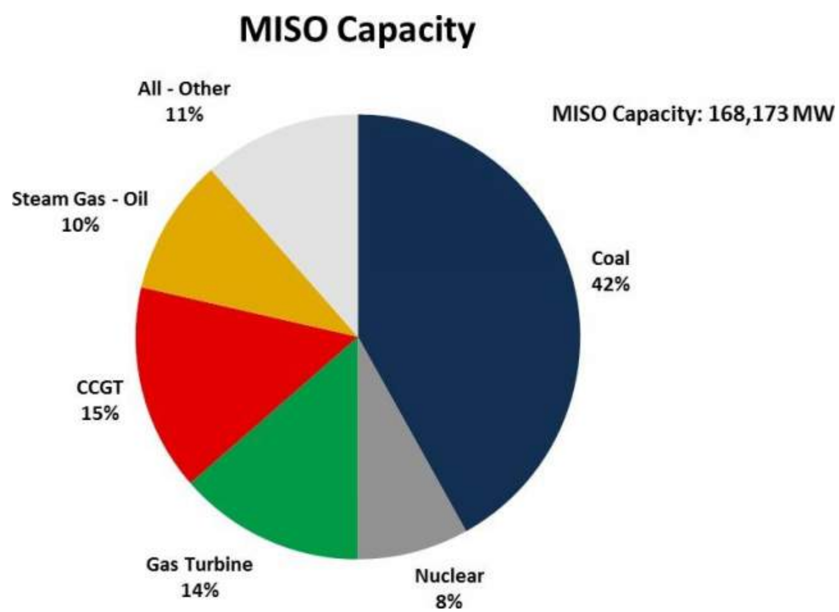
- Compared to EVA's forecast of normal summer demand, the hot summer demand was 3.5% higher on average where as the peak demand was higher by 11%.





MISO SUMMER ANALYSIS: EXISTING SUPPLY DURING SUMMER HEAT WAVE

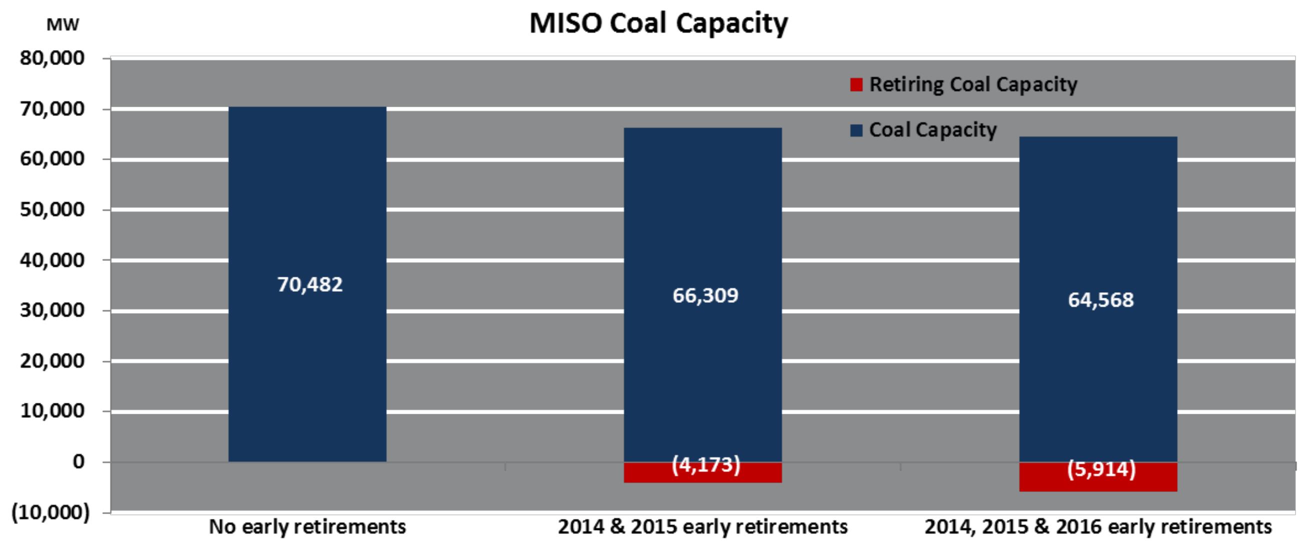
MISO CAPACITY



- MISO also relies heavily on coal to provide system reliability and for producing power – nearly 42% of all MISO capacity is coal-fired.
- CCGTs currently comprise 15% of total capacity though this share is expected to grow steadily as coal retirements mount.
- Like in PJM, coal units are very important for reliability especially in the summer, when MISO's peak demand occurs.

MISO SUMMER ANALYSIS: TESTING SYSTEM RELIABILITY WITH EARLY RETIREMENTS

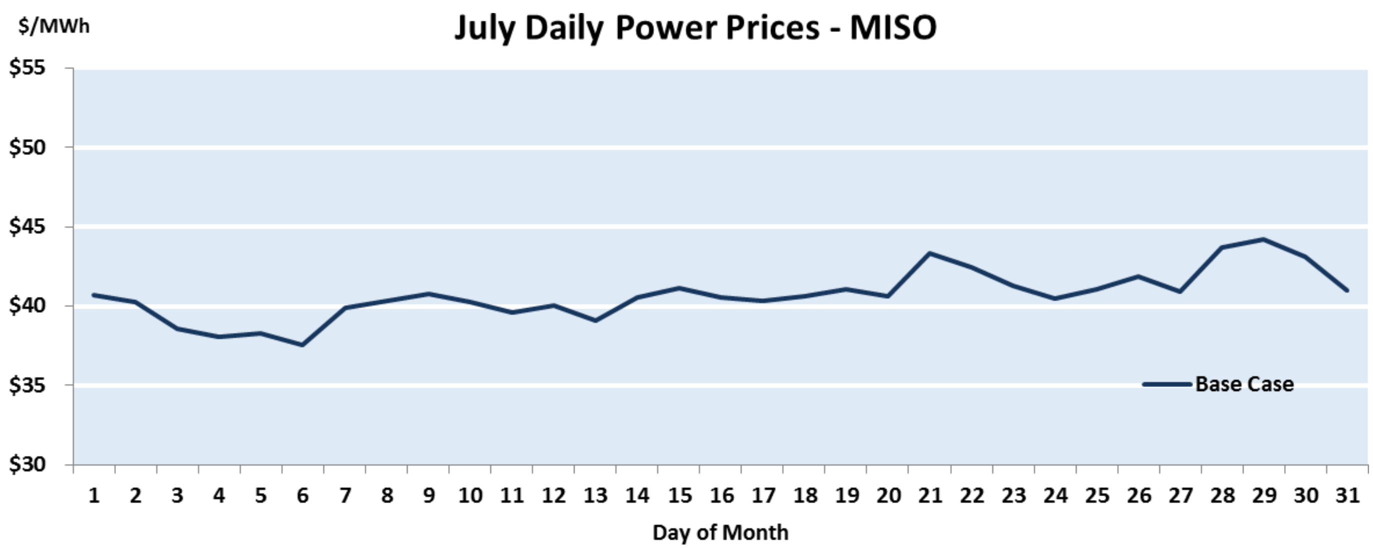
MISO CAPACITY OUTLOOK



- Of the 70,000 MW of coal capacity in MISO, close to 4,000 MW is schedule o retire by the end of 2015 with an additional 1,800 MW by the end of 2016.
- EVA sought to determine the impact of:
  - Extreme summer weather resulting in high power demand
  - The loss of coal capacity
- On MISO reliability and prices by simulating an environment where these units were pulled from the market prior to the winter of 2014.

MISO SUMMER ANALYSIS

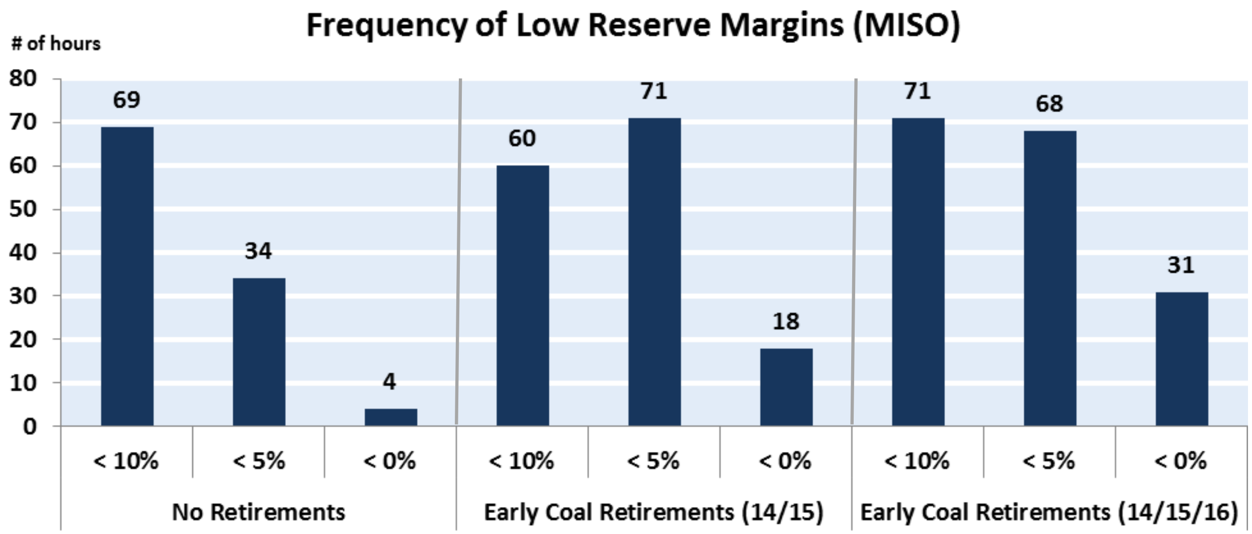
MISO POWER PRICES



- EVA incorporated all of the market data into its modeling and developed the Base Case power prices to the left
- The power prices remained relatively consistent throughout the month of July in the Base Case.

MISO SUMMER ANALYSIS

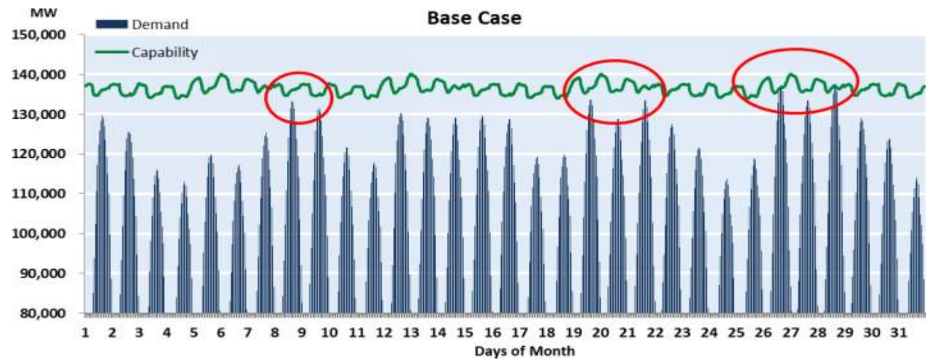
POTENTIAL SUMMER CAPACITY SHORTAGES DUE TO EARLY COAL RETIREMENTS – MISO

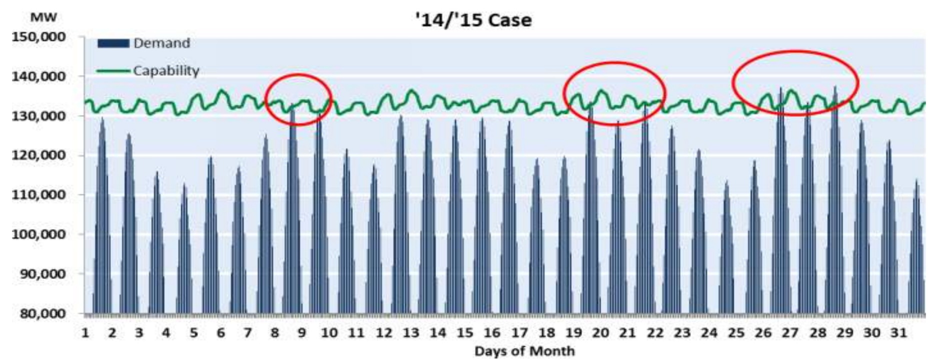


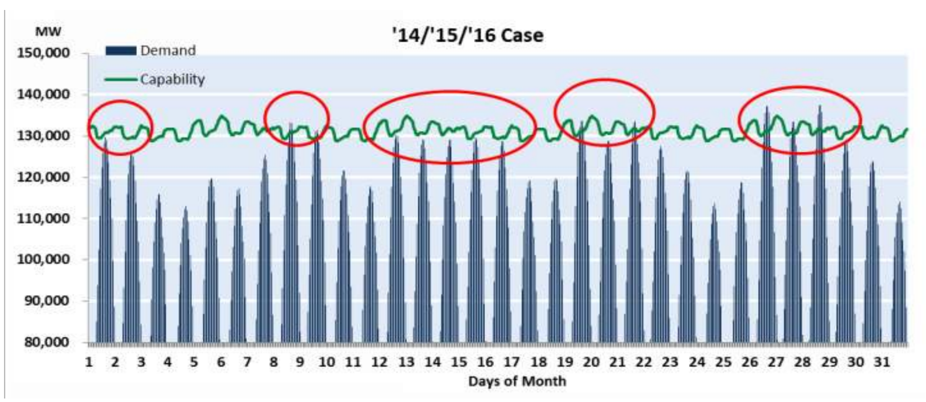
- To gauge the impact of these coal retirements during a warmer than normal summer period, EVA created a high demand scenario based upon historical data during peak summer months
- In MISO, 31 hours were found to have reserve margins below 0% based on installed capacity, while 68 hours had reserve margins below 5%
- For the '14/'15 Case, 18 hours were found to be below 0% and 71 hours below 5% reserve margin resulting in potential reliability issues.

MISO SUMMER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

MISO RELIABILITY ANALYSIS FOR JULY



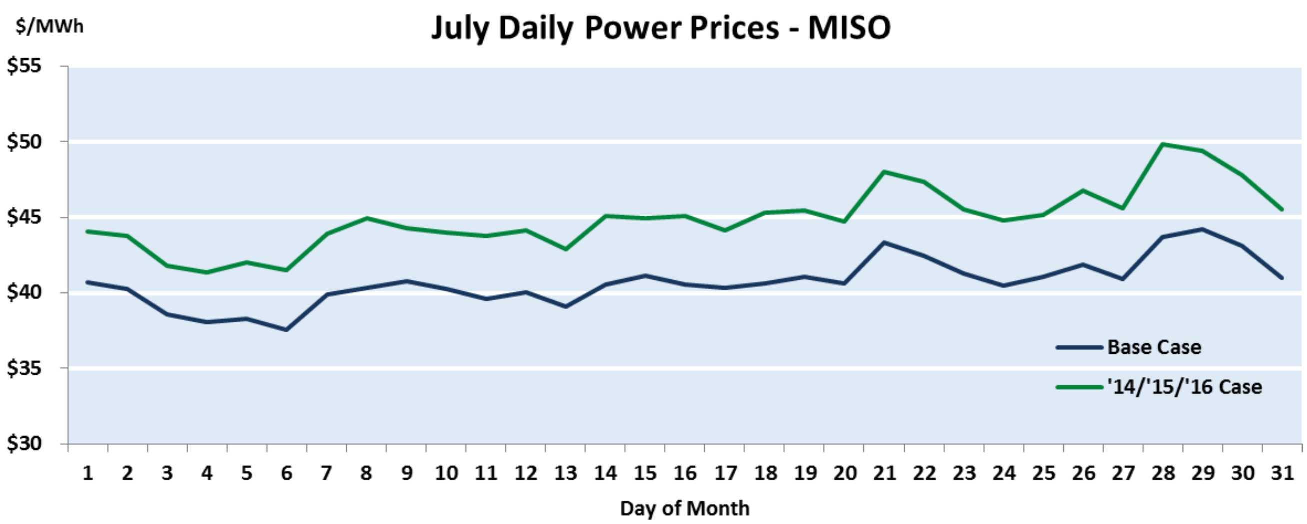


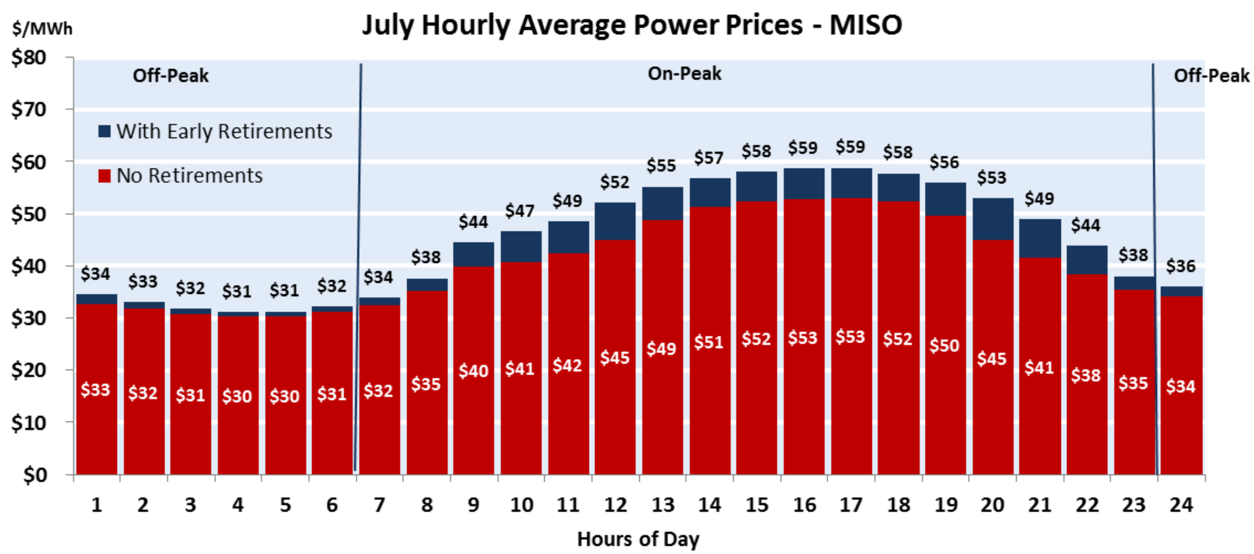


- In the Base Case, the hot summer weather only leads to a capacity shortage on two days in July, but there are several instances where the system gets tight and demand response capacity may be needed.
- In Case 1, there are roughly 7 days where demand exceeds capacity, with the bulk of them occurring between July 19-22 and 26-29 time period.
- In Case 2, there are roughly 7 days in which demand exceeds capacity and potentially 8 more days where reserves become very tight.

MISO SUMMER ANALYSIS

MISO POWER PRICES





- Being a coal-heavy region like PJM, MISO is expected to be as adversely affected by coal retirements as its neighbor to the East in terms of reliability.
- However, the power prices are not affected much largely due to the availability of gas resources to provide for the lost base load generation.
- In the '14/'15 Case, July prices climbed an average of 9% overall and 10% at peak hours.
- The impact was only slightly greater in the '14/'15/'16 Case.

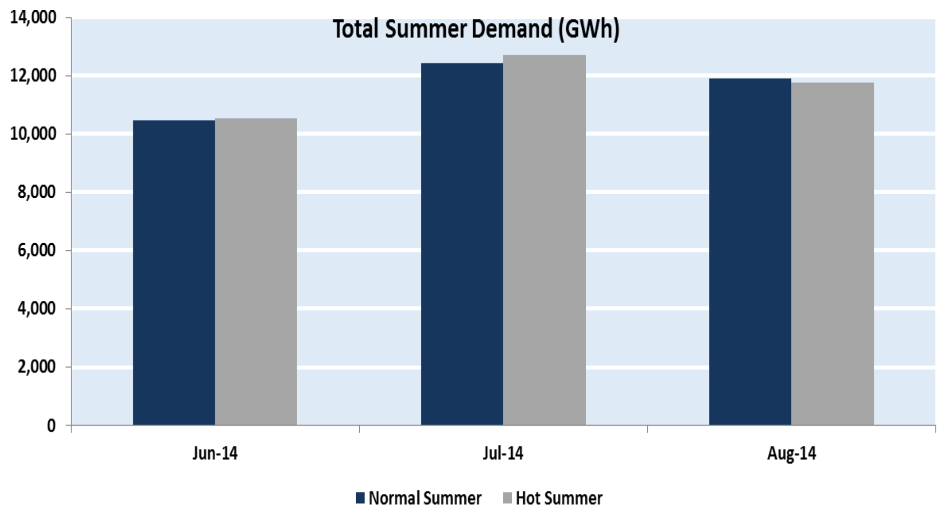
DETAILED POWER ANALYSIS OUTLINE

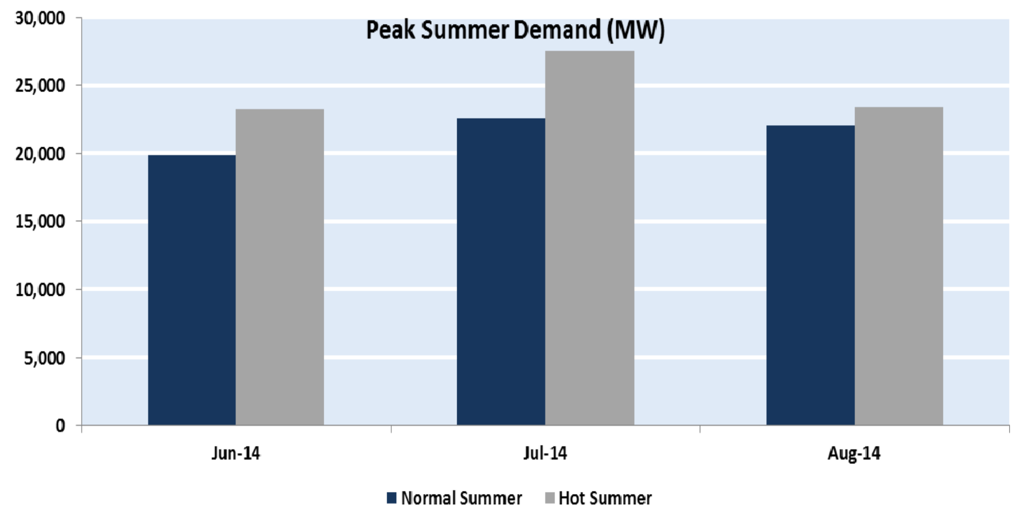
- PJM Winter Analysis
- MISO Winter Analysis
- ISO-NE Winter Analysis
- PJM Summer Analysis
- MISO Summer Analysis
- ISO-NE Summer Analysis

ISO-NE SUMMER ANALYSIS: EFFECTS OF HEAT WAVE ON ELECTRICITY DEMAND

ISO-NE SUMMER DEMAND

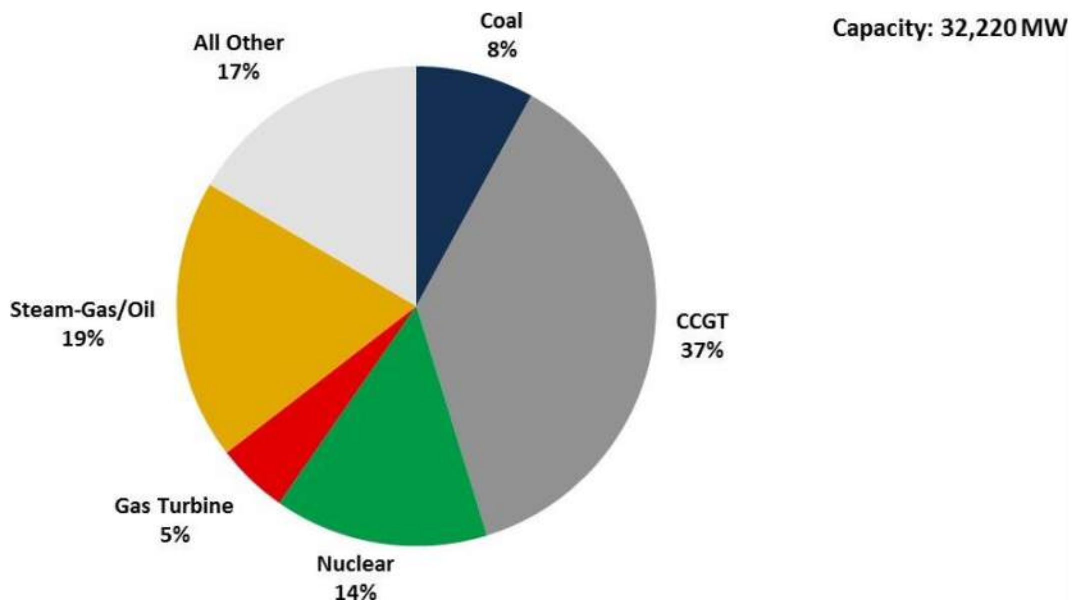
- Only 8% of ISO-NE's capacity is coal-fired – by far the smallest of the three markets EVA analyzed.
- At first glance, it does not appear that the existing coal capacity is important to reliability, but EVA realized that because of the especially unpredictable nature of gas availability in the region, having a diverse supply is vital to maintaining the system in the winter.
- MATS regulations have a very limited effect on the supply in ISO-NE.





ISO-NE SUMMER ANALYSIS: EXISTING SUPPLY DURING SUMMER HEAT WAVE

ISO-NE CAPACITY



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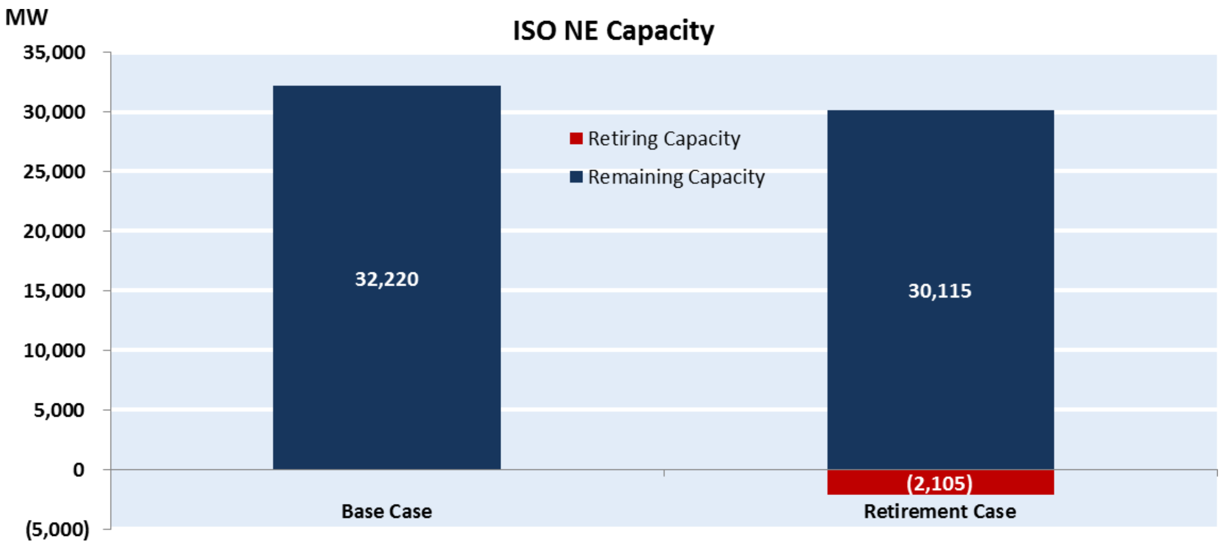
ISO-NE SUMMER ANALYSIS: TESTING SYSTEM RELIABILITY WITH EARLY RETIREMENTS

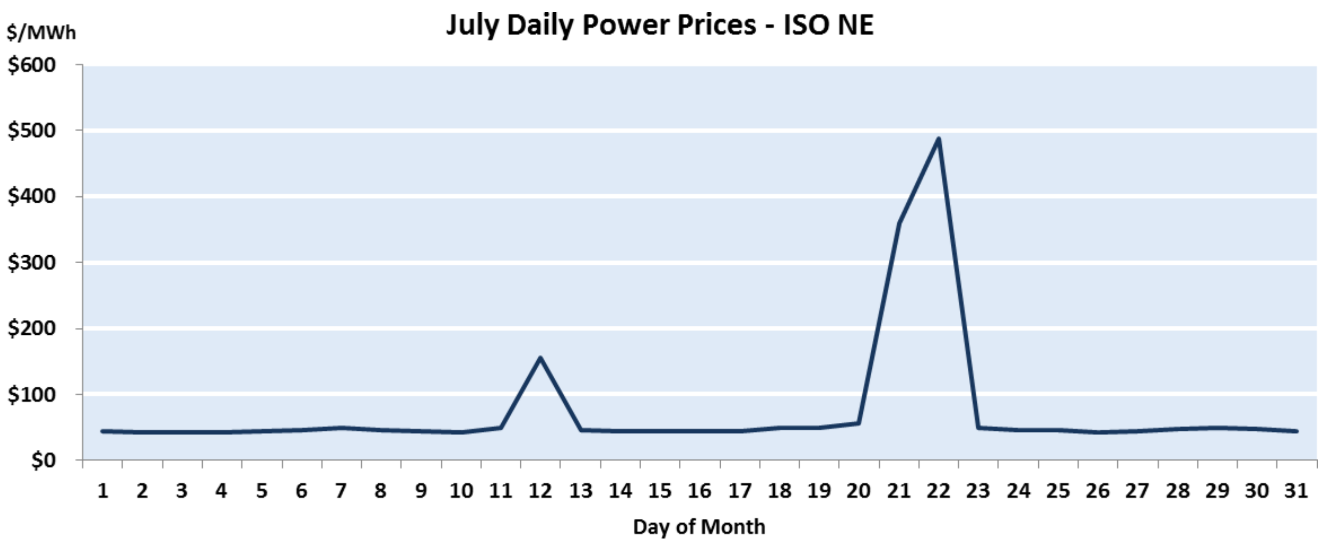
ISO-NE CAPACITY



- Of the 2,600 MW of coal capacity in ISO-NE, EVA assumed that 2,100 MW had left the market prior to the winter of 2014 in Cases 1 and 2.
- Because gas is scarce in New England in the winter, EVA sought to determine the reliability and price impact on the region under the three Cases.

ISO-NE SUMMER ANALYSIS

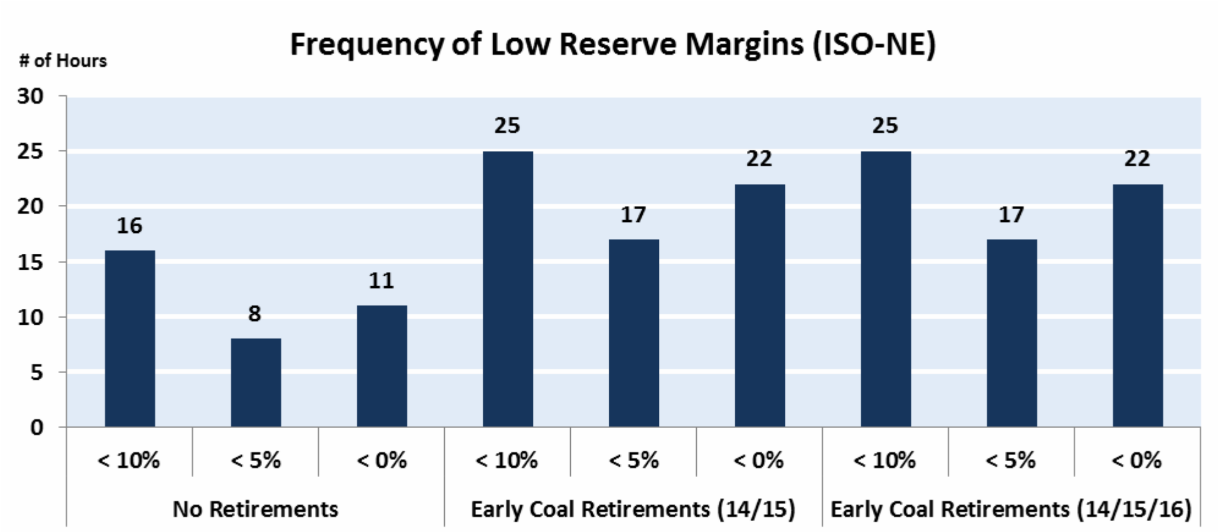
ISO-NE POWER PRICES



- EVA incorporated all of the market data into its modeling and developed the Base Case power prices to the left
- One specific heat wave led to elevated prices around July 20-22, but they remained fairly tempered for the remainder of the month in the Base Case.
- The prices also spiked around 12th of July due to high demand.

ISO-NE SUMMER ANALYSIS

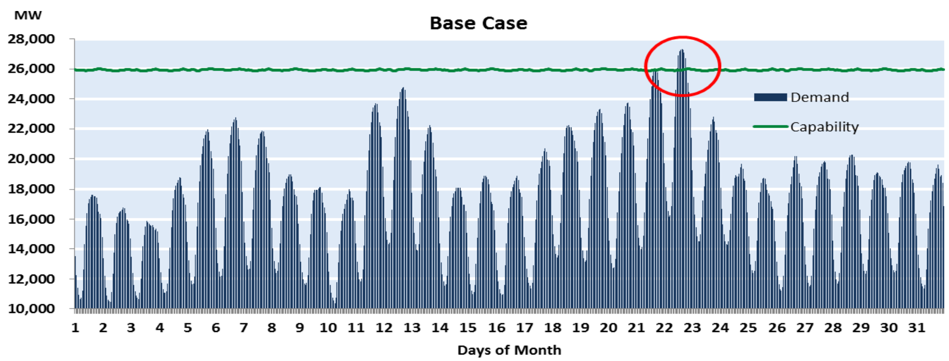
POTENTIAL SUMMER BLACKOUTS DUE TO EARLY COAL RETIREMENTS

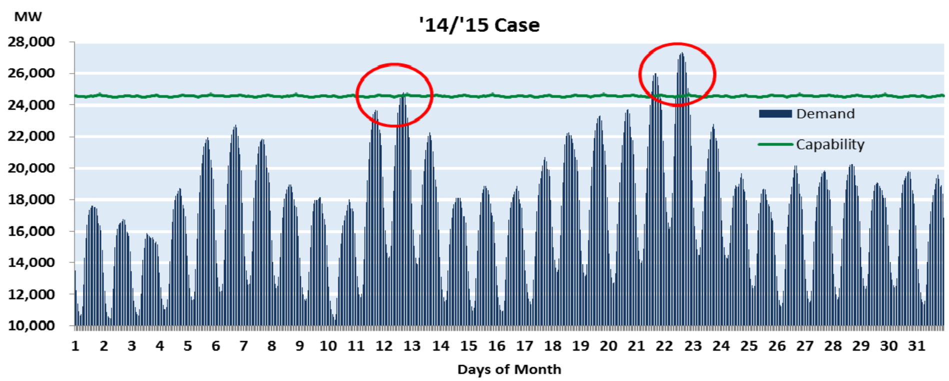


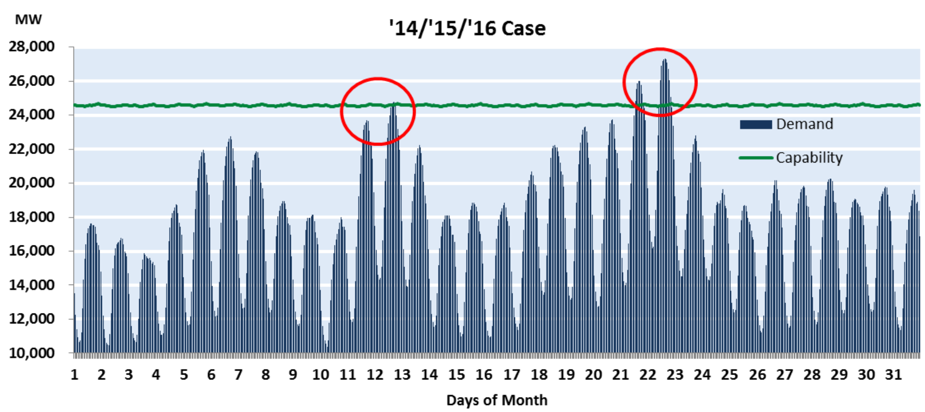
- To gauge the impact of these coal retirements during a warmer than normal summer period, EVA created a high demand scenario based upon historical data during peak summer months
- In ISO-NE, for the '14/'15 as well as the '14/'15/'16 Case, 22 hours were found to have reserve margins below 0% based on installed capacity, while 17 hours had reserve margins below 5%

ISO-NE SUMMER ANALYSIS: TIMING OF POTENTIAL CAPACITY SHORTAGES

ISO-NE RELIABILITY ANALYSIS FOR JULY



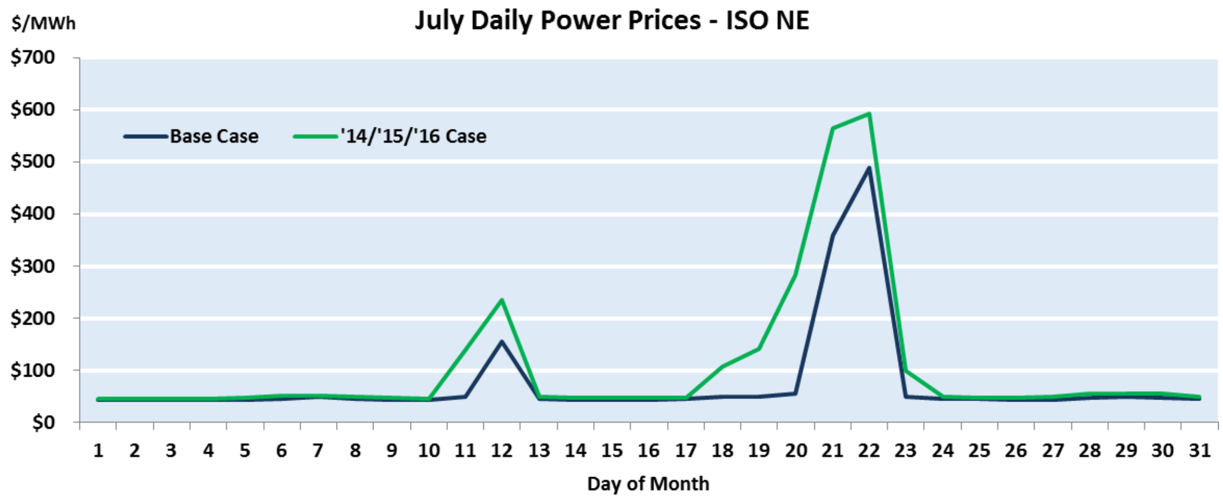


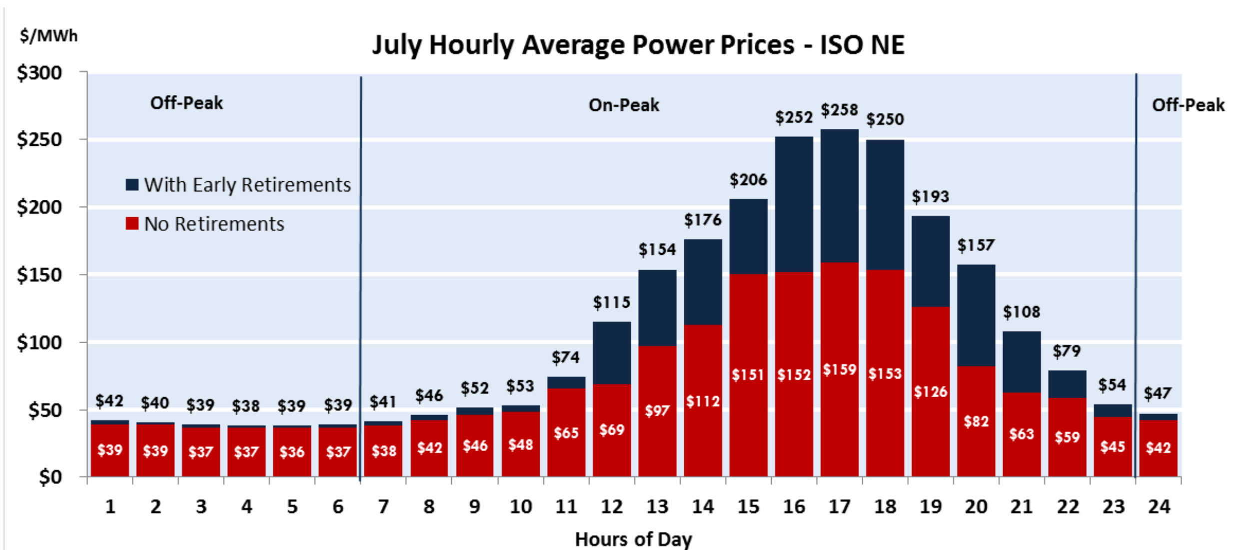


- In the Base Case, the hot summer weather only leads to a capacity shortage on two day in July, but there are several instances where the system gets tight and demand response capacity may be needed.
- In Case 1, there are roughly three days where demand exceeds capacity, with the bulk of them occurring between July 19 and 22.
- In Case 2 as well, there are roughly 7 days in which demand exceeds capacity and potentially two more where reserves become very tight.

ISO-NE SUMMER ANALYSIS

ISO-NE POWER PRICES





- The prices in the Base case are driven up due to the high demand during the hot summer. With summer peaks approaching the available capacity in New England, the power prices are dictated by the high cost marginal resources in the region.
- In the '14/'15/'16 Case, prices averaged 44% higher than in the Base Case, as gas demand and prices are further increased.
- EVA did not assume any constrained gas-fired capacity in ISO-NE for the summer scenarios.
- During this period, ISO-NE daily average prices went as high as $600/MWh.

OUTLINE

- Problem Statement
- Methodology
- Impact of Early Coal Retirements in Winter
- Impact of Early Coal Retirements in Summer
- Detailed Gas Analysis
- Detailed Power Analysis
- **Conclusions**
- Appendix

CONCLUSIONS

POWER MARKET CONCLUSIONS

- Potential capacity shortages in PJM and ISO-NE during winter due to the early coal retirements.
- Potential capacity shortages in PJM, MISO and ISO-NE during a hot summer due to high demand and early coal retirements.
- High wholesale power prices during both winter and summer months resulting in a potential addition of $35 billion to the energy costs of consumers in 2014.

CONCLUSIONS

NATURAL GAS MARKET CONCLUSIONS

- Without projected retirements gas industry already at a precipice.
  - Pipelines, LDCs and storage operators restrict supplies to non-firm customers.
  - Gas-fired generating capacity lost in several regions due to curtailment of gas supplies.
  - Near record low storage inventories at the end of winter leave industry with a challenge to refill storage to adequate levels.

- With projected retirements
  - Winter
    - Records for demand, storage withdrawals and prices would have been reset to higher levels.
    - Additional pipeline, LDC, and storage operator curtailments likely would have occurred.
      - More power plants likely would have had gas supplies curtailed.
    - Inadequate pipeline capacity in NEPOOL.
      - Alternatives for either increased oil-fired generation or imported power would have been unlikely.
      - Remaining alternative is to curtail electricity demand.
  - Summer
    - Storage levels at the start of next winter (Nov 1, 2014) at unprecedented low levels and likely inadequate, except in the case of a mild winter.
    - Higher gas prices on a sustained basis.

- Total cost to consumers for all sectors for 2014 is approximately $70 billion, and for the period 2014-2016 is $100 billion.

OUTLINE

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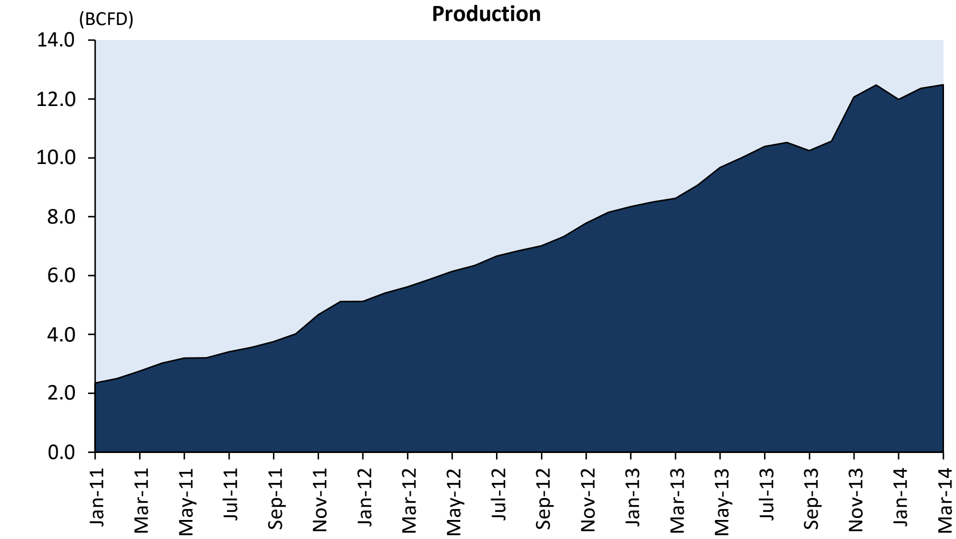
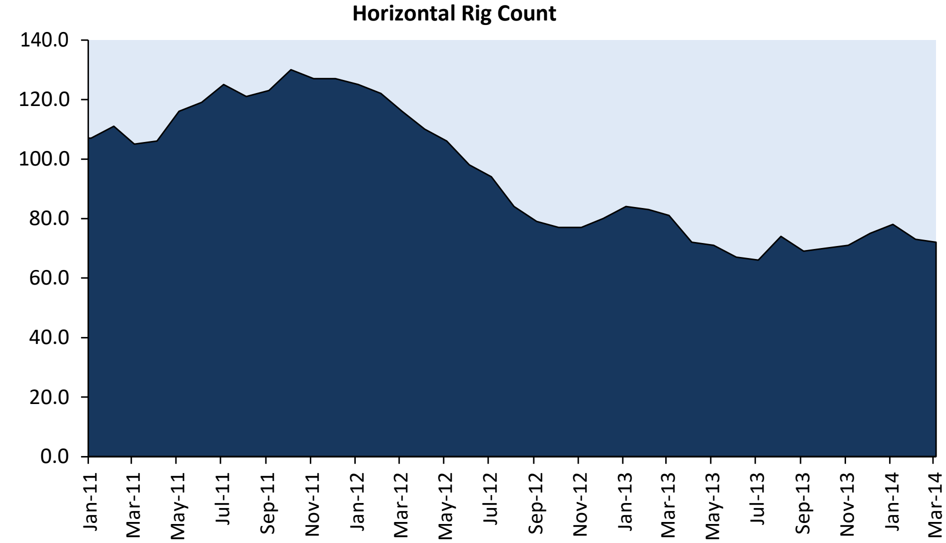
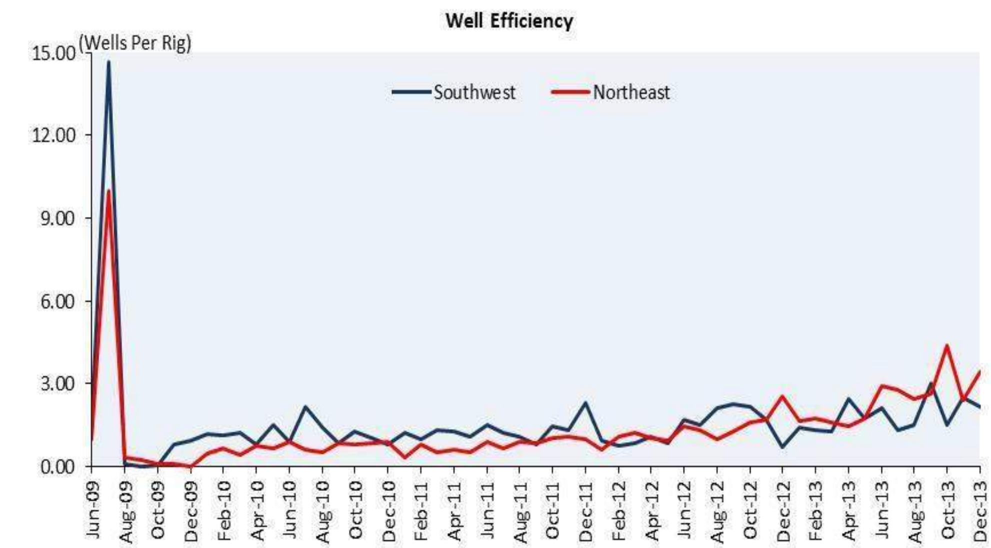
MARCELLUS SHALE PROFILE



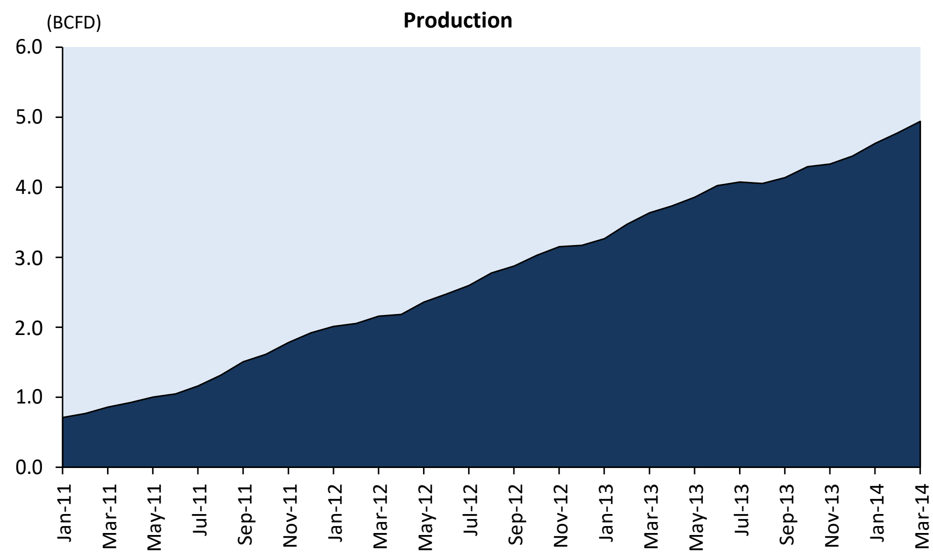


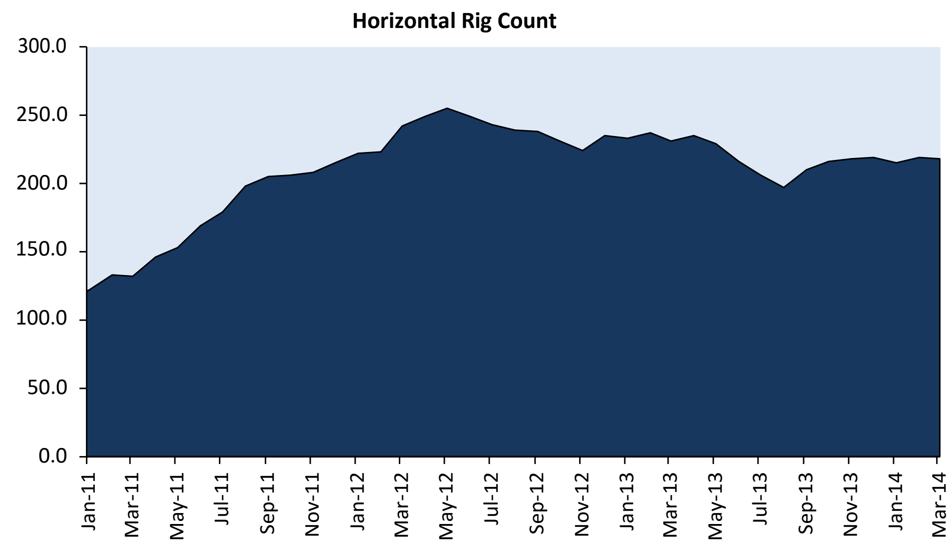


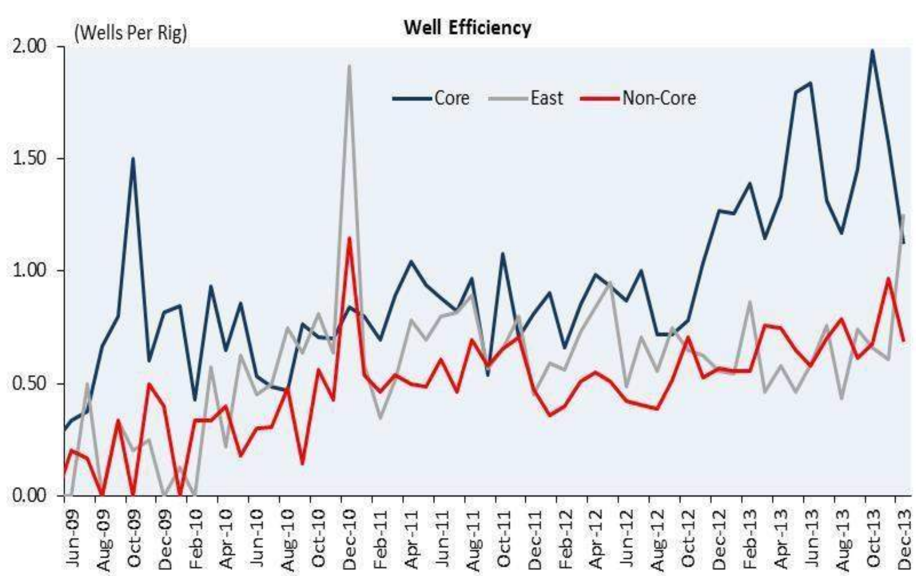
Source: Lippman Consulting

While the growth rate in Marcellus production levels has started to decline, it is still on a growth trajectory, albeit a modest one. For example, when the November 2013 event is excluded Marcellus production over the last nine months has increased only 10%. This decline in the growth rate primarily is due to the decline in drilling activity, as the rig count has declined about 45 percent from prior peak levels. Interestingly, most of the increase in Marcellus production in 2013 is from the dry gas segment of the Marcellus play in northeastern Pennsylvania (+2.1 BCFD), rather than the much discussed wet gas segment in southwestern Pennsylvania and northern West Virginia (1.4 BCFD).

EAGLE FORD SHALE PROFILE

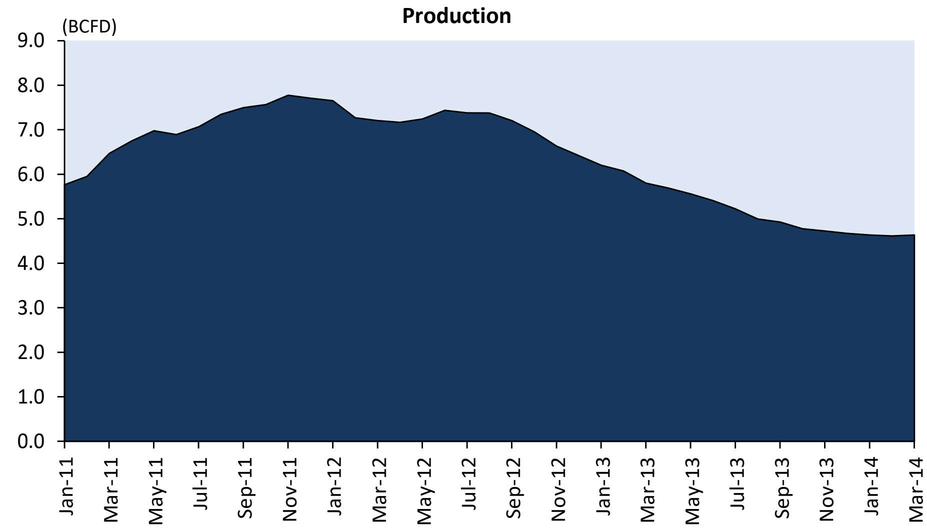


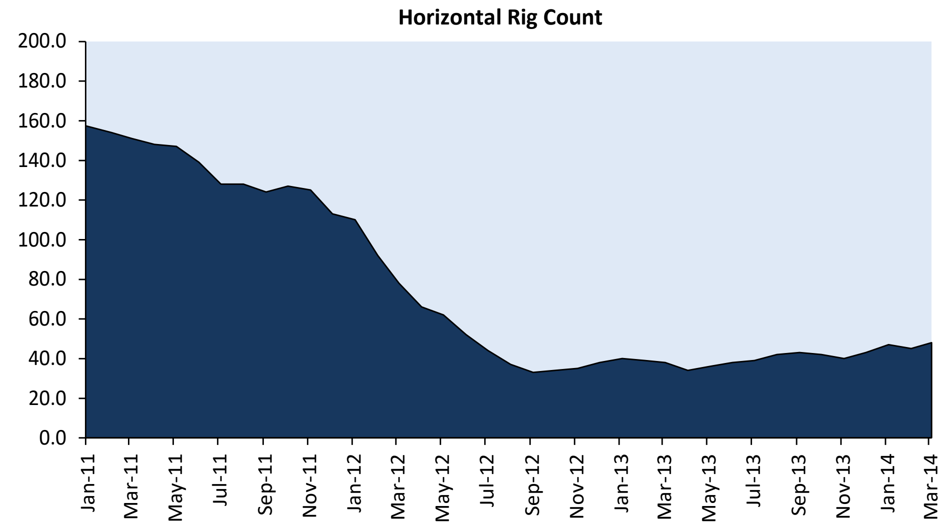


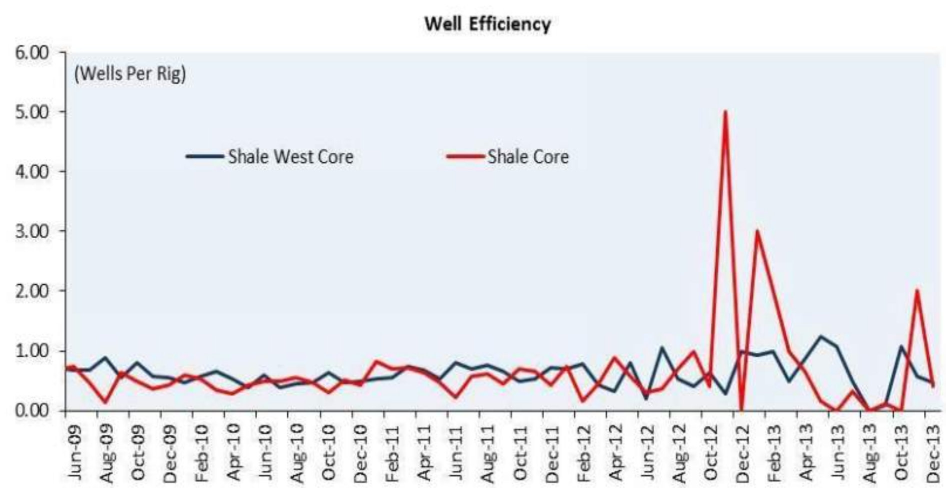


Eagle Ford gas production continues to increase, as does oil production from the Eagle Ford play (i.e., in 2013 Eagle Ford oil production nearly doubled to 1.1 MMBD). As indicated, while drilling activity is slightly below prior peak levels, overall drilling activity in the play remains strong, with approximately 218 horizontal rigs currently active in the play. For 2013 about 75 percent of the 1.5 BCFD increase in Eagle Ford production was produced form the core area of the play, which is oil prone. Complementing this increase in associated gas was a 0.4 BCFD increase from the non-core area, which for the most part has a significant NGL component. Well economics for the latter, because of the liquids credit, can be viable at $1.00 per MMBTU gas prices.

HAYNESVILLE SHALE PROFILE

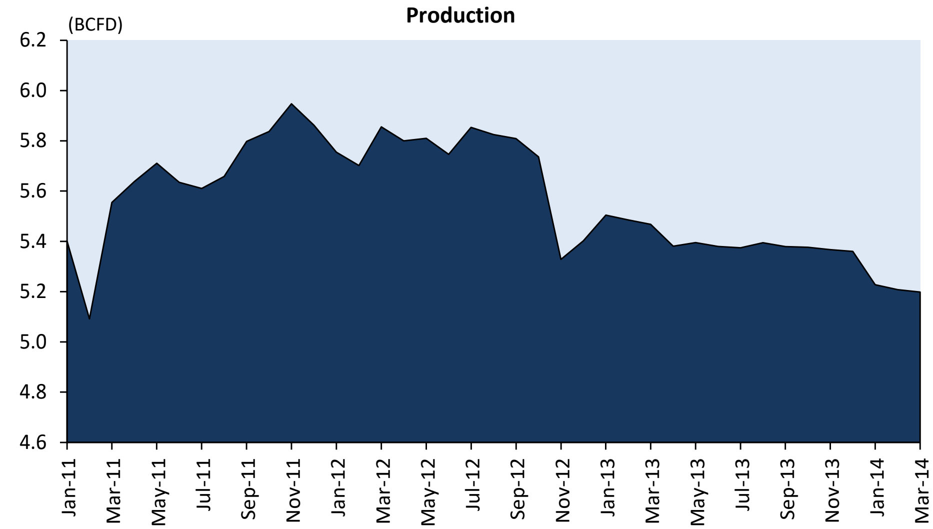


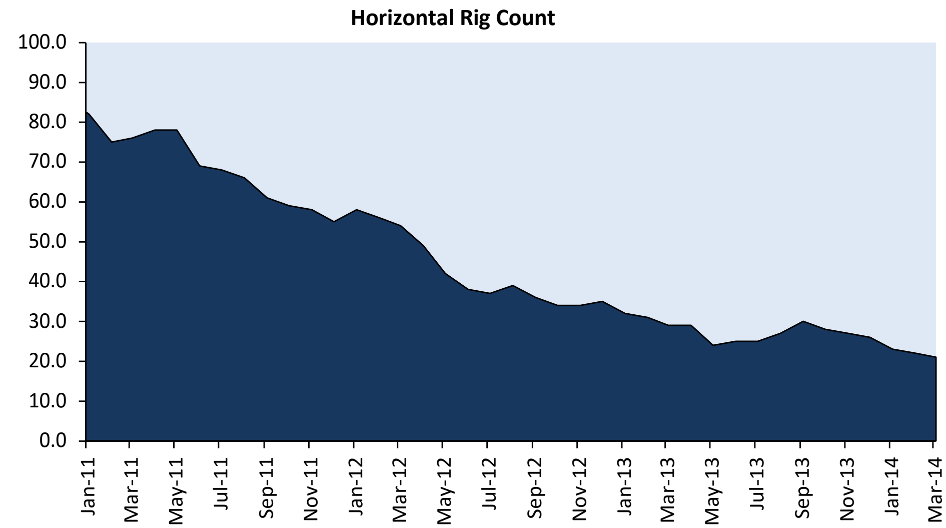


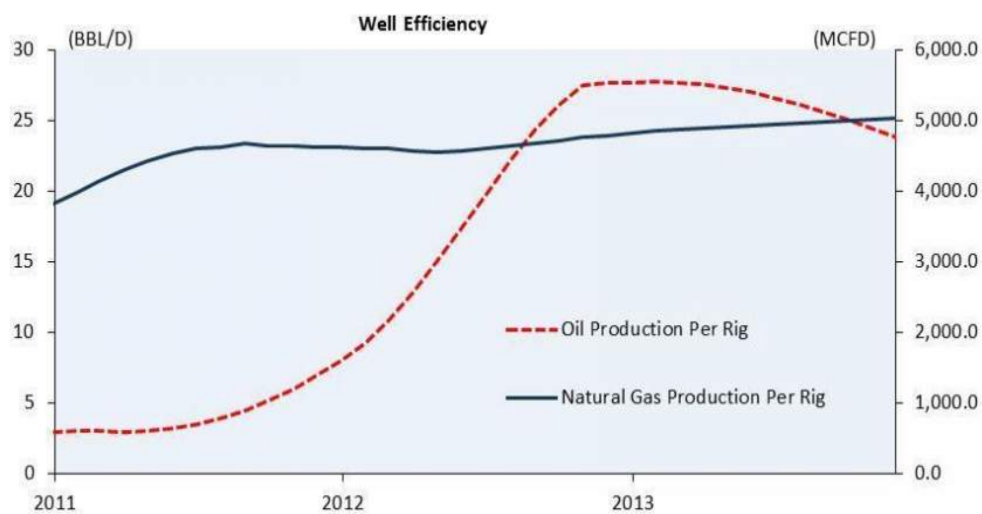


The Haynesville shale play, which is a dry gas play, on average declined about 1.5 BCFD in 2013, with year end production levels being 3.1 BCFD below prior peak levels. This decline is the net result of the decline in drilling activity, as the current horizontal rig count for the play (i.e., 48 rigs) is about 140 rigs below prior peak levels. While parts of the play appear economic at sub -$4.00 per MMBTU gas prices, sustained gas prices at just above $5.00 per MMBTU are required to attain a 40% ROR in core areas, which would be required to compete with oil projects.

BARNETT SHALE PROFILE

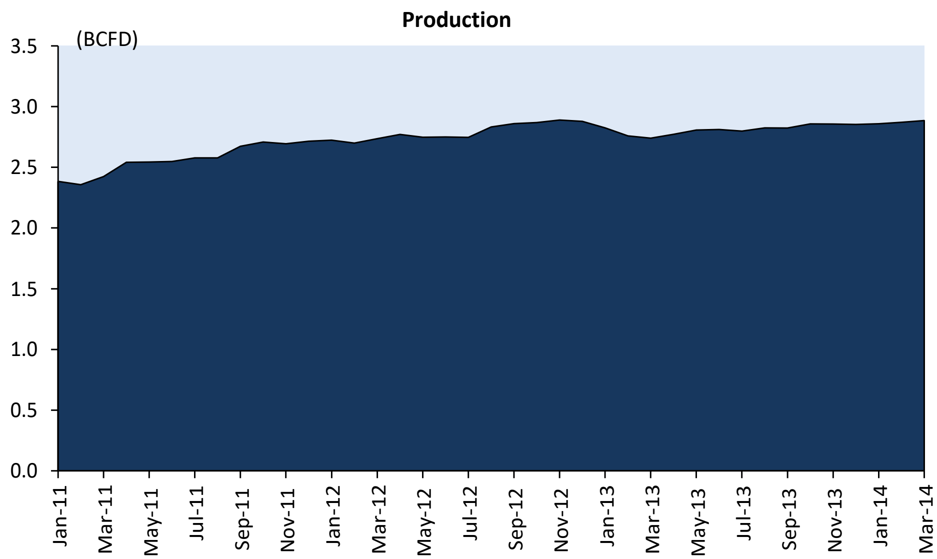


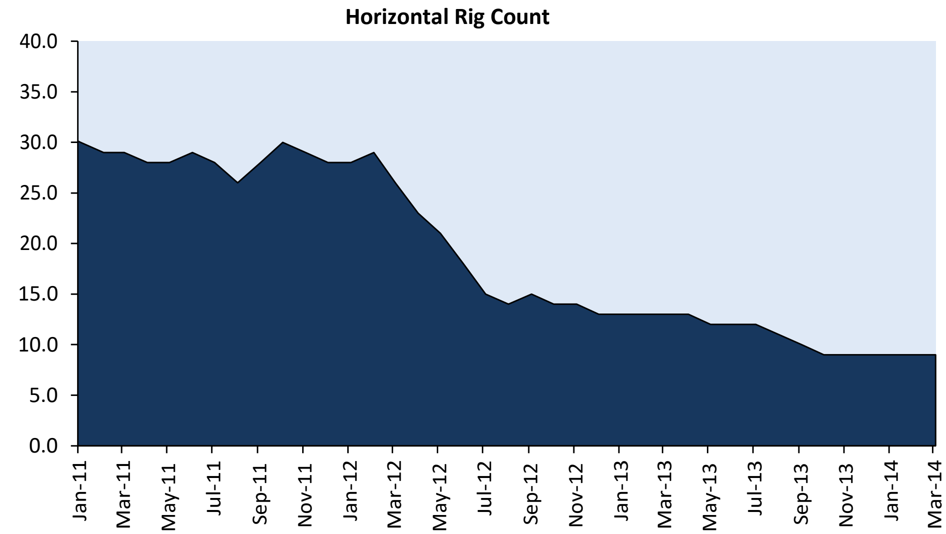


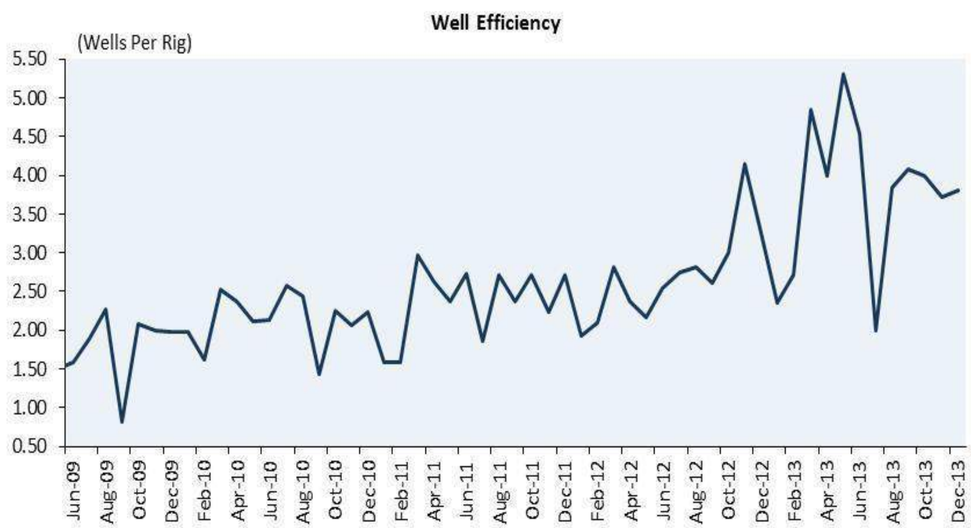


Production from the Barnett shale play, which is the most mature of the seven major shale plays, declined 0.4 BCFD in 2013, with almost all of this decline occurring in the mature core area of the play. Drilling activity for the play has been in steady decline for the last six months, despite the attractiveness of the Barnett Combo play, which has a significant liquids component. Expect drilling activity to continue to decline until gas prices on a sustained level reach $5.00 per MMBTU.

FAYETTEVILLE SHALE PROFILE

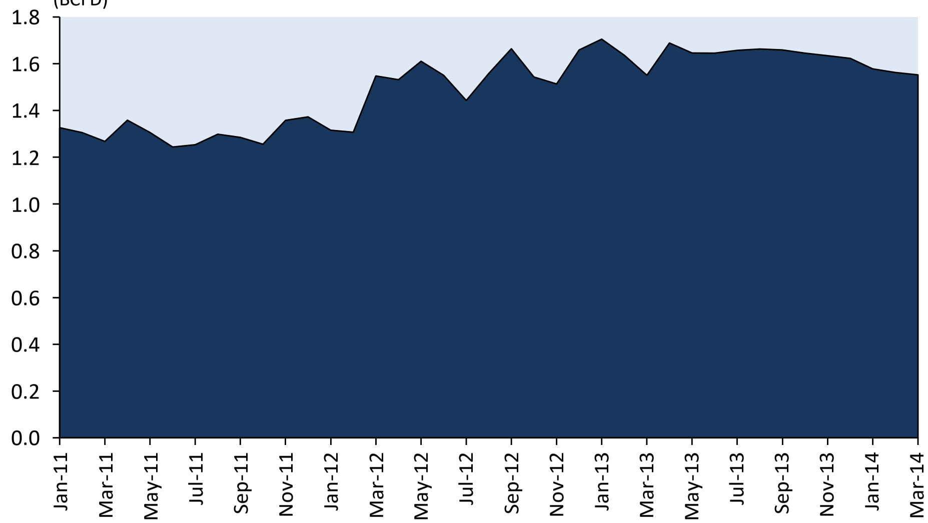


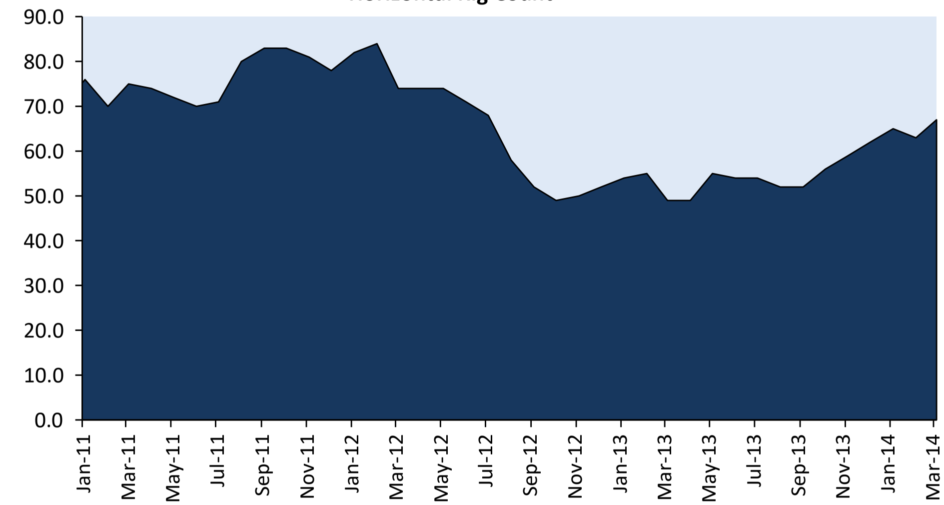




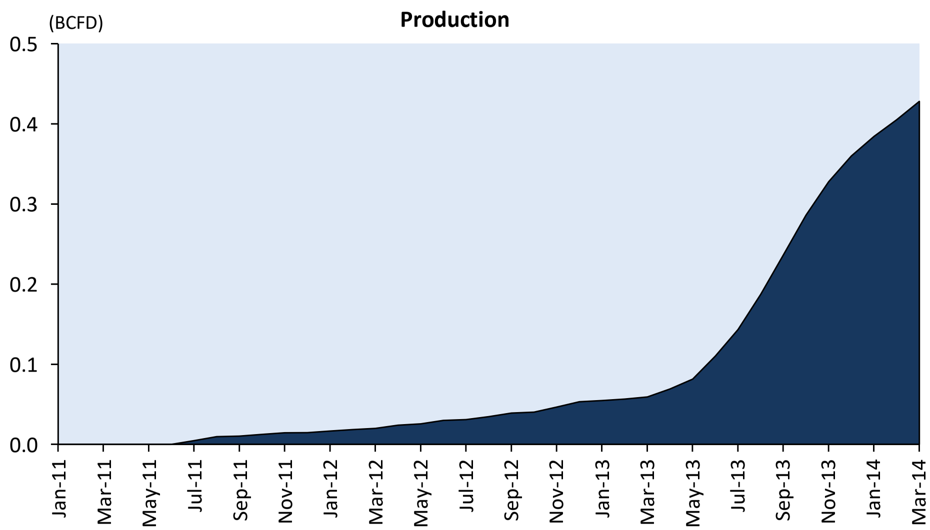
Fayetteville production basically has been flat for the last year, despite the success of the industry leader, Southwestern Energy, in improving well economics. Drilling activity has been in a steady decline for twp years and currently is at only nine rigs.

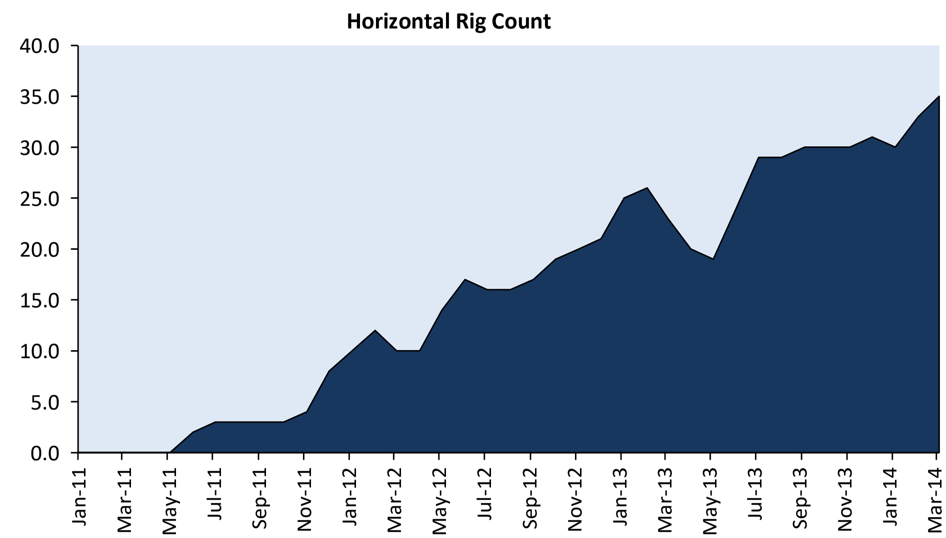
WOODFORD SHALE PROFILE





UTICA SHALE PROFILE





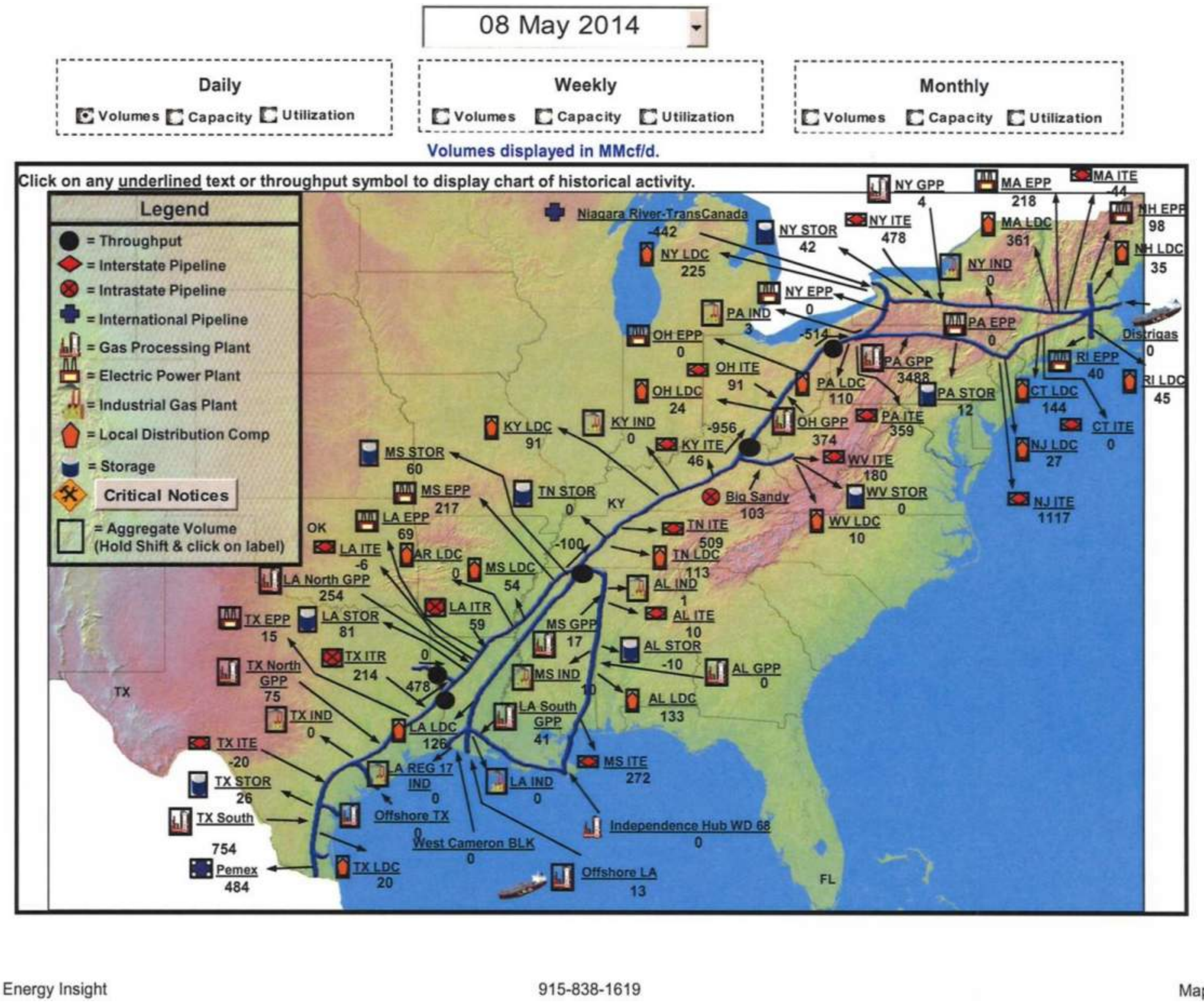
IPP OWNED GAS UNITS IN ISO-NE

GAS-FIRED UNITS IN ISO-NE THAT LIKELY WOULD HAVE GAS SUPPLIES CURTAILED

Zone	ID	Name	Capacity (M	Primary_Fuel	Owner
isoNE-Boston	1595-CCGT	Kendall Square Station	217.4	EVA GAS:Algonquin	IPP CHP
isoNE-ConnSouthwest	55149-CCGT	Lake Road Generating Plant	795.0	EVA GAS:Algonquin	IPP Non-CHP
isoNE-Boston	1588-CCGT	Mystic Generating Station	1550.5	EVA GAS:Algonquin	IPP Non-CHP
isoNE-Boston	54586-CCGT	L'Energia Energy Center	74.0	EVA GAS:Algonquin	IPP Non-CHP
isoNE-ConnCentral	56798-CCGT	Kleen Energy Systems Project	622.5	EVA GAS:Algonquin	IPP Non-CHP
isoNE-Boston	1588-7-GSTM	Mystic Generating Station	581.7	EVA GAS:Algonquin	IPP Non-CHP
isoNE-Boston	55999-GEN1-PEAK	NECCO Co-Generation	2.9	EVA GAS:Algonquin	IPP CHP
isoNE-Boston	55999-GEN2-PEAK	NECCO Co-Generation	2.9	EVA GAS:Algonquin	IPP CHP
isoNE-MassWest	1642-GT-1-GTRB	NAEA Energy Massachusetts LLC	42.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassWest	1642-GT-2-GTRB	NAEA Energy Massachusetts LLC	42.7	EVA GAS:Algonquin	IPP Non-CHP
isoNE-ConnCentral	57068-12-GTRB	Middletown Peaking	48.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-ConnCentral	57068-13-GTRB	Middletown Peaking	48.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-ConnCentral	57068-14-GTRB	Middletown Peaking	48.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-ConnCentral	57068-15-GTRB	Middletown Peaking	48.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassSoutheast	52026-CCGT	Dartmouth Power Associates	65.0	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassSoutheast	55026-CCGT	Dighton Power Plant	169.8	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassSoutheast	55048-CCGT	Tiverton Power Plant	267.3	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassSoutheast	55317-CCGT	Fore River Generating Station	762.5	EVA GAS:Algonquin	IPP Non-CHP
isoNE-MassSoutheast	52026-GEN3-GTRB	Dartmouth Power Associates	22.0	EVA GAS:Algonquin	IPP Non-CHP

ALGONQUIN GAS TRANSMISSION COMPANY

TENNESSEE GAS PIPELINE



A N A L Y S I S A N D P R E S E N T A T I O N B Y

Aqeel Adenwala

Thomas Hewson

Rupert R. Jennings

Benjamin Stravinsky

Stephen L. Thumb

Energy Ventures Analysis
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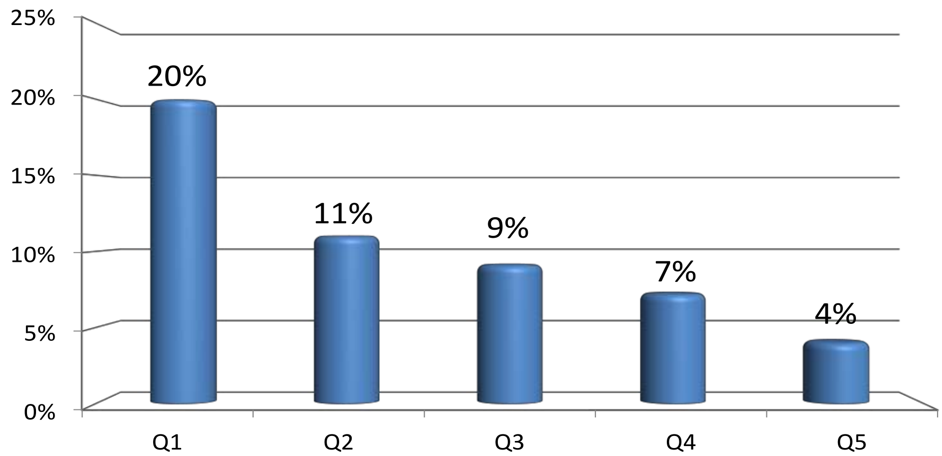
Appendix B

AMERICAN COALITION FOR CLEAN COAL ELECTRICITY

Energy Expenditures by American Families

Energy costs consume one-fifth of the after-tax incomes of America's poorest families, the 26 million households in the lowest income quintile. Increased costs for residential electricity have a more regressive impact on lower-income consumers than cost increases for other basic household necessities including food, gasoline, housing, clothing, and health care.

Energy Expenditures as Percentage of Household After-Tax Income, by Income Quintile



Source: Bureau of Labor Statistics, 2015 Consumer Expenditure Survey (August 2016). Includes electricity, natural gas, other household fuels, and motor gasoline.

November 2016

Executive Summary

This report examines patterns of consumer expenditures for five categories of basic household necessities by income quintile as reported by the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey for 2015. Each income quintile represents approximately 25.7 million American households. The five expenditure categories analyzed are food, housing, clothing, health care, and energy (residential utilities and gasoline).

Key findings of the analysis are:

- The average after-tax income of the two lowest income quintiles, representing more than 51 million households, is $20,072. This is equivalent to a take-home income of less than $1,700 per month.

- Residential electricity and motor gasoline are the largest energy expenditures for households in all income quintiles.

- Households in the lowest income quintile, with an average after-tax income of $11,416, spend 20% of their after-tax income on residential utilities and gasoline, while households in the two lowest quintiles spend 16%. This compares with 4% for households in the top income quintile, whose average after-tax income is $142,446.

- Black and Hispanic households account for 32% of households in the two lowest income quintiles, compared with 14% in the top income quintile. Senior citizens are also overrepresented in the lowest income quintiles.

- The real pre-tax incomes of American households have declined across the three lowest income quintiles since pre-recession 2007 levels, measured in constant 2015 dollars. The largest losses of income are in the two lowest income quintiles, representing families with pre-tax incomes below $37,600. In contrast, households in the top-5% of incomes experienced a 7% increase in real median incomes between 2007 and 2015, an average increase per household of $22,570.

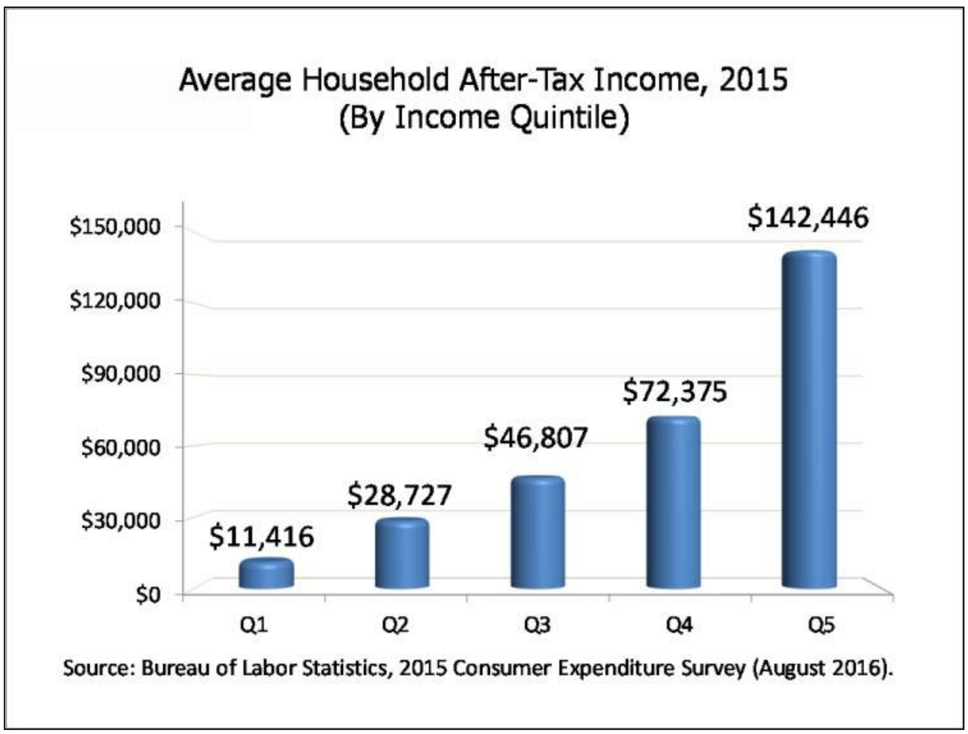
- Cost increases affecting residential energy goods and services have the most regressive impact on low-income households. Among all basic necessities, increases in residential electricity prices have the most regressive impact, followed by natural gas and heating oil. Increases in the prices of food, gasoline, housing, health care, and clothing all have less regressive impacts on lower-income families than residential energy price increases.

This report examines consumer expenditures by income quintile as reported in August 2016 by the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey for 2015.[i] BLS surveys the income and expenditure patterns of American households and reports its findings by income quintile. Each income quintile represents approximately 25.7 million American households.

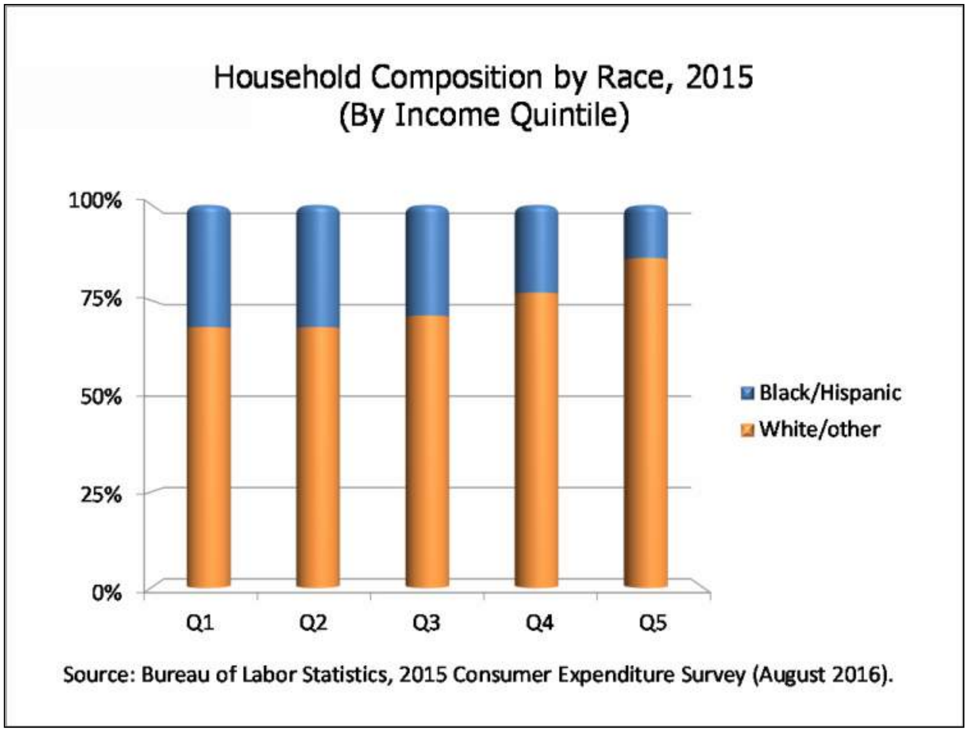
Household incomes

The BLS survey estimates that 128 million U.S. households had an average after-tax income of $60,448 in 2015. Average income before taxes for all U.S. households, including Social Security and other forms of transfer payments, was $69,627.

The distribution of average household incomes by income quintile is shown in the chart below. Households in the lowest income quintile had average after-tax incomes of $11,416. Households in the second income quintile had an average after-tax income of $28,727. The average after-tax income of the two lowest income quintiles, representing 51 million households, was $20,072. This is equivalent to a take-home income of less than $1,700 per month.



Black and Hispanic families are disproportionately represented among the lowest income quintiles. Black and Hispanic households account for 32% of households in the two lowest income quintiles, compared with 14% in the top income quintile. Senior citizens are also overrepresented in the two lowest income quintiles. In 2015, the pre-tax median household income of senior households aged 65 or more was $38,515, 32% below the U.S. pre-tax median income of $56,516.[ii]



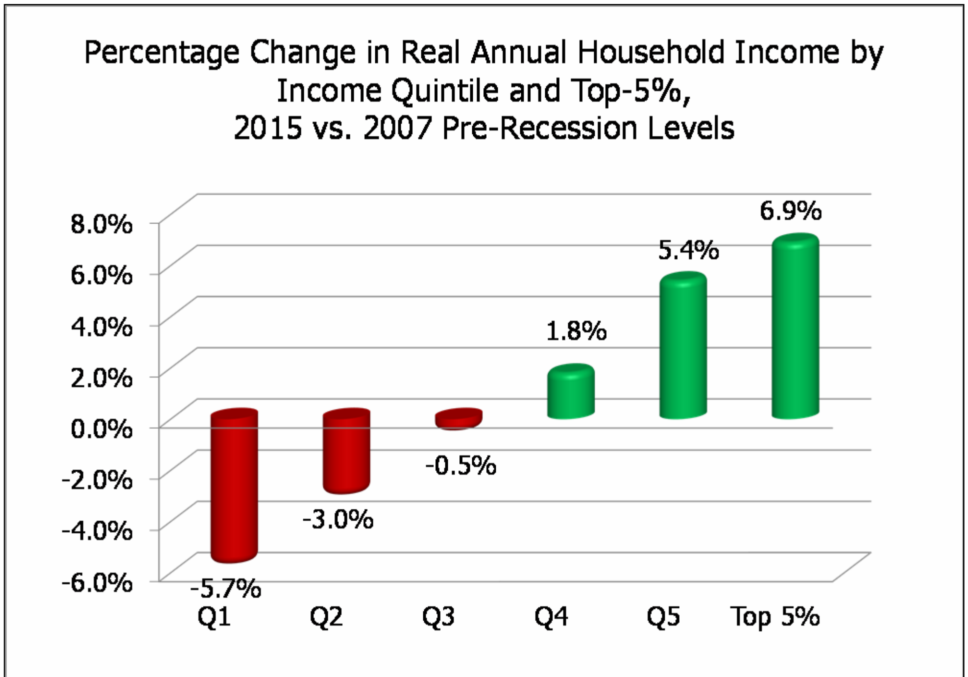
American households enjoyed a 5.2% annual increase in real median family incomes in 2015, the first such increase since 2007.[iii] Real median household income - the midpoint of the income distribution among all households - was $56,516 in 2015, compared with $53,718 in 2014. Even with this increase, real median income remains below the median household income peak of $57,843 that occurred in 1999.[iv]

The distribution of household incomes reveals that the real pre-tax incomes of American households have declined across the three lowest income quintiles since pre-recession 2007 levels. As shown below, the largest losses of income are in the two lowest income quintiles, representing families with pre-tax incomes below $37,600.[v] In contrast, households in the top-5% of incomes experienced a 7% increase in real median incomes between 2007 and 2015, an average increase per household of $22,570.

Average Real U.S. Pre-tax Household Incomes by Income Quintile
and for the Top-5%, 2007 and 2015
(In constant 2015$)

	Q1	Q2	Q3	Q4	Q5	Top-5%
2007	$13,205	$33,656	$57,120	$90,435	$192,014	$328,300
2015	$12,457	$32,631	$56,832	$92,031	$202,356	$350,870
$ Chg	($748)	($1,025)	($288)	$1,596	$10,352	$22,570

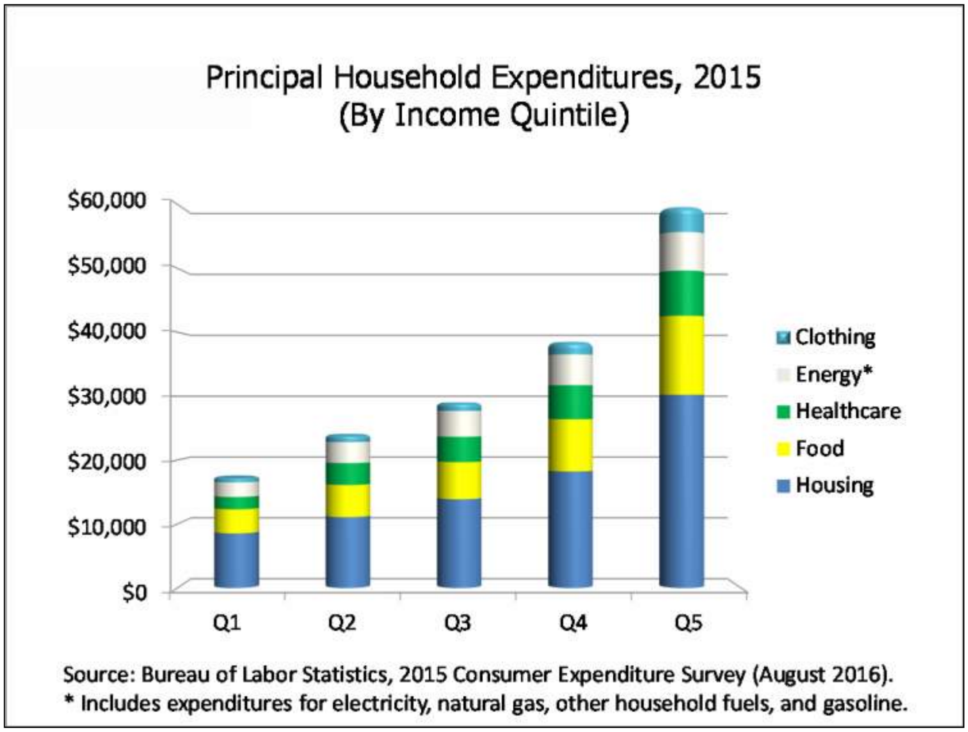
Source: https://www.census.gov/hhes/www/income/data/historical/household/



Source: U.S. Bureau of the Census (2016).

Consumer expenditures

The BLS survey estimates household expenditures for all categories of expenses, from basic necessities such as food and housing to luxury items such as jewelry. The chart below shows the increasing levels of expenditures by income quintile for five categories of basic necessities: housing (rent or mortgage payments), food, energy, health care (including insurance), and clothing. Energy expenditures include those for residential utilities such as electricity, heating oil and natural gas, and motor gasoline.

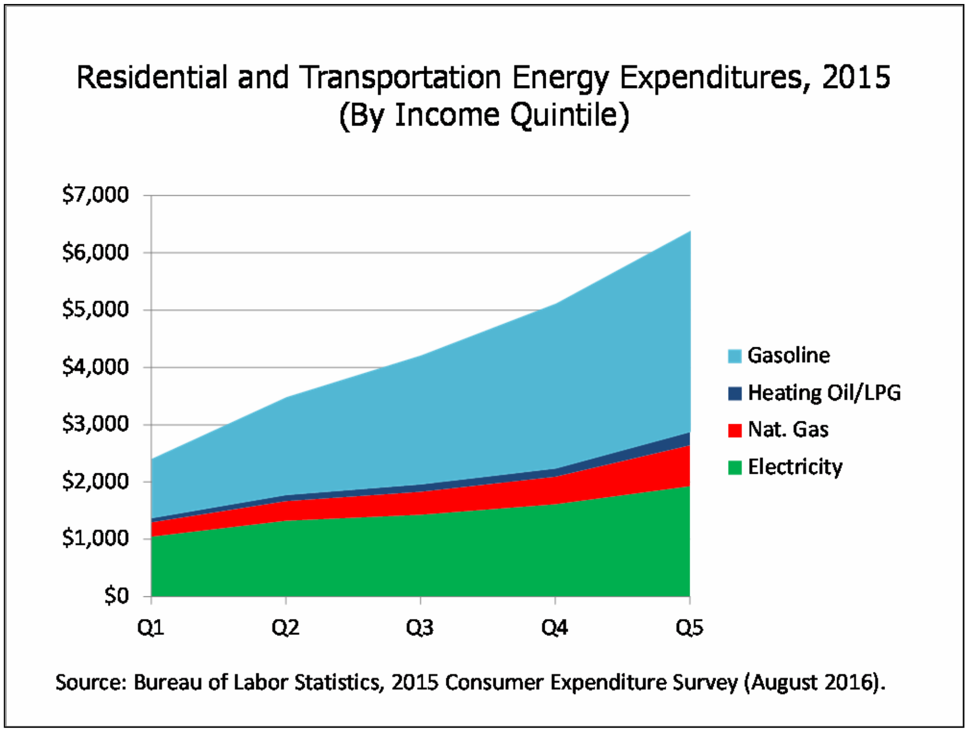


The largest expenditure category across all income quintiles is housing, followed by food. Expenditures for housing average $16,412 for all households, compared with $7,023 for food. Energy and health care expenditures are $4,087 and $4,342, respectively. Average expenditures for clothing are $1,846 per household.

Energy expenditure patterns

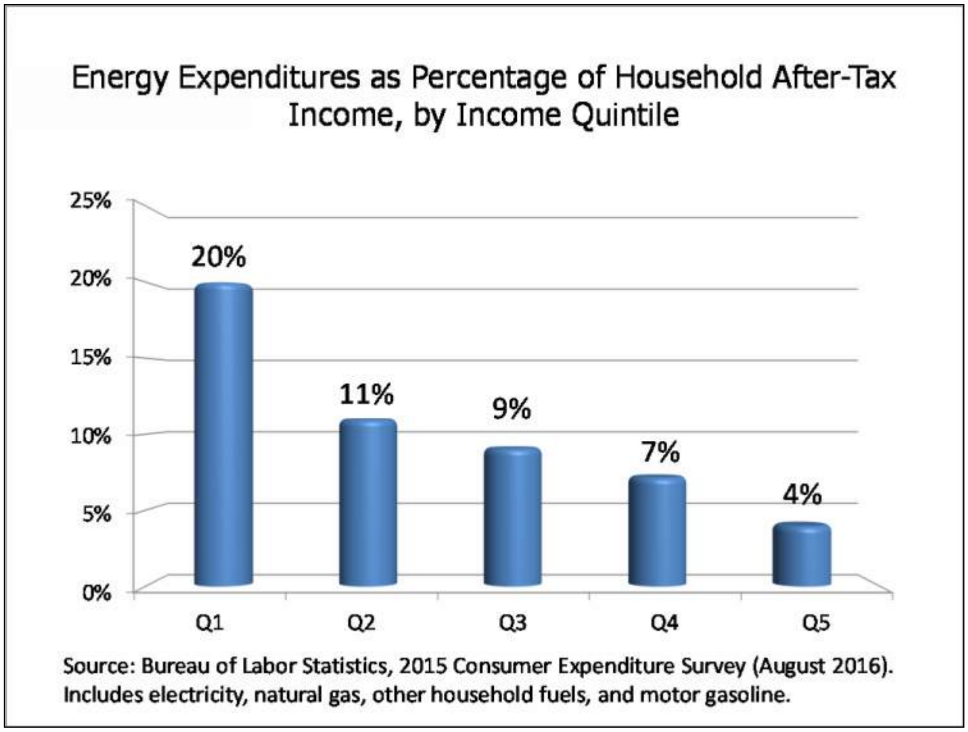
Residential electricity and motor gasoline are the largest energy expenditures for households in all income quintiles. As shown below, expenditures for motor gasoline increase rapidly with higher household income, reflecting increased numbers of vehicles and greater vehicle-miles traveled per household. The average U.S. household had 1.9 vehicles in 2015. Households in the lowest income quintile had 0.9 vehicles per family, while those in the top income quintile had 2.7 vehicles per household.

Household expenditures for electricity increase gradually with higher household income due to larger residential floor space and the increased number and use of appliances and other electrical equipment.[vi] With higher incomes, consumers also tend to substitute natural gas for electricity in home heating, and to use more efficient appliances, lighting, and space heating and cooling equipment.



Energy cost impacts on family budgets

Households in the lowest income quintile spend 20% of their after-tax income on residential utilities and gasoline, compared with 4% for households in the top income quintile. Households in the two lowest income quintiles, representing 51 million households, spend an average of 16% of their after-tax incomes on residential energy and gasoline. On average, energy expenditures represented 7% of after-tax income for all U.S. households in 2015.

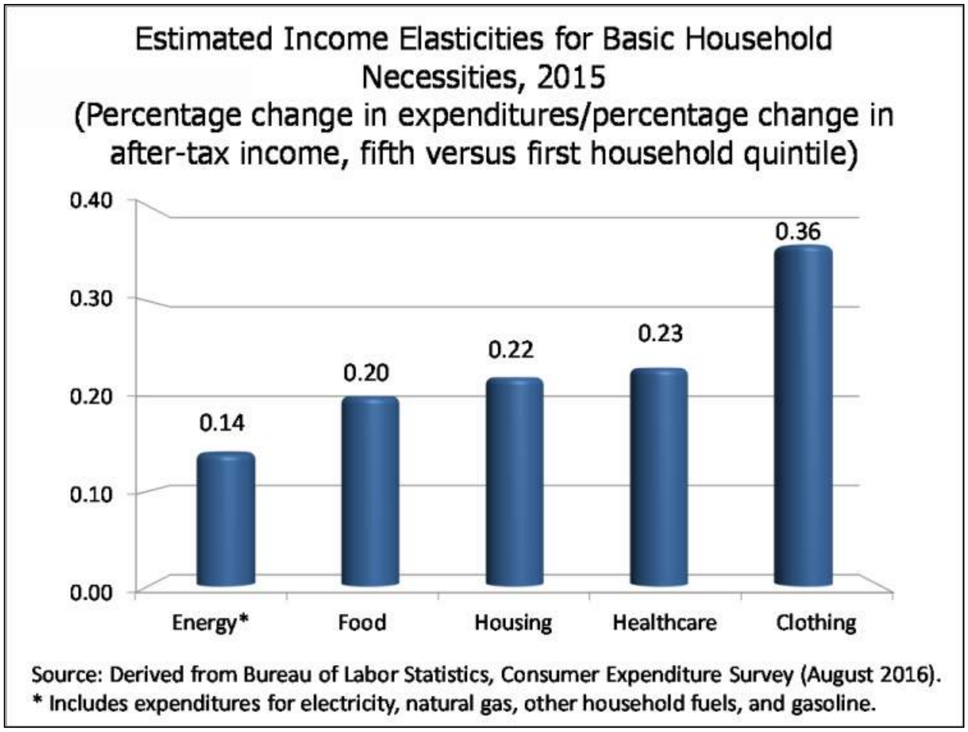


Inadequate Low-Income Energy Assistance

Many low-income consumers qualify for energy assistance programs such as LIHEAP, a federal block grant program that funds state energy assistance programs. LIHEAP appropriations have declined in recent years. The FY 2016 program was funded at $3.4 billion, compared with $5.0 billion in FY 2010.[vii] In FY 2010, LIHEAP provided an average benefit of $467 per household to 8.1 million households.[viii] Only 22% of the 37 million low-income households potentially qualified to receive benefits that year participated in the LIHEAP program.

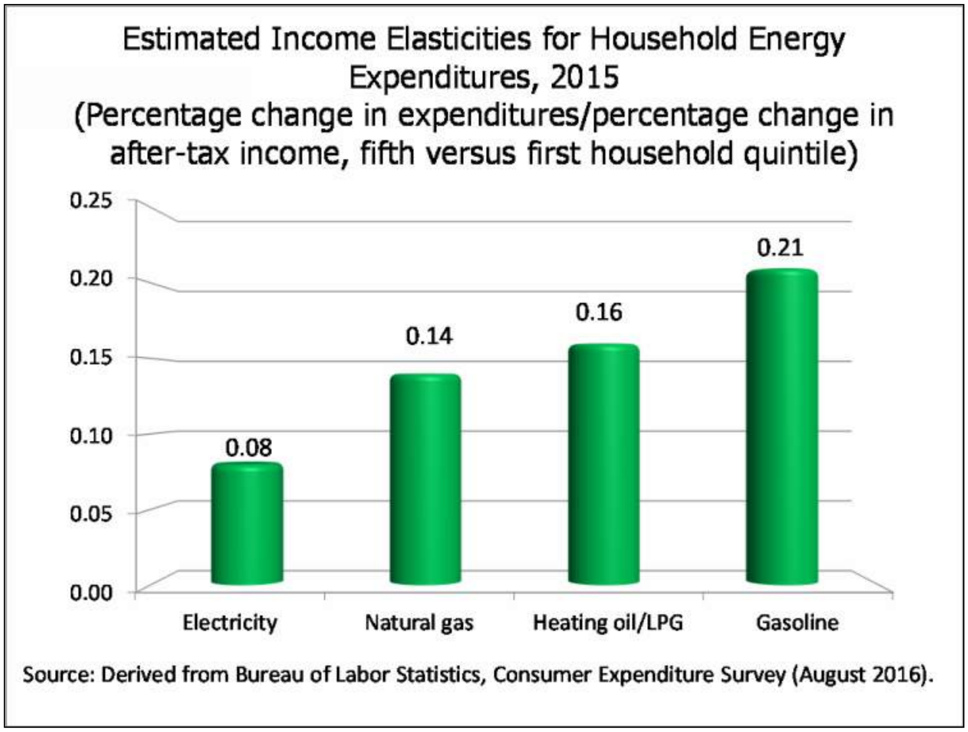
Income and Energy Use

Among consumer expenditures for basic necessities, energy is the least sensitive to changes in household income. The chart below shows the estimated income elasticities for five basic household expenditures. Income elasticity is a measure of the relative increase in expenditures for each of the five categories of basic necessities in relation to increased household incomes. It is calculated by dividing the percentage change in expenditures for each category of basic necessities by the percentage change in average incomes between the lowest and the highest income quintiles.



With rising household incomes, consumers tend to spend more on food, housing, health care, and clothing than on energy. Similarly, when faced with reduced income due to unemployment or other factors, family budgets are likely to cut back expenditures for clothing and other basic necessities to a much greater extent than energy.

Residential electricity expenditures - the most common monthly utility bill - are the least sensitive to changes in income among the principal categories of energy expenditures. As household incomes increase, consumers spend relatively more for heating oil, natural gas, and gasoline than for electricity:



The Regressive Impact of Energy and Other Consumption Taxes

Any increase in the costs of basic household necessities is an effective tax on household income. The BLS Survey provides the basis for estimating the relative regressivity of any consumption-based tax or price increase affecting basic necessities such as food or energy. A carbon tax on energy, an increase in electric prices due to government regulation, or higher sales taxes on food and clothing are consumption-based taxes reducing available after-tax income.

The table below shows the effective reduction of after-tax household incomes by income quintile for an assumed across-the-board 10% increase in the costs of housing, food, clothing, health care, and energy. For all U.S. households, the largest impacts are in housing (2.7%) and food (1.2%), followed by health care (0.7%), energy (0.7%), and clothing (0.3%). These differences are determined by the absolute magnitude of expenditures for each of these basic necessities, and do not account for any price-related response in consumer purchasing behavior.

Impacts of Assumed 10% Increase in the Costs
of Basic Necessities as a Percentage of After-Tax Income,
by Income Quintile

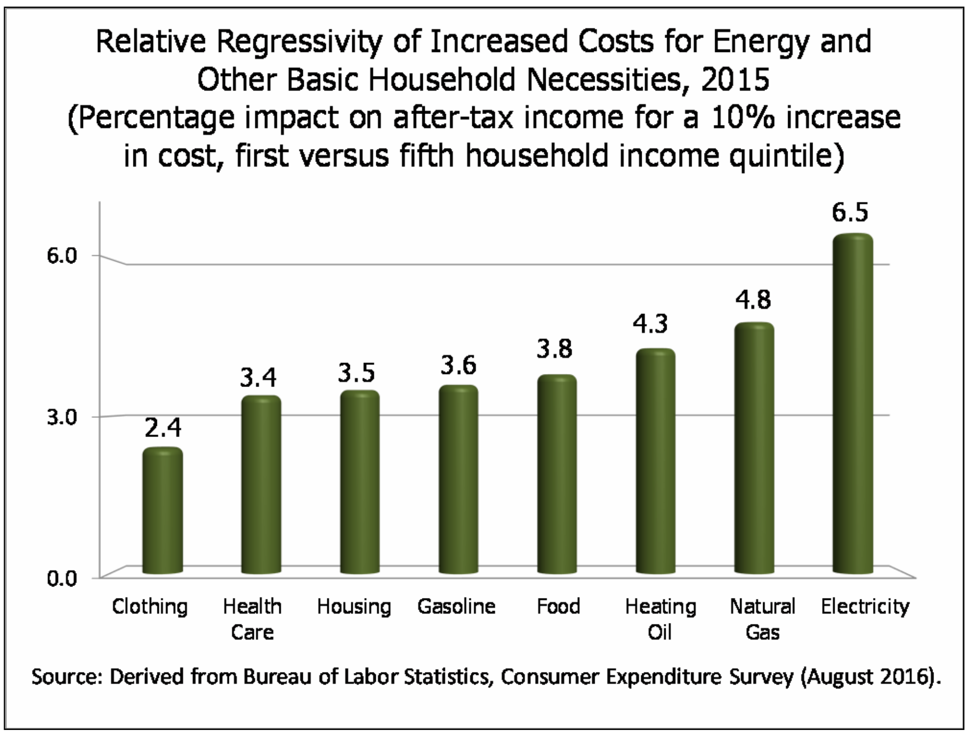
Item	All H/Hs	1st Q	2nd Q	3rd Q	4th Q	5th Q
Housing	2.72%	7.49%	3.86%	2.97%	2.52%	2.12%
Food	1.16%	3.30%	1.75%	1.24%	1.13%	0.87%
Health Care	0.72%	1.69%	1.19%	0.85%	0.74%	0.49%
Clothing	0.31%	0.68%	0.40%	0.28%	0.27%	0.28%
All Energy	0.68%	2.00%	1.14%	0.86%	0.66%	0.42%

Electricity	0.24%	0.89%	0.45%	0.31%	0.22%	0.14%
Heat. Oil	0.02%	0.06%	0.03%	0.02%	0.02%	0.01%
Nat. Gas	0.07%	0.23%	0.12%	0.08%	0.06%	0.05%
Gasoline	0.35%	0.82%	0.53%	0.45%	0.36%	0.23%

Source: Derived from Bureau of Labor Statistics, 2015 Consumer Expenditure Survey (August 2016).

The relative degree of regressivity of increased costs for consumer necessities can be measured by dividing the percentage impacts on after-tax income in the above table for the first and fifth income quintiles. For example, a 10% increase in housing costs would have a negative impact on the after-tax incomes of families in the first income quintile three and a half times greater than families in the highest income quintile (7.49%/2.12%).

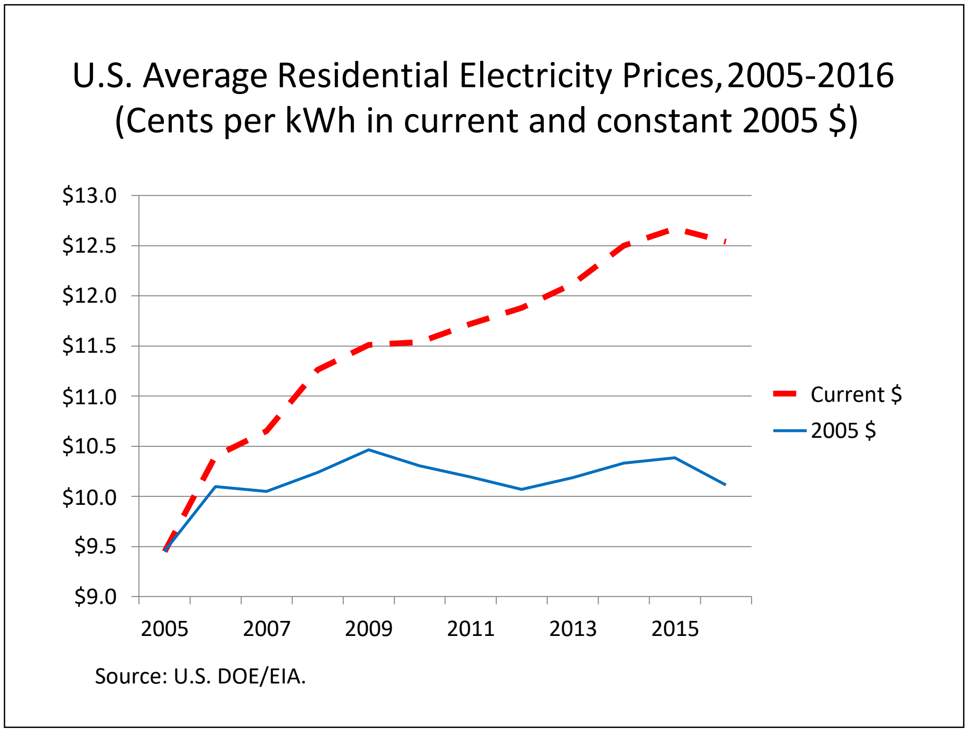
The chart below summarizes the regressivity of increased costs for energy and other basic household necessities, assuming an across-the-board 10% increase in costs:



Cost increases affecting residential energy have the most regressive impact on low-income households. Among energy necessities, increases in residential electricity costs have the most regressive impact, followed by natural gas and heating oil. Increases in the costs of food, gasoline, housing, health care, and clothing all have less regressive impacts on lower-income families than residential energy cost increases.

Policy Implications

The highly regressive nature of electricity price increases, together with recent trends in household electricity prices, underscore the importance of maintaining stable and affordable electric prices for lower- and middle-income consumers. Since 2005, national average electricity prices have increased by 33% in current dollars, and by 7% in constant 2005 dollars (see chart below). U.S. DOE projects that the average price of residential electricity will increase from 12.5 cents per kWh in 2016 to 13.0 cents in 2017.[ix] Residential natural gas prices are expected to rise by 9% from $10.18 per thousand cubic feet in 2016 to $11.10 per tcf in 2017, while home heating oil is projected to increase by 23% from $2.12 per gallon to $2.60 per gallon next year.[x]



A portion of the increase in residential electricity prices since 2005 is due to the capital and operating costs associated with new emission controls to meet Clean Air Act and other environmental requirements, as well as state laws mandating the construction of renewable energy facilities. The trend toward steadily rising electricity prices is likely to continue:

> "We are now in an era of rising electricity prices," said Philip Moeller, a (former) member of the Federal Energy Regulatory Commission, who said the steady reduction in generating capacity across the nation means that prices are headed up. "If you take enough supply out of the system, the price is going to increase."

> The problems confronting the electricity system are the result of a wide range of forces: new federal regulations on toxic emissions, rules on greenhouse gases, state mandates for renewable power, technical problems at nuclear power plants and unpredictable price trends for natural gas.[xi]

These diverging trends - stagnant or declining real family incomes and rising residential electricity prices - will continue to create difficult family budget choices among lower-income families.

Acknowledgment – This report was prepared for ACCCE by Eugene M. Trisko, who has conducted state and national energy cost analyses periodically since 2000. Mr. Trisko is an attorney and energy economist who represents labor and industry clients. He previously served as an energy economist with Robert Nathan Associates, an attorney in the Bureau of Consumer Protection of the U.S. Federal Trade Commission, and as an expert economic witness on utility cost of capital. He may be contacted at emtrisko@earthlink.net.

End notes

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[i] U.S. Bureau of Labor Statistics, 2015 Consumer Expenditure Survey (August 2016).
[ii] U.S. Bureau of the Census, Income and Poverty in the United States, 2015 (September 2016) at Table 1.
[iii] *Id.*, at 1.
[iv] *Id.*, at 6.
[v] U.S. Bureau of Labor Statistics, 2015 Consumer Expenditure Survey, Table 1101.
[vi] *See*, U.S. DOE/EIA 2009 Residential Energy Consumption Survey, Table HC2.5, Structural and Geographic Characteristics of U.S. Homes, by Household Income, 2009, and Table HC3.5, Appliances in U.S. Homes, by Household Income, 2009.
[vii] *See*, Congressional Research Service, LIHEAP: Program and Funding (July 29, 2015).
[viii] *Id.*, at Table 2.
[ix] U.S. DOE/EIA, Short-Term Energy Outlook, October 2016, Table 2.
[x] *Id.*
[xi] "U.S. Electricity Prices May Be Going Up for Good," The Los Angeles Times, April 25, 2014.

From: Scott Wedertz
To: Integrated Resource Plan
Subject: TVA / Red Hills Mine
Date: Wednesday, April 11, 2018 7:06:57 PM
Attachments: image011.png
image012.png
image013.png
image014.png
image015.png
TVA Red Hills Mine.pdf

TVA External Message. Please use caution when opening.

Scott Wedertz
International Sales Manager

L&H CANADA

cell: 307.689.3231
office: 307.682.7238

LnH.net

April 11, 2018,

Ms. Ashley Pilakowski

NEPA Project Manager

Tennessee Valley Authority

400 West Summit Hill Drive, WT 11D

Knoxville, TN 37902

Dear Ms. Pilakowski:

By way of introduction, L&H Industrial is a supplier of aftermarket parts for mining companies. We are located in Arizona, Wyoming and Tennesee with over 300 employees. We are a supplier to the Red Hills Coal Mine.

We want to help you promote the interest in general welfare of the people of the TVA service territory. We believe TVA should consider the benefits that the Red Hills coal mine brings to the local, state, and regional economy. We hope that you will consider supporting the coal industry for all the extra benefits it brings to the people of the TVA region. Please continue to use all of the resources options which in turn benefit the people of Mississippi, but also the people of the Tennessee Valley Authority.

If the TVA goal is to meet the purpose and mission of providing for agricultural and industrial development, then we would encourage TVA to look no further at the commitment they made to the Red Hills power plant and Red Hills coal mine. It is the epitome of success in all three major factors of TVA's goals: reliable and clean energy at an affordable price, environmentally sustainable energy production, and direct and indirect economic development for its people. By utilizing and optimizing the Red Hills power plant and Red Hills coal mine at maximum capacity, you will help fulfill this mission, and as a side benefit—TVA will obtain baseload support and resiliency for the electrical grid.

We urge the TVA to consider the potential positive impact that the Red Hills power plant and Red Hills coal mine have in the communities where their employees live. We hope you can source as much opportunities from this regions as a maximum utilization means more socio-economic and economic benefit to many businesses, people, and organizations. Those facilities offer you a low-risk diverse fuel source, environmentally responsible, reliable, and can be counted on as a backbone to a successful power grid. We hope you will consider it as such. This country has built a reputation on low-cost, environmentally responsible, reliable, and domestic fuel. We want to help TVA have an optimal resource plan that will give you reliable power for years to come.

We also respectfully ask you to consider the effect on our business and the employees who depend on the Red Hills coal mine and power plant. It is with great consideration and understanding that you will do right by all interested parties. Thank you for receiving these comments.

Respectfully submitted,

Scott Wedertz
L&H Industrial
321 Banbury Park Lane
Franklin TN 37069

Name: Kristin West

Comments: Please do not change your billing policy to a fixed rate system. Such a system would charge the same rate for individuals and businesses which strive to be as efficient as possible, including low-income families living in small apartments, as it would charge for wealthy individuals living energy-inefficient lifestyles in enormous houses. This system would adversely affect low-income families and eliminate incentives for wealthy people and others to lead a more energy-efficient lifestyle. We need a system that encourages increased levels of conservation - not one that charges low-income people for the excesses of wealthy people's lifestyles.
Thank you.

close window

Name: Jennifer Westerholm

Comments: I am writing to encourage TVA to take a bold stance in this 2019 IRP, emphasizing fuels, technologies, and distribution systems that prioritize clean, renewable, and distributed energy. This includes principally wind and solar, but should include a diverse stock of existing and cutting-edge renewable electricity sources. The least expensive energy source in existence, energy efficiency, should also be at the top of the priority list in this IRP. As a native Tennessean and parent of a toddler, I know the air quality in our city and state can and should be improved for future generations. Phasing out fossil fuels and investing in renewable technologies in where TVA should be heading.

Thank you for the opportunity to comment.

close window

Name: Ernie Williams

Comments: As an owner of a small solar installation company in West TN since 2009, and NABCEP certified installer- I have observed TVA's prograns for renewable energy since 2008. For the most part, I've understood and agreed with most of the changes- including the gradual reductions in premiums paid to small system owners (GPP). One item Id like to see TVA adopt (maybe for 2019) would be to give consumers a small incentive to actually help levelize the grid loads by allowing homeowners/small businesses to use battery storage and solar combined to help reduce peak demands on these sites. Japan did this after Fukashima to

close window

From: Jeff Williams
To: Integrated Resource Plan
Subject: IRP and EIS
Date: Wednesday, March 21, 2018 6:41:30 PM

TVA External Message. Please use caution when opening.

I'm in favor of TVA looking a lot more heavily into sustainable wind and solar power. You are way behind on that. If you have any desire to favorably impact the environment, you should move ahead rapidly in that direction.

--
Best regards,
Jeff

Jeff Williams
jiwms3@gmail.com
629-203-6970

Graham, Cierra

From: Wilson Arlene <arlenedwilson@comcast.net>
Sent: Tuesday, April 03, 2018 12:24 PM
To: Integrated Resource Plan
Cc: Paul Slentz
Subject: Coal plants

TVA External Message. Please use caution when opening.

Dear TVA

Please move quickly to shut down all of your high CO_2-emitting coal plan and replace them with solar and wind energy. My sister lives in Tallahassee and they have solar farms at their airport on all the grassy areas. As the biggest utility in the US, TVA can play a huge role in the world-wide effort tok cut greenhouse gas emissions. Please help save our jEarth for our grandchildren and beyond. IT'S TIME TO ACT!!

Sincerely,
Arlene Wilson
383 Normandy Circle
Nashville TN 37209

Name: Harold Wilson

Comments: In my view the overriding number one priority for TVA should be to provide the lowest possible cost electric power to it's customers. It is impossible to do this by paying premiums for solar, wind etc. Unless these programs pay their own way, they should wait until the technology is improved to the point they are competitive. I'm not against these other forms of power, I think it's foolish to invest in an emerging technology. I would support investing in research to lower the cost of these alternate forms of power.

All other expenses including those for 'community programs, economic development, etc' should be sharply curtailed.

close window

Graham, Cierra

From: james wohlgemuth <jrwohlgemuth@outlook.com>
Sent: Friday, April 06, 2018 2:13 PM
To: Integrated Resource Plan
Subject: best practices

TVA External Message. Please use caution when opening.

You know that when TVA was first created it was seen as the savior, the innovator, the standard bearer of power generation to the common man. Times change and I thought I would share with you some of the ideas I found from another power company Green Mountain Power in Vermont that is working with its customers to conserve and serve. They are definitely a forward thinking company; like TVA once was.

Take a look…

thanks Jim Wohlgemuth
7408 riverland dr

Sent from Windows Mail

tva.com/irp