CHAPTER 1: INTRODUCTION

Problem and Need

Wildlife conservation responds to the challenges of the times. The original wildlife conservation movement began in the first half of the twentieth century in response to unregulated harvest for sporting and commercial purposes. During this period, a number of landmark federal laws were enacted, notably the Migratory Bird Treaty Act, the Pittman-Robertson Federal Aid in Wildlife Restoration Act, the Lacey Act, and the Dingell-Johnson Sport Fisheries Restoration Act. All were created following education campaigns by the conservation community.

State and federal fish and wildlife agencies grew rapidly, supported by increases in state and federal conservation funding. The US Bureau of Sport Fisheries and Wildlife (now the US Fish and Wildlife Service) was formed and state fish and wildlife agencies either developed from scratch or became greatly centralized and expanded, using revenue from a combination of state license fees and federal funding from excise taxes on sporting equipment. The resulting state fisheries and wildlife management programs were well established by the late 1960s and early 1970s and were largely game-oriented.

As times and conditions changed, new laws were enacted. In the early 1970s, the Endangered Species Act, Clean Water Act, and Clean Air Act all were developed and companion state laws and programs were enacted. In order to provide early direction to the South Carolina Department of Natural Resources (SCDNR) Nongame and Endangered Species Program, a statewide symposium on endangered species was held in 1976. At that meeting, committees of specialists in vertebrate taxa (mammals, birds, herpetofauna, fish) were formed to provide information about species that had uncertain status or were believed to be in jeopardy (Forsythe and Ezell 1976). Out of this meeting came the formation of the nation's first Heritage Trust Program wherein the taxa committees continued to meet periodically and update the species lists. Rare plants were also added to the list of species tracked.

As the economic changes begun in the 1970s progressed, many states, including South Carolina, entered a period of rapid economic expansion and human population growth that continues to this day. South Carolina has one of the fastest rural-to-urban conversion rates and is the 9th ranked state in terms of total land area developed annually (Miley, Gallo and Associates LLC 2008). In 2010, South Carolina was ranked as the 24th most populated state in the nation at 153.9 people per square mile (US Census Bureau 2012) and one of the fastest growing in the nation (Miley, Galo and Associates LLC 2008). By 2030, the projected housing density is expected to reach anywhere from 16 to 128 housing units per square kilometer throughout much of the state (Hammer and Radeloff 2003) as the population nears five million (Miley, Gallo and Associates LLC 2008). The biggest population increases currently occurring are in the Upstate, coastal counties, and around the capital (Lexington and Richland Counties) (SCFC 2010).

The conversion of prime forest and agricultural land to residential uses is changing the landscape of South Carolina. In addition, rising costs coupled with falling prices are creating hardships for many family farms. Long-term declines in farmland are dramatic: in 1920, 192,693 farms were producing goods in South Carolina, and 63.7% of the land in the State consisted of farms (US

Bureau of the Census 1954). By 2006, the number of farms in the state had been reduced to 24,700 (Miley, Gallo and Associates LLC 2008). Over 13 million acres of forests, which cover two thirds of South Carolina's total land area, are also at risk for development since 11 million acres are in private ownership (Miley, Galo and Associates LLC 2008; SCFC 2010).

As land use is converted from rural to urban uses and the population of South Carolina increases, new challenges arise for fish and wildlife species in the state. Long-standing downward trends in numbers of some species that previously had been overlooked have become evident. In a state-by-state analysis of biodiversity conducted for The Nature Conservancy, South Carolina ranked 14th among all states in species diversity and 15th in terms of risks to native species (NatureServe 2002). In a planning exercise conducted in 1994, SCDNR biologists estimated that as many as one third of the State's vertebrate species are now—or soon will be—experiencing serious declines (SCDNR 1994). The South, as a whole, has already lost an estimated 614 species to extinction—64 terrestrial vertebrates and 550 vascular plants (Wear et al. 2012).

The SCDNR continues to support a large number of conservation initiatives on public and private lands, including habitat protection; technical guidance and cost sharing; and education. Farm Bill programs have helped provide assistance to landowners across the State, positively affecting 264,950 acres as of 2007 (USDA-ERS 2013). A statewide wildlife strategy would align all conservation activities with common goals that can be consulted by all South Carolinians, especially resource managers, local governments, and the scientific community. The State Wildlife Grants program provides a vehicle to create such a strategy.

In order to sustain South Carolina's diverse wildlife resources in the future, the following actions are critical: (1) increase baseline biological inventories with emphasis on natural history, distribution, and status of native species; (2) increase commitment by natural resource agencies, conservation organizations, and academia toward establishing effective conservation strategies; (3) increase financial support and technological resources for planning and the implementation of these strategies; and (4) create public-private partnerships and educational outreach programs for broad-scale conservation efforts. This Action Plan is a first step toward instituting these actions.

Legislative Mandate and Guidance

The charge to state wildlife agencies to develop comprehensive strategies had its origins in the Wildlife Conservation and Recreation Program (WCRP) that was created in the federal Appropriations Act of 2001. Appropriations language provided that funds may be used for "...the planning and implementation of [a state's] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education, and wildlife-associated recreation projects" (114 STAT. 2762A -118 PUBLIC LAW 106–553 — APPENDIX B — Title IX).

The WCRP appropriations language challenged the states to develop projects in the three major areas anticipated in the Teaming with Wildlife initiative: conservation, education, and recreation. WCRP appropriations language also provided that "Within five years of the date of the initial apportionment, [the states shall] develop and begin implementation of a wildlife conservation strategy based upon the best available and appropriate scientific information and data …."

Specific criteria for the wildlife conservation strategies were developed. South Carolina committed to developing its "wildlife conservation strategy" within the required five years in order to qualify for WCRP funds.

WCRP was only funded for one year and was replaced in 2002 and subsequent years by the State Wildlife Grants Program (SWG), also through the appropriations process. Unlike WCRP, the SWG program emphasizes conservation projects alone and charges the states "…to develop by October 1, 2005, a comprehensive wildlife conservation plan [strategy], consistent with criteria established by the Secretary of the Interior, that considers the broad range of the State, territory, or other jurisdiction's wildlife and associated habitats, with appropriate priority placed on those species with the greatest conservation need and taking into consideration the relative level of funding available for the conservation of those species…" (115 STAT. 414 PUBLIC LAW 107-63 — APPENDIX A). The document that all states ultimately prepared in response to this mandate was referred to as a Comprehensive Wildlife Conservation Strategy (CWCS). The 2005 version of South Carolina's document was therefore named accordingly. Over time, the Strategy became referred to internally as well as in other states as the State Wildlife Action Plan or SWAP. Thus, the 2015 iteration of this document underwent a name change to this more familiar title.

As per Element 6 of the original legislation, all states made a commitment to review and revise their plans within 10 years. South Carolina began the review process in September 2010. Due to personnel turnover and emerging issues (e.g. the spread of white-nose syndrome), the completion of the final version was delayed until 2014. These revisions were completed in accordance with the current SWG Guidance Document (2007). Any significant changes to the Strategy/Action Plan and an up-to-date public review process were documented. Congress version was identified the required elements of the strategies in the WCRP legislation and the USFWS adopted those same elements to also apply to the SWG required SWAP, so one document will satisfy both needs. The SWAP must identify and be focused on the "species in greatest need of conservation," yet address the "full array of wildlife" and wildlife-related issues. They must provide and make use of the elements identified in Box 1-1: The Eight Required Elements. This original guidance has been expanded considerably during the course of SWAP preparation; however the eight elements remain the core standard for the strategies.

Box 1-1: The Eight Required Elements

1) Information on the distribution and abundance of species of wildlife, including low and declining populations as the State fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the State's wildlife.
2) Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1).
3) Descriptions of problems, which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors, which may assist in restoration and improved conservation of these species and habitats.
4) Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions.
5) Descriptions of the proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions.
6) Descriptions of procedures to review the Strategy/Plan at intervals not to exceed ten years.
7) Descriptions of the plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Plan/Strategy with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the State or administer programs that significantly affect the conservation of identified species and habitats.
8) Descriptions of the necessary public participation in the development, revision, and implementation of the Plan/Strategy.

Roadmap to the Required Elements in South Carolina's SWAP

As part of the additional guidance received, States were instructed to highlight the location of information specific to the eight elements for reviewers of the SWAP. Therefore, Table 1-1: Roadmap to the Required Elements presents this information.

TABLE 1-1: ROADMAP TO THE REQUIRED ELEMENTS

ELEMENT	SC SWAP CHAPTER	LOCATION
1. Distribution and abundance of species	Chapter 2	Throughout chapter
	Chapter 3	Throughout chapter
	Appendices 1 A-D	Entire appendices
	Supplemental Volume	Entire volume
2. Location and relative condition of key habitats	Chapter 2	Throughout chapter
	Chapter 4	Throughout chapter
	Supplemental Volume	Entire volume
3. Problems that affect species	Chapter 3	Throughout chapter
	Chapter 5	Throughout chapter
	Supplemental Volume	Entire volume
4. Conservation actions described	Chapter 5	Throughout chapter
	Chapter 6	Throughout chapter
	Chapter 9	Throughout chapter (completed actions described)
	Appendix 2	Entire appendix
	Supplemental Volume	Entire volume
5. Plans for monitoring and adaptive management	Chapter 5	Throughout chapter
	Chapter 6	Throughout chapter
	Appendix 2	Entire appendix
	Appendix 7	Entire appendix
	Supplemental Volume	Entire volume
6. Review and revise Plan	Chapter 8	Throughout chapter
7. Coordinating with federal, state, and local agencies as well as Indian tribes.	Chapter 3	Throughout chapter (taxa teams)
	Chapter 7	Throughout chapter
	Appendix 3	Entire appendix
	Supplemental Volume	Entire volume appendix
8. Public participation	Chapter 7	Throughout chapter
	Supplemental Volume	Entire volume (see contributions to data)

SWAP Organization

The SWAP, or Action Plan, is organized to first make the reader aware of the need for a strategy then to discover how the actual Action Plan was developed and presented. In the **Introduction**, a discussion of the need for the SWAP and the legislative mandate that allows SCDNR to develop and implement the strategy is presented. The selection of South Carolina's priority wildlife species is discussed in **Chapter 2: SC's Priority Species** while the methods for prioritizing those species and the challenges they face are detailed in **Chapter 3: Taxonomic Groups**. The condition and location of habitats and challenges to the management of those habitats is presented in **Chapter 4: South Carolina's Landscape**. Appendices 1 A-D are spreadsheets that list the species of concern and their habitat associations. The conservation strategies that will be implemented to address the challenges identified in the three previous chapters is discussed in detail in **Chapter 5: Statewide Conservation Strategies**; the nine conservation action areas around which strategies have been constructed are also presented in that chapter. After listing conservation actions to address species and habitat challenges, the manner in which they will be monitored is contained in **Chapter 6: SC's Comprehensive Monitoring Program**. Strategies for monitoring the effectiveness of conservation actions are also discussed. The SCDNR formed extensive partnerships during the initial development of the SWAP and has retained them through the revision process. These partnerships are discussed in **Chapter 7: Seeking Public Input and Maintaining Partnerships**. The public input process is also summarized. The manner in which the SCDNR prioritized conservation actions, will implement the conservation actions in the SWAP, and adapt the Action Plan as new information becomes available is presented in **Chapter 8: Implementation and Adaptive Management**. Since the original Plan was completed in 2005, the State Wildlife Grants (SWG) that have resulted from the implementation of that Plan are summarized in **Chapter 9: SWG Project Summaries**. Finally, we include a list of references in the **Literature Cited** as well as provide a **Glossary** and **Appendices** associated with the SWAP. The last Appendix (8) is a list of acronyms used within the SWAP and Supplemental Volume.

A **Supplemental Volume: South Carolina's Priority Species** is submitted with this Action Plan. The Supplemental Volume contains reports for the species of greatest conservation need (hereafter also referred to as priority species) included on South Carolina's Priority Species List. Each of these reports includes a description of the distribution and abundance of each species and its habitat requirements, the challenges that the species faces, and specific conservation actions for addressing those challenges. Additionally, some of these reports discuss ways to work with public and private entities toward conservation as well as strategies for monitoring species, habitats, and effectiveness of conservation actions.

The Supplemental Volume to South Carolina's SWAP provides a unique look into challenges and conservation actions that pertain to each of the species on this state's Priority Species List. By providing species-specific actions, the SCDNR can use the Action Plan in two ways: (1) to manage species of concern over large areas or habitat and (2) to manage particular species in any habitat where that species occurs, no matter the size of the management area. Further, the species-specific approach in the Supplemental Volume allowed for development of very concise conservation actions for each species, which are expected to permit SCDNR or its partners to easily convert those actions to project proposals/plans.

Authority and Capability of the SCDNR to Prepare and Implement the SWAP

Article III, Section 34, South Carolina Constitution, 1895, as revised, states in relevant part: "that the General Assembly is empowered to divide the State into as many game zones as may appear practicable, and to enact legislation that may appear proper for the protection of game in the several zones."

Legislation creating the SC Department of Natural Resources and governing its activities is covered under Titles 48 and 50 of the SC Code of Laws. The entire code covers the generalities of operating the agency, as well as special laws pertaining to certain species, penalties, and subdivisions of the state. The most concise, broad charge to the SCDNR is found in the following sections:

> §48-4-10 provides that "The South Carolina Department of Natural Resources is created to administer and enforce the laws of this State relating to wildlife, marine resources, and natural resources and other laws specifically assigned to it."
>
> §48-4-80. Provides for the creation of a Board to serve as "the governing body of the agency."
>
> §50-3-80 provides that the Department shall continuously investigate the game and fish conditions of the State and the laws relating thereto. It shall annually make report of its activities to the General Assembly and recommend legislation and other action by the General Assembly in its judgment conducive to the conservation of wildlife.

Subsequent legislation provides assent to federal fish and wildlife restoration acts and authorizes the SCDNR to "perform such acts as they be necessary to the conduct and establishment of cooperative fish and wildlife restoration project(s) as defined in such act(s) of Congress…" Authorities under Title 50 include jurisdiction over saltwater fish and related activities.

In addition, Title 50 authorizes SCDNR to promulgate regulations relating to hunting, fishing, the taking and possession of wildlife, and provides for penalties relating thereto. Authorization is further extended to SCDNR to acquire and dispose of property, conduct hearings, and "own, sell, lease, exchange, transfer or rent real property" for purposes of carrying out its authorities. Concerning recreation, this authority extends to "furnishing the people of the State with hunting areas and fishing facilities."

The South Carolina Nongame and Endangered Species Conservation Act (§50-15-10 et seq.) authorizes the Department to "…conduct investigations on nongame wildlife in order to develop information relating to population, distribution, habitat, needs, limiting factors and other biological and ecological data to determine management measures necessary for their continued ability to sustain themselves successfully." The Act further authorizes SCDNR to issue regulations and "develop management programs designed to insure the continued ability of nongame wildlife to perpetuate themselves successfully."

Subsequent sections of the Act set forth administrative procedures for developing regulations—penalties for taking and possession of nongame wildlife considered by SCDNR under this Act to be endangered. The Act also provides that the agency will maintain lists of endangered species and amend them periodically. The Act further authorizes SCDNR to establish programs, including "acquisition of land or aquatic habitat, as are deemed necessary for management and endangered wildlife." Further, SCDNR is authorized to enter into cooperative agreements for purposes of carrying out its responsibilities under the Act.

Criteria for listing species as endangered under the state statute closely follow those for the federal Endangered Species Act. A second category, "Species in Need of Management," is also provided for recognizing and providing less stringent protection for species whose status does not warrant listing as endangered. Under the "species in need of management" category, SCDNR is charged with conducting ongoing investigations of nongame wildlife in order to determine which species are in need of management and for developing programs for their management in order to "sustain themselves successfully." This section of the statute roughly parallels that of the federal statute dealing with threatened species; however, the intent of the state statute is not only to provide listing authority, but also to establish authority for SCDNR to engage in conservation activities in addition to or in lieu of, formal listing and regulatory actions.

A closely related statute establishes the South Carolina Heritage Trust Program (§51-17-10 et seq.). This legislation designates SCDNR as the lead agency to develop and conduct a program whose purpose is "protecting lands and making them available to state agencies, educational institutions and public and private groups" for a number of conservation purposes. The statute authorizes SCDNR to conduct inventories of lands having natural significance, acquire fee simple lesser interest in land, and establish strong legal protections for property thus acquired.

In 1994, the legislative mandate of the SCDNR was updated in a general reorganization of state government. Subsequently, SCDNR adopted the following mission statement:

> *The South Carolina Department of Natural Resources (SCDNR) is the advocate for and the steward of the state's natural resources.*

Within five divisions are numerous individual programs that are responsible for executing the mission in areas such as wildlife and fisheries management, endangered species management, marine fisheries conservation, education, ground and surface water management, soil and water conservation, habitat protection, and a broad array of law enforcement activities in addition to enforcement of fish and game laws. Therefore, from a legal and organizational standpoint, SCDNR was well equipped to lead the development and execution of the SWAP and now the revision of it.

Changes to This Edition of the SWAP

The 2005 version of South Carolina's document was named the Comprehensive Wildlife Conservation Strategy (CWCS). Over time, the Strategy became referred to internally as the State Wildlife Action Plan, or SWAP, for ease of discussion and to match terminology with

neighboring states. Thus, the 2015 iteration of this document underwent a name change to this more familiar title.

The changes to the **mammals** section of the Plan included the listing of 8 new species, all bats. The additional species included all of South Carolina's colonial cavity roosting and foliage roosting bats. Upon the discovery of White-nose Syndrome (WNS) in 2006 and subsequent confirmation in South Carolina in 2013, these bats were immediately considered at risk due to their roosting and swarming behavior and were placed in the "highest" priority category within the SWAP. WNS is caused by the fungus, *Pseudogymnoascus destructans* (formerly *Geomyces destructans*). Other changes in the mammals section involved correcting the listing of the subspecies name of the fox squirrel to the Southern fox squirrel. The Atlantic right whale was also renamed to specify that the North Atlantic right whale was the priority species.

Birds had 48 new species added to the list this iteration (including subspecies) while 42 species underwent priority reassignments. Changes in priority ranking were due, in part, to the methodology change for species selection, but also new trends in populations for these species have become available and are documented in various national plans.

Changes made to the 2015 list of priority **herpetofauna** included some removals and additions. The canebreak rattlesnake was removed from the list as it was not supposed to be included as a separate species of the timber rattlesnake. Hellbender and southern dusky salamander were also removed due to recent research showing they are not naturally found in South Carolina. Painted turtle was added to the priority list as it had been inadvertently left off the first time. New species that were recently discovered included the patch-nosed salamander and dwarf black-bellied salamander, both of which earned a place on the list in the "highest priority" and "high priority" categories, respectively. The Eastern box turtle was also added to the list since recent concerns over the pet trade put it at risk. Other changes to the priority list included 10 priority ranking changes—upgrades to a higher priority listing or downgrades to a lower listing due to more available data on the species.

Freshwater fishes underwent several changes due to improved knowledge of the species' populations and ranges learned through the most recent South Carolina Stream Assessment (2006-2011) funded by State Wildlife Grants. There were 9 new additions to the list; one in the "highest priority" category and the rest in the "moderate priority" category. There were 3 fish that had corrections to their common names. One species, the Saluda Darter, is now considered synonymous with the Carolina Darter. South Carolina's form of what was formerly the Sailfin Shiner is now recognized as the Lowland Shiner (*Pteronotropis stonei*). The Lowland Shiner was a Priority species in 2005 and remains one in 2015. The Bluefin Killifish and Banded Darter are considered introduced species in South Carolina, and although rare, do not warrant priority status. Five fish species were removed from the list altogether. No existing listed priority species were demoted or promoted to other categories.

In the **diadromous fish** category, the American Eel and American Shad have now been given a status in the State of South Carolina as a "species of concern" while the Atlantic sturgeon has since been listed as Federally and State Endangered.

Changes to the **crayfish** list for South Carolina included the addition of 2 new species, the endemic Carolina needlenose crayfish and *Cambarus* sp. "B". The latter species has yet to be described and fully understood. The Oconee stream crayfish was renamed the Chauga crayfish. Additionally, 10 other species received common names in this iteration of the SWAP. The latest stream surveys also indicated that the Pee Dee lotic crayfish and Carolina Sandhills crayfish (formerly simply called the Sandhills crayfish) were more abundant than first realized and were thus demoted to the "moderate priority" category. The Ohio River **shrimp**, first discussed in the 2005 version of the SWAP in the marine invertebrates section, was moved to the freshwater section because of its association with rivers.

The **freshwater mussel** list underwent some changes such as the renaming of the Carolina Slabshell (*Elliptio canagarea*) as Carolina Elephantear. The reason for the change was due to the fact that the shell was not shaped like other typical slabshells. Likewise, the Southern Rainbow (*Villosa vibex*) was renamed the Eastern Rainbow (*V. modioliformis*). The Atlantic Spike moved up in priority ranking from 'moderate' to 'high' due to new information available on the status and distribution of the species. A new species this iteration is the Altamaha Arcmussel (*A. arcula*). Eastern Lampmussel (formerly mislabeled in the text as Eastern Lampshell) and the Rayed Pink Fatmucket have been broken out into separate species, *L. radiata* and *L. splendita*, respectively. In 2011, 4 mussel species that occur in South Carolina were proposed as candidates for listing as Federally Threatened or Endangered species (USFWS 2011).

Freshwater snails underwent a few changes as well. *Somatogyrus sp.* (a pebblesnail) was given a formal name, panhandle pebblesnail, and downgraded to "high priority" due to better knowledge of population estimates. The "*Physa* species A" mentioned in the previous (2005) version of the SWAP was formally described as *Physa carolinae* by Wethington, Wise, and Dillon in 2009. *Physa carolinae* is actually rather common, and does not merit any special conservation concern (R. Dillon, pers. comm.).

A new taxa category was added to cover **freshwater, marine and terrestrial leeches** to which 4 species were added. The 2006-2011 South Carolina Stream Assessment, although not specifically designed to target leeches, documented the occurrence of the New England medicinal leech, which was previously not known to occur in the State.

For **marine fish and invertebrates**, the priority species lists were substantially shortened this iteration of the Plan from 938 down to 91 to make them more manageable. Initially, the marine taxa team had considered all species for which information was lacking. This iteration, however, they used a feasibility of study filter to make prioritizations. Some species received new state and global ranks (S and G ranks), and all were able to be priority ranked for the first time. All received species or guild accounts in the Supplemental Volume this iteration.

In the first edition of the SWAP, 15 **insects** were highlighted. Since that time, there have been additions to state species records along with new species descriptions. Therefore, in the 2015 version, 32 were highlighted because the taxonomic committee felt there was enough information to discuss them. In the past, no S-ranks existed for insects in South Carolina. Where knowledge was sufficient, based on the opinions of the various experts, S-ranks were included

for certain groups in this iteration of the Plan, but these should be considered approximations. None of the insects can be ranked as highest, high, or moderate priority at this time.

A major component of this revision includes updates to the current landscape or habitat chapter (Chapter 4) that provide a more comprehensive way of describing and mapping priority habitats within the State. For the initial SWAP preparation (previously referred to as the CWCS), the principal source of information for terrestrial habitat definitions was Nelson's (1986) classification of South Carolina's natural communities. In the previous edition, no GIS supporting maps were included in the Plan. Habitats within the chapter were described in narrative form and were not mapped within the ecoregions. Given the utility that GIS support maps provide, we felt that their addition was an appropriate measure to update our plan that would also echo neighboring states' efforts.

As GAP data has been criticized for its low accuracy rate, it was proposed to use it as a support system for land cover types, which were loosely based on Nelson's *Natural Communities of South Carolina*, and not as the sole basis for classifications. Utilizing our Technology Development Program staff, SC GAP data were isolated by ecoregion and then re-classified to "fit" into the original habitat classes creating the crosswalk table seen in Appendix 4. SC GAP habitat class descriptions—found in the 2001 final report entitled, *"A GAP Analysis of South Carolina"*—and expertise from the Heritage Trust staff were used to justify merging of the GAP map units into their respective SWAP original habitats. SC GAP data actually identified more land cover types within the ecoregions, therefore, providing a more comprehensive overview of the actual habitats present.

The 2005 Plan's Chapter 2 detailing South Carolina's priority species was split into two chapters in this revision and the prioritization process for species and Conservation Action Areas (CAAs) more succinctly defined. The statewide conservation strategies chapter (Chapter 5) was updated to include measures of success that had occurred under each CAA since 2005. A new ninth CAA was added to cover the emerging issue of climate change. South Carolina's Monitoring Program chapter (Chapter 6) was also updated with the latest accomplishments.

The newest public input received is discussed in Chapter 7 and came in the form of climate change workshops. Strategies developed from theses workshops as well as a new Agency climate change guidance document were incorporated in Chapter 5's CAAs. The draft 2015 SWAP was posted to the SCDNR website, advertised, and the suggestions received from the public and our partners incorporated into Chapter 7.

Now that the SWAPs from the states are actively being implemented, an updated explanation of that process is discussed in Chapter 8. An altogether new chapter was added at the end of the document, Chapter 9: State Wildlife Grant Project Summaries. This chapter highlights the 33 grant projects funded through SWG as part of the implementation of the SWAP that have been completed since 2005. Subjects range from research and survey to habitat enhancement projects.

In the Supplemental Volume's species/guild accounts, some of the conservation recommendations have been accomplished and were thus moved to/discussed in the species/guild's conservation accomplishments section. In addition, any ongoing or new

recommendations were kept or added. The habitat section of the Supplemental Volume was incorporated into Chapter 4: SC's Landscape of the main document and thus removed from the Supplement altogether.

CHAPTER 2: SOUTH CAROLINA'S PRIORITY SPECIES (SPECIES OF GREATEST CONSERVATION NEED)

In setting priorities for the SWAP, two separate but equally important prioritization processes were conducted. It was necessary to determine which species in the State should be placed on the list of South Carolina's priority species—"species of greatest conservation need" (SGCN)— and those species would need to be ranked based on existing data and expertise associated with those species. Additionally, the priority for implementing conservation actions to address challenges to SGCN needed to be determined. The following identifies how the South Carolina Department of Natural Resources (SCDNR) conducted the prioritization process of both species and conservation actions to address the needs of those species.

Species Prioritization

The State Wildlife Grants (SWG) program established funding for species not traditionally covered under federal funding programs. To qualify for these funds, each state was mandated to develop a strategy/plan with a focus on "species of greatest conservation concern;" guidance was provided to the states to begin identifying these species. For the first iteration of the Plan, completed in 2005, SCDNR recognized the importance of including species that are currently rare or designated as at-risk, those for which we have knowledge deficiencies, and those that have not received adequate conservation attention in the past. Additionally, SCDNR included species for which South Carolina is "responsible," that is, species that may be common in our state, but are declining or rare elsewhere. SCDNR also included species that could be used as indicators of detrimental conditions. These indicator species may be common in South Carolina; however, changes in their population status would likely indicate stress to other species that occur in the same habitat.

The diversity of animals in South Carolina is vast (Fig. 2-1). Habitats in this state range from the mountains to the ocean and include many different taxonomic animal groups. SCDNR wanted to address as many of those groups as possible for inclusion in the list of priority species (also referenced as SGCN) for the SWAP. Therefore, 15 taxonomic groups are included in the Strategy: mammals, birds, reptiles, amphibians, freshwater fish, diadromous fish, marine fish, marine invertebrates, crayfish, freshwater shrimp, freshwater mussels, freshwater snails, leeches (freshwater, marine, and terrestrial), insects (freshwater and terrestrial), and plants. Both leeches and plants are new additions to the 2015 SWAP. Though not a requirement of the SWG program, the inclusion of plants is a proactive response to the need for landscape-level management, wherein plants are an integral component. Other taxonomic groups that are excluded from this version of the SWAP may be included in future revisions of the Action Plan as additional information and experts specific to those groups are identified.

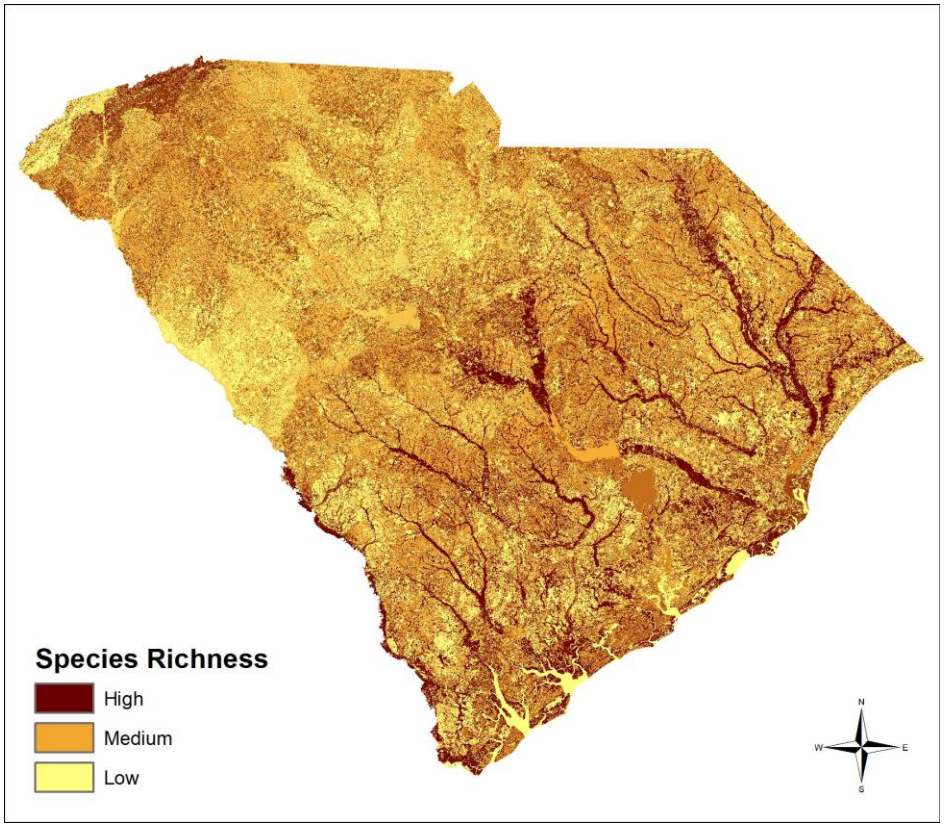


FIGURE 2-1: Total species richness in South Carolina

After the 15 taxonomic groups were identified, a taxa leader was appointed that managed the process for identifying priority species for conservation within that group. This leader formed a committee of experts for the particular taxa. First, the committee reviewed a list of all known species within that group that are found in South Carolina. The SCDNR maintains lists of rare, threatened and endangered plants and animals as part of the Heritage Trust and Endangered Species programs. One list comprises species that are officially designated as endangered or in need of management (threatened). This list was created under the SC Nongame and Endangered Species Act, and applies only to animals; it can only be modified through the regulatory process. The second list comprises species, both plants and animals, thought to be rare, declining, or their population status is unknown. These are termed "Species of Concern," and correspond to the "Watch List" species in other states. The Species of Concern list does not carry the weight of law and is used only as a conservation tool to assist in protection planning and to direct research and survey efforts.

There are various other definitions assigned to species indicating rarity, extinction risk, or trends that may be discussed within the various species or guild accounts in the SWAP's Supplemental Volume and may cause some confusion for the reader. Within the federal government, there are Threatened and Endangered species which are protected under the Endangered Species Act (ESA). In addition, other designations exist. "At-Risk Species" are those species (plants and animals) that have either been proposed for listing, are candidates for listing, or have been petitioned for listing under the ESA. Candidate species are those species (plants and animals) for which the Service has sufficient information on their biological status and threats to propose

them as Threatened or Endangered under the ESA but for which the development of a proposed listing regulation is precluded by other higher priority listing activities. Candidate species receive no statutory protection under the ESA, but the Service encourages their consideration in environmental planning. Although not required by law, it is the Service's policy to monitor candidate species. Organizations also have their own priority designations such as Partners In Flight's (PIF) Watch List species, the International Union for Conservation of Nature's (IUCN) Red List Species, and NatureServe's state and global rankings (S and G ranks). Various reports also include their own scoring systems with associated tiers of species.

After the species lists were assembled, SCDNR developed a list of 8 criteria for consideration in the determination of priority species and are presented in Box 2-1. It should be noted that some taxa groups had more data available than others to utilize when listing and ranking their species of concern so more than these 8 factors could be considered by the various taxa groups when making their decisions.

BOX 2-1: EIGHT CRITERIA USED FOR DETERMINATION OF SGCN

- State and federal protection status: endangered, threatened, rare or special concern
- South Carolina Natural Heritage Program state rank: S1 through S5
- Degree of exploitation/harvest: high, medium or low
- Availability of past or current funding to address species challenges
- Feasibility measure: the likelihood that conservation activities in South Carolina can make a difference for this species
- Knowledge of the species' population status: status mostly known, slightly known or unknown
- Knowledge of species' distribution in the state: distribution mostly known, slightly known or unknown
- Knowledge of limiting factors affecting the species: limiting factors mostly known, slightly known or unknown
- Population status (trend): population decreasing, stable or increasing

The process for determining priority species by each taxa committee is identified herein for each taxa group and was utilized in 2005 and in the 2015 revision. South Carolina's Priority Species List is presented in its entirety in Appendix 1 A-D which also details each species' priority habitat associations as determined by the taxa committees and consulting the texts of Hamel (1992), Trani et al. (2007), and Wilson (1995). Appendix 1 is broken into terrestrial ecosystems (1-A), freshwater ecobasins (1-B), marine habitats (1-C), and plant ecoregion associations (1-D).

After determining which species would be included on South Carolina's Priority Species List, taxa committees categorized species into three groups: Highest, High and Moderate Priority. Once the lists were complete, species or guild/group accounts were prepared for each animal on South Carolina's Priority Species List, with the exception of plants. Specific accounts were not prepared for plants due to the large number of species and the limited knowledge for those species.

For those species that received an account in the Supplemental Volume, each followed the following format: authors described the species, their status, population size and distribution, habitat requirements, challenges faced, conservation accomplishments and conservation recommendations. This approach allowed for identification of both general conservation strategies for wildlife and habitats in South Carolina, as well as development of species-based conservation strategies. The latter allows for management of particular species within a given habitat. The separate volume, **Supplemental Volume: Priority Species and Habitat Accounts**, contains these reports in their entirety. Authors were often taxa team members, but not necessarily; they may have been consultants.

The total number of species included in South Carolina's 2015 SWAP is 496 members of the animal kingdom and 333 plants for a grand total of 829. Table 2-1 identifies the number of species included in each taxa group. Additionally, Table 2-2 presents the list of species that were prioritized by taxa committees. As with first drafts, mistakes were made in the 2005 version of the Plan in the form of typographical errors, incorrect nomenclature, or inaccurate guild placement. These were corrected for the 2015 revision of the SWAP. Within the Supplemental Volume's species/guild accounts, changes have been made. Species S and G ranks have been updated along with the newest available data to report. New threats were identified in some cases (i.e. see bats and Eastern woodrat). Some of the conservation recommendations have been accomplished and were thus moved to/discussed in the species/guild's conservation accomplishments section. In addition, any ongoing or new recommendations were kept or added.

TABLE 2-1: NUMBER OF SOUTH CAROLINA SPECIES OF GREATEST CONSERVATION NEED BY TAXA

Taxa	No. of Species
Mammals (Terrestrial and Marine)	32
Birds	164
Reptiles and Amphibians	54
Freshwater Fish	57
Diadromous Fish	6
Crayfish (Freshwater and Terrestrial)	24
Freshwater Shrimp	1
Freshwater Mussels	28
Freshwater Snails	3
Leeches	4
Marine Fish	37
Marine Invertebrates	54
Insects	32
Plants	*333*
Total Number of Animals Species	**496**
Grand Total of All Species (including plants)	**829**

TABLE 2-2: CATEGORIZED PRIORITY SPECIES (SGCN)

Taxa	Highest Priority	High Priority	Moderate Priority
Mammals	Big Brown Bat Florida Manatee Eastern Small-footed Myotis Hoary Bat Little Brown Bat Northern Long-eared Bat Northern Yellow Bat Rafinesque's Big-eared Bat Red Bat Seminole Bat Silver-haired Bat Southeastern Bat Tri-colored Bat	Appalachian Cottontail Bottlenose Dolphin Carolina Red-backed Vole Dwarf Sperm Whale Hairy-tailed Mole Humpback Whale Masked Shrew Meadow Vole Mink North Atlantic Right Whale Pygmy Sperm Whale Star-nosed Mole Swamp Rabbit	Black Bear Eastern Spotted Skunk Eastern Woodrat Pygmy Shrew (Southern) Southern Fox Squirrel Woodland Jumping Mouse
Birds	American Bittern American Black Duck American Golden Plover American Kestrel American Oystercatcher Bachman's Sparrow Black-crowned Night Heron Black Rail Black Scoter Black Skimmer Black-throated Green Warbler Buff-breasted Sandpiper Cerulean Warbler Clapper Rail Common Ground-dove Common Tern Golden-winged Warbler Grasshopper Sparrow Green Heron Gull-billed Tern Henslow's Sparrow Horned Grebe King Rail Least Bittern Least Tern Lesser Scaup Little Blue Heron Loggerhead Shrike Long-billed Curlew Marbled Godwit Northern Bobwhite Northern Pintail Painted Bunting (Eastern) Pied-billed Grebe Piping Plover Prairie Warbler Purple Gallinule Red-cockaded Woodpecker Red Crossbill Red Knot Reddish Egret Royal Tern Ruddy Turnstone	Acadian Flycatcher American Avocet Bald Eagle Baltimore Oriole Belted Kingfisher Black-and-white Warbler Black-bellied Plover Black-billed Cuckoo Brown Pelican Canvasback Chimney Swift Chuck-will's-widow Dunlin Eastern Kingbird Eastern Meadowlark Eastern Towhee Eastern Wood-pewee Field Sparrow Forster's Tern Great Egret Greater Scaup Greater Yellowlegs Kentucky Warbler Least Sandpiper Lesser Yellowlegs Louisiana Waterthrush Mallard Prairie Warbler Purple Martin Purple Sandpiper Redhead Royal Tern Semipalmated Sandpiper Sora Stilt Sandpiper Swaison's Warbler Tricolored Heron Virginia Rail Whip-poor-will (Eastern) White-winged Scoter Willet Wood Duck Wood Thrush Yellow-billed Cuckoo Yellow-breasted Chat	American Coot American Woodcock Anhinga Baird's Sandpiper Barn Owl Bewick's Wren Black-throated Blue Warbler Blue Grosbeak Blue-winged Teal Blue-winged Warbler Broad-winged Hawk Brown-headed Nuthatch Brown Thrasher Carolina Chickadee Carolina Wren Chestnut-sided Warbler Common Gallinule Common Loon Common Raven Dark-eyed Junco Dickcissel Downy Woodpecker Glossy Ibis Golden-crowned Kinglet Gray Kingbird Great Blue Heron Hooded Warbler Indigo Bunting Long-billed Dowitcher Macgillivray's Seaside Sparrow Mottled Duck Northern Parula Orchard Oriole Pectoral Sandpiper Peregrine Falcon Pileated Woodpecker Pine Warbler Prothonotary Warbler Red-bellied Woodpecker Red-breasted Nuthatch Red-headed Woodpecker Red-shouldered Hawk Ring-necked Duck

Taxa	Highest Priority	High Priority	Moderate Priority
Birds (continued)	Ruffed Grouse Rusty Blackbird Sanderling Sandwich Tern Sedge Wren Short-billed Dowitcher Solitary Sandpiper Swainson's Warbler Swallow-tailed Kite Upland Sandpiper Wayne's Black-throated Green Warbler Western Sandpiper Whimbrel White Ibis Wilson's Plover Wood Stork Wood Thrush Yellow-crowned Night Heron Yellow Rail	Wilson's Snipe	Rosette Spoonbill Scarlet Tanager Semipalmated Plover Snowy Egret Spotted Sandpiper Summer Tanager Tundra Swan White-eyed Vireo White-rumped Sandpiper Worm-eating Warbler Yellow-throated Vireo Yellow-throated Warbler
Reptiles and Amphibians	Bog Turtle Broad-striped Dwarf Siren Chamberlain's Dwarf Salamander Coal Skink Coral Snake (Harlequin) Flatwoods Salamander Florida Green Watersnake Gopher Frog (Carolina) Green Salamander Green Sea Turtle Gopher Tortoise Hawksbill Sea Turtle Island Glass Lizard Kemp's Ridley Sea Turtle Leatherback Sea Turtle Loggerhead Sea Turtle Milk Snake (Eastern) Mimic Glass Lizard Patch-nosed Salamander Pine Barrens Treefrog Pine Snake (Northern & Florida) Shovel-nosed Salamander Southern Hognose Snake Tiger Salamander Webster's Salamander	Black Swamp Snake Diamondback Terrapin Dwarf Black-bellied Salamander Eastern Diamondback Rattlesnake Florida Softshell Turtle Four-toed Salamander Mud Salamander (Gulf Coast) Pickerel Frog Pine Woods Snake Seepage Salamander Spotted Turtle Timber Rattlesnake Wood Frog Yellow-bellied Slider	American Alligator Bird-voiced Treefrog Chicken Turtle Eastern Box Turtle Northern Cricket Frog Painted Turtle (Eastern) River Cooter Florida Cooter Slender Glass Lizard Snapping Turtle (Common) Spiny Softshell Turtle Striped Mud Turtle Upland Chorus Frog
Freshwater Fishes	Bluebarred Pygmy Sunfish Bridle Shiner "Broadtail" Madtom Carolina Pygmy Sunfish Christmas Darter Highfin Carpsucker "Bartram's" Redeye Bass Robust Redhorse Sandhills Chub Savannah Darter "Thinlip" Chub	Bannerfin Shiner Blackbanded Sunfish Carolina Darter Carolina Fantail Darter "Carolina" Redhorse Piedmont Darter Pinewoods Darter Quillback Santee Chub Seagreen Darter "Smoky" Sculpin Turquoise Darter	Banded Killifish Banded Sunfish Blacknose Dace Central Stoneroller Comely Shiner Eastern Brook Trout Everglades Pygmy Sunfish Fieryblack Shiner Flat Bullhead Florida Gar Greenfin Shiner Highback Chub Highfin Shiner

			Ironcolor Shiner Lowland Shiner Mirror Shiner Notchlip Redhorse Redlip Shiner Rosyface Chub Rosyside Dace Sandbar Shiner Satinfin Shiner Sawcheek Darter Snail Bullhead Striped Bass Swallowtail Shiner Swampfish Tennessee Shiner Thicklip Chub V-lip Redhorse Warpaint Shiner White Catfish Whitemouth Shiner Whitetail Shiner
Diadromous Fishes	American Eel American Shad Atlantic Sturgeon Blueback Herring Hickory Shad Shortnose Sturgeon		
Crayfish	"A Crayfish" (*Cambarus* sp. nov. "B") Chauga Crayfish Edisto Crayfish Mimic Crayfish Newberry Burrowing Crayfish Pine Savannah Crayfish Red Burrowing Crayfish Saluda Burrowing Crayfish	Broad River Spiny Crayfish Piedmont Prairie Burrowing Crayfish Waccamaw Crayfish	Black Mottled Crayfish Brushnose Crayfish Carolina Needlenose Crayfish Carolina Sandhills Crayfish Cedar Creek Crayfish Coastal Plain Crayfish Ditch Fencing Crayfish Hummock Crayfish Pee Dee Lotic Crayfish Rocky River Crayfish Santee Crayfish Shaggy Crayfish Wandering Crayfish
Freshwater Shrimp			Ohio River Shrimp
Freshwater Mussels	Atlantic Pigtoe Barrel Floater Brook Floater Brother Spike Carolina Creekshell Carolina Heelsplitter Creeper Eastern Rainbow Notched Rainbow Savannah Lilliput Triangle Floater Waccamaw Spike Yellow Lampmussel	Alewife Floater Altamaha Archmussel Atlantic Spike Eastern Lampmussel Eastern Pondmussel Northern Lance Pod Lance Rayed Pink Fatmucket Roanoke Slabshell Tidewater Mucket	Carolina Elephantear Carolina Lance Eastern Creekshell Eastern Elliptio Variable Spike
Freshwater Snails		Buffalo Pebblesnail Panhandle Pebblesnail Ridged Lioplax	
Freshwater, Marine, and Terrestrial		"A terrestrial leech" (*Haemopis septagon*) New England Medicinal	Biannulate Leech "A marine leech" (*Branchellion ravenelii*)

Leeches		Leech	
Marine Fish	Carolina Hammerhead Gafftopsail Catfish Hardhead Catfish Scalloped Hammerhead Southern Flounder	Bonnethead Cobia Mummichog Tarpon Weakfish	Atlantic Bumper Atlantic Croaker Atlantic Menhaden Atlantic Spadefish Black Drum Blackcheek Tonguefish Blacktip Shark Bluefish Bull Shark Cownose Ray Fringed Flounder Gag Hogchoker King Mackerel Lemon Shark Off-shore Tonguefish Red Snapper Sheepshead Silver Perch Smooth Dogfish Southern Kingfish Spanish Mackerel Spinner Shark Spot Striped Mullet Tiger Shark Tomtate
Marine Invertebrates	Atlantic Blue Crab Atlantic Horseshoe Crab	Crested Oyster	"A polychaete" (*Aphelochaeta* sp.) "A polychaete" (*Arabella mutans*) "A polychaete" (*Capitella capitata*) "A polychaete" (*Caulleriella* sp.) "A polychaete" (*Drilonereis longra*) "A polychaete" (*Glycera americana*) "A polychaete" (*Glycera dibranchiata*) "A polychaete" (*Laeonereis culveri*) "A polychaete" (*Mediomastus* sp.) "A polychaete" (*Monticellina* sp.) "A polychaete" (*Paraonis fulgens*) "A polychaete" (*Scolelepis* sp.) "A polychaete" (*Streblospio benedicti*) "A polychaete" (*Tharyx acutus*) "An amphipod" (*Acanthohaustorius millsi*) "An amphipod" (*Ampelisca abdita*) "An amphipod" (*Neohaustorius schmitzi*) "An amphipod" (*Parahaustorius longimerus*) "An amphipod" (*Protohaustorius wigleyi*) "An amphipod" (*Rhepoxynius hudsoni*) "An isopod"

			(*Cyathura* sp.) "An oligochaete/sludge worm" (*Tubificoides* sp.) "An oligochaete/sludge worm" (*Tubificoides wasselli*) "An amphipod" (*Lepidactylus dytiscus*) Atlantic Brief Squid Atlantic Ghost Crab Atlantic Mud Crab Atlantic Sand Fiddler Crab Brackish Grass Shrimp Brown Shrimp Cannonball Jellyfish Channeled Whelk Colorful Sea Whip Common Southern Clamworm Coquina Clam Daggerblade Grass Shrimp Dwarf Surf Clam Eastern Oyster Florida Stone Crab Knobbed Whelk Lightning Whelk Marsh Grass Shrimp Marsh Periwinkle Mud Fiddler Crab Northern Pink Shrimp Northern Quahog Northern White Shrimp Red-jointed Fiddler Crab Ribbed Mussel Southern Quahog Tellin Clam species (*Tellina* sp.)
Plants	Black-spored Quillwort Bog Asphodel Bunched Arrowhead Canby's Dropwort Chaffseed Dwarf-flowered Heartleaf Georgia Aster Harperella Miccosukee Gooseberry Michaux's Sumac Mountain Sweet Pitcher-plant Pondberry Pool Sprite Reflexed Blue-eyed Grass Relict Trillium Rocky Gnome Lichen Rough-leaved Loosestrife Schweinitz's Sunflower Seabeach Amaranth Small Whorled Pogonia Smooth Coneflower Swamp-pink White Fringeless Orchid	Alexander's Rock Aster American Ginseng Appalachian Lophocolea Awned Meadowbeauty Bay Starvine Beak Rush Biltmore Sedge Blue Ridge St. John's-wort Blue-Ridge Bittercress Bog Spicebush Boykin's Lobelia Broad-leaved Tickseed Brown Beaked-rush Bryocrumia Moss Carey Saxifrage Carolina Bird-in-a-nest Carolina Bugleweed Carolina Campylopus Moss Carolina Dropseed Carolina Goldenrod Carolina Grass-of-parnassus Chapman's Redtop Chapman's Sedge Chapman's Yellow-eyed Grass Ciliate-leaf Tickseed Climbing Fetter-bush Clingman's Hedge-nettle Creeping St. John's-wort Crestless Plume Orchid Cypress-knee Sedge Dune Bluecurls Earleaf Foxglove Elliott's Croton Evan's Cheilolejeunea False Dandelion Florida Dropseed	Acid-swamp Yellow-eyed Grass Aethusa-like Trepocarpus Alabama Black Cherry Algae-like Pondweed American Bog Violet American Golden-saxifrage American Lily-of-the-valley American Water-pennywort Appalachian Pellia Appalachian Sedge Ashy-hydrangea Bartram's Rose-gentian Beakrush Bearded Milk-vetch Biennial Gaura Bigleaf Magnolia Black Huckleberry Black-stem Spleenwort Blue-grass Bluff Oak Bog Oat-grass Bottom-land Post Oak Bradley's Spleenwort Bristle-fern Canada Burnet Canada Lily Carolina Dog-hobble Carolina Fluff Grass Carolina Larkspur Carolina Lilaeopsis Carolina St. John's-wort Carolina Whitlow-grass Catawba Rhododendron Cayaponia Cliff-brake Fern Coastal Plain False-foxglove

		Florida Thorough-wort	Coastal-plain Thorough-wort
		Fort Mountain Sedge	Coastal-plain Water-hyssop
		Fraser Loosestrife	Corymb Fiddleleaf
		Georgia Oak	Crinkled Hairgrass
		Georgia Plume	Culver's-root
		Giant Spiral Ladies'-tresses	Deep-root Clubmoss
		Godfrey's Privet	Deer-haired Bulrush
		Godfrey's Stitchwort	Dutchman's Breeches
		Gorge Leafy Liverwort	Dwarf Juniper
		Granite Dome Goldenrod	Dwarf Milkwort
		Granite Rock Stonecrop	Eared Goldenrod
		Harper's Fimbry	Early Buttercup
		Harper's Yellow-eyed Grass	Eastern Wahoo
		Hooker's Milkwort	Eel-grass
		Incised Groovebur	Eggert's Sunflower
		Lance-leaf Seedbox	Elliott's Bluestem
		Large-leaved Grass-of-parnassus	Elliott's Milkpea
		Lejeunea blomquistii	Elliott's Sedge
		("A Liverwort")	Engelmann's Quillwort
		Sharp's Leptohymenium Moss	False Rue-anemone
		Lobelia sp. 1	Featherfoil
		Long Beach Seedbox	Fernleaf Phacelia
		Many-flower Grass-pink	Florida Adder's-mouth
		May White	Florida Bladderwort
		Mountain Wavy-leaf Moss	Georgia Beargrass
		Mountain Witch-alder	Georgia Leadplant
		Narrow-fruited Beaksedge	Glade Fern
		Narrow-leaved Trillium	Golden-heather
		Oconee-bells	Goldie's Woodfern
		Oglethorpe's Oak	Gopher-apple
		Open-ground Whitlow-grass	Granite-loving Flatsedge
		Ovate Catchfly	Grassleaf Arrowhead
		Pale Beakrush	Gray-head Prairie Coneflower
		Panhandle Lily	Great Indian Plantain
		Piedmont Azalea	Greater Bladderwort
		Piedmont Cowbane	Gum Bully
		Piedmont Quillwort	Gum Bumelia
		Piedmont Ragwort	Hairy Fever-tree
		Piedmont Strawberry	Harper Beakrush
		Piedmont Water-milfoil	Harper's St. John's-wort
		Pine Barren Gentian	James' Sedge
		Pine Barrens Boneset	Kidneyleaf Mud-plantain
		Pineland Dropseed	Kidney-leaf Twayblade
		Pineland Plantain	Lace-lip Ladies'-tresses
		Plagiochila sharpii	Lance-leaf Loosestrife
		("A Liverwort")	Large Twayblade
		Plagiochila sullivantii	Large-flower Milkweed
		("A Liverwort")	Large-flower Trillium
		Pringle's Platyhypnidium Moss	Large-fruited Sanicle
		Plymouth Gentian	Large-stem Morning-glory
		Pondspice	Leafless Swallow-wort
		Purple Balduina	Least Trillium
		Radford's Sedge	Leconte Flatsedge
		Rain Lily	Limestone Petunia
		Reclined Meadow-rue	Lobed Spleenwort
		Rose Coreopsis	Long Sedge
		Sandhills Heartleaf	Long-beaked Baldrush
		Sandhills Milkvetch	Longleaf Cupgrass
		Shiny Spikegrass	Long-spike Fluff Grass
		Shoals Spider-lily	Longstalk Sedge
		Small-flowered Buckeye	Longstem Adder's-tongue Fern
		Small's Purslane	Manhart Sedge
		Southern Nodding Trillium	Marshland Flatsedge
		Spatulate Seedbox	Missouri Rock-cress
		Spring-flowering Goldenrod	Mohr's Three-awn Grass
		Sun-facing Coneflower	Mullein Foxglove
		Sweet Pinesap	Myrtle-leaf Oak
		Sweet White Trillium	Narrow-leaved Vervain
		Taylor's Fern	Needle Palm
		Venus' Fly-trap	Nodding Pogonia

		Wateree Trillium White-wicky Winter Quillwort Wire-leaved Dropseed	Nuttall Warea Ogeechee Tupelo Ovate Marsh Fern Pale Jewel-weed Pale Manna Grass Piedmont Cucumber Tree Pine-barrens Reed-grass Pineland Yellow-eyed Grass Pinelands Mountain Mint Pocosin Beaksedge *Porella japonica* ssp. *appalachiana* ("A Liverwort") Prairie Goldenrod Prairie Rosinweed Pretty Sedge Purple-stem Cliff-brake Pyramid Magnolia Ravenel's Eryngo Rayner's Blueberry Reticulated Nutrush Rock Clubmoss Rose Balm Rough Thoroughwort Running Pine Rusty Lyonia Salt-marsh False-foxglove Sampson Snakeroot Sandhills Rosemary Sandhills Wild Petunia Savannah Yellow-eyed Grass Schwerin Indigobush Shooting-star Short-bristle Baldrush Shortleaf Sneezeweed Short-leaved Yellow-eyed Grass Single-haired Mountain-mint Single-sorus Spleenwort Slender Gayfeather Slender Naiad Slender Sedge Small Sundrops Small-head Gayfeather Small's Bog Button Smooth Hedge-nettle Smooth Three-parted Violet Social Sedge Soft Groovebur Soft-hair Coneflower Soft-haired Thermopsis Southern Horse-balm Southern Privet Southern Thimble-weed Spike-rush Spinulose Shield Fern Spoon-flower Stiff Dogwood Swamp White Oak Sweet Fern Tall Bellflower Texas Pipewort Thread-leaf Sundrops Tuberous Gromwell Tunbridge Fern Tussock Sedge Twig Rush Twisted Yellow-eyed-grass Two-leaf Bishop's-cap Two-wing Silverbell Vahl Fimbry Virginia Spiderwort

			Viviparous Spike-rush Wagner's Spleenwort Walter's Iris Well's Pixie-moss West Indian Meadow-beauty Whisk Fern White Beakrush White Colicroot White False-asphodel White-leaved Sunflower Whorled Horse-balm Wild Bleeding-heart Wing-podded Purslane Winter Grape-fern Woods-rush Woody Goldenrod Woolly Dutchman's-pipe Woolly Huckleberry Yellow Birch Yellow Fringeless Orchid Yellow Sunnybell Yellowwood

Table 2-3 contains those priority insect species that are unable to be ranked at this time but for which species accounts are available in the Supplemental Volume.

TABLE 2-3: UNRANKED PRIORITY INSECT SPECIES*

"A Mayfly" *(Acanthametropus Pecatonica)*	Elephant (Tree Hole Mosquito) *(Toxorhynchites rutilus septentionalis)*
"A Mayfly" *(Arthroplea bipunctata)*	Forestiera Lace Bug *(Leptoypha elliptica)*
"A Mayfly" *(Barbaetis benfieldi)*	Forestiera Lace Bug *(Leptoypha ilicis)*
"A Mayfly" *(Heterocloeon berneri)*	Hairy Springfly
"A Mayfly" *(Homoeoneuria dolani)*	Moretti's Protoptila Caddisfly
"A Mayfly" *(Maccaffertium lenati)*	Pointy-Lobed Firefly
"A Mayfly" *(Tsalia berneri)*	Pyramid Ant *(Dorymyrmex bureni)*
"A Moth" *(Agnorisma bolli)*	Pyramid Ant *(Dorymyrmex medeis)*
"A Mayfly" *(Siphlonurus decorus)*	Sandhills Earth Boring Scarab Beetle
American Sand Burrowing Mayfly	Savannah Willowfly
Arogos Skipper	Smokies Needlefly
Black Fly	Smokies Stripetail
Blackwater Sallfly	Two-Spotted Skipper
Calvert's Emerald	White Beach Tiger Beetle
Coyle's Purseweb Spider	Zigadenus Sawfly
Diana Fritillary	
Elephant (Tree Hole Mosquito) *(Toxorhynchites rutilus rutilus)*	

* Due to a lack of data, these species cannot be ranked at this time. However, species/guild accounts are provided in the Supplemental Volume.

Conservation Action Prioritization

Once species were prioritized, it was necessary to determine the priority of conservation actions that need to be implemented to conserve those species. The vast number of species in the SWAP and conservation actions necessary for each of those species is staggering. It is apparent that all of the species in the Plan are important to the natural diversity of South Carolina and should be conserved. However, it is also apparent that it would be impossible to immediately implement all the conservation actions developed for inclusion in the SWAP. Therefore, conservation actions were consolidated because it was necessary to use a realistic approach to determine which

BOX 2-3: SIX CRITERIA USED FOR DETERMINATION OF PRIORITY CONSERVATION ACTIONS

- **Feasibility:** Challenges can be mitigated, solutions are apparent. SCDNR can feasibly staff and implement the action and the results will be beneficial.
- **Opportunity**: SCDNR is able to implement the conservation action (i.e., opportunities exist; SCDNR has the authority to carry out the action).
- **Benefit**: Implementation of the action will result in benefits to the natural diversity of South Carolina. Benefits are considered in terms of unit of effort to achieve those benefits; that is, implementation results in multiple benefits to a given species or multiple species are benefited by a single action.
- **Proactive**: Implementation will result in proactive changes to address challenges; actions are more than a reactive response to ongoing challenges.
- **Partnerships**: Partnership opportunities exist for implementation, which provides the ability to leverage other resources.
- **Funding**: Implementation is eligible for SWG funding and/or matching funds exist.

conservation actions would be implemented first; that is, which actions would receive the highest priority in South Carolina. SCDNR's goal was to identify conservation actions that could realistically be executed and benefit the most priority species. A steering committee was thus formed in 2005 in order to accomplish conservation action prioritization. This committee consisted of senior personnel within the SCDNR. The members of this committee were asked to consider the 6 criteria when ranking conservation actions, which are presented in Box 2-3. For this current iteration of the Action Plan, no new steering committees were formed as the previously set objectives and goals are still in place. Each of the priority conservation actions identified were then attempted over the years and the measures of success documented in Chapter 5: Statewide Conservation Strategies.

CHAPTER 3: TAXONOMIC GROUPS

This chapter contains an introduction to each taxonomic group considered in the SWAP. The species selection process used by each committee is also included. Many existing conservation plans were consulted during the selection process and are listed in Appendix 2. Finally, a summary of the threats for each taxonomic group is listed in this chapter. Lack of knowledge of population size, distribution, and life histories was considered a challenge to many of the species in South Carolina's SWAP.

Mammals

According to the American Society of Mammalogists, South Carolina is home to approximately 101 native species of mammals with a higher diversity found in the Coastal Plain and the Mountains (Fig. 3-1). The largest group of mammals in the Southeast is the rodents at around 36 members. However, back in colonial times, South Carolina was also home to several additional species including the buffalo, elk, red wolf, gray wolf, and eastern cougar. Overhunting, persecution, and habitat changes eventually led to their extinction in the region. Declines in other species such as white-tailed deer in sections of the State prompted the creation of restocking programs beginning in 1951 and ending in 1989 which were extremely successful. Because all 642 deer were not brought in from other states in order to accomplish this, the genetic integrity of the species was retained (C. Ruth, pers. comm.). Beavers, which had been extirpated in the 1800s, were reintroduced to the Pee Dee region in the 1940s by the US Fish and Wildlife Service. Fox squirrels have also been translocated from healthy populations in the State to depauperate areas in the Coastal Plain by SCDNR, the University of Georgia, and other private entities (B. Dukes, pers. comm.). We are now experiencing changes in the State's mammalian assemblage once again as new species colonize the landscape. Some have been introduced by humans, as in the case of coyotes and feral pigs, while others have made it here on their own such as the nine-banded armadillo.

The following mammal species are legally classified as furbearers and may be taken by hunting or trapping during the open season by those with a valid license: bobcat, coyote, red fox, gray fox, opossum, raccoon, otter, mink, weasel, striped skunk, spotted skunk, muskrat and beaver. All of these species, except for the coyote, are also classified as small game. Although the spotted skunk, mink, Appalachian cottontail, swamp rabbit, Southern fox squirrel, and black bear are considered priority species for the purposes of the SWAP, they are still game animals capable of being harvested. Their populations are currently stable and hunting has not been found to be a threat to their continued existence in the State. They are monitored here due to concerns about potential population fluctuations.

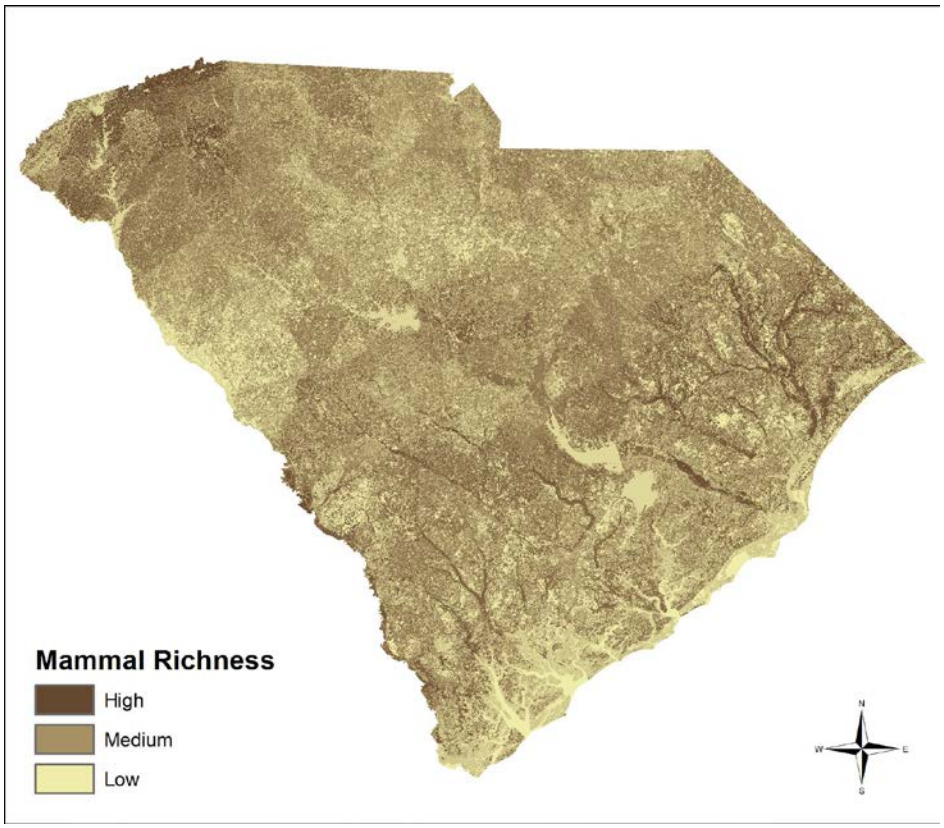


FIGURE 3-1: Mammal richness in South Carolina

Species Selection Process

State and regional experts periodically review rankings and designations for all mammal species in South Carolina. The last terrestrial mammal review, conducted in 2001, had 39 species listed for discussion. Included among those were 4 subspecies, an extirpated species, some species never reported in South Carolina but found in neighboring states, and all of the mammalian species tracked by the SCDNR's Heritage Trust database. For the purposes of the 2005 Plan, the list was narrowed to 27 mammals and was sent to experts for review in this conservation planning process. Ultimately, 24 mammals were chosen for inclusion on South Carolina's Priority Species List.

In 2012, the final list was revisited by the new taxa committee. There were no deletions to the list and 8 additions. The additional species included all of South Carolina's colonial cavity roosting bats and foliage roosting bats. Upon the discovery of White-nose Syndrome (WNS) in 2006, these bats were immediately considered at risk due to their roosting and swarming behavior and were placed in the "highest" priority category within the SWAP. In addition, the subspecies name of the fox squirrel, the Southern fox squirrel, was corrected in the listing. The Atlantic right whale was also renamed to specify that the North Atlantic right whale was the priority species being considered here.

Many of the experts contacted in this process have previously participated in reviews of mammal rankings and designations for South Carolina; several were involved in conservation

prioritization in neighboring states. The information about mammals contained in the SWAP was supplied by the expertise of several biologists who formed our Mammal Taxonomic Committee. The members of that committee invested considerable time to the development of the SWAP and are graciously thanked for their efforts; these individuals are listed in Table 2-3. Other sources of information included published literature and unpublished data from a number of sources.

TABLE 2-3: MAMMAL TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Craig Allen	South Carolina Cooperative Fish and Wildlife Res. Unit
Mary Bunch	South Carolina Department of Natural Resources
Jay Butfiloski	South Carolina Department of Natural Resources
Julia Byrd	South Carolina Department of Natural Resources
John Cely	South Carolina Department of Natural Resources
David Cupka	South Carolina Department of Natural Resources
Steve Fields	Culture & Heritage Museums
Rudy Mancke	University of South Carolina
Alex Menzel	United States Fish and Wildlife Service
Wayne McFee	National Oceanic and Atmospheric Administration
Sally Murphy	South Carolina Department of Natural Resources
Tom Murphy	South Carolina Department of Natural Resources
Jim Ozier	Georgia Department of Natural Resources
Toni Piaggio	University of Colorado, Boulder
Perry Shatley	United States Forest Service
Oscar Stewart	United States Forest Service
Johnny Stowe	South Carolina Department of Natural Resources
Heather Thomas	Auburn University
William David Webster	University of North Carolina Wilmington

Because South Carolina started the 2005 prioritization process after the same process was well underway in North Carolina and Georgia, SCDNR was able to benefit from the information those states had accumulated and shared. In 2012, we again consulted with our partners in other states and utilized similar methods for species prioritization.

Reviewers were asked to rank each species using the eight criteria for consideration in species prioritization outlined in Chapter 2. Species or subspecies were added or dropped from the list if two or more reviewers suggested the addition/deletion. If one reviewer clearly stated the group should keep a species on the list and another suggested dropping the species, the species remained on the list. Potential species (those without museum records in South Carolina) were dropped from the list. Species/guild accounts can be found in the Supplemental Volume and habitat associations in Appendix 1-A.

The intent of the conservation planning process is to periodically revisit the priority list and adjust it as more is learned about each species, as was the case with the bats. With this group in particular, more acoustical research had been conducted in the interim since the 2005 Plan to provide us with better baseline data for prioritization which will be beneficial in tracking future population decreases due to white-nose syndrome. South Carolina plans to initiate a statewide bat acoustic survey using North American Bat Monitoring Program (NABat) protocols starting in 2015.

Challenges

One of the major challenges to mammals in South Carolina is loss, fragmentation and/or alteration of habitat. As urban development expands in this state, changes to forests and grasslands often lead to outright loss or degradation of foraging, roosting (bats), and denning/nesting habitat. Additionally, habitats are fragmented by development. Roads can limit movement of many species and often result in mortality to individuals. Coastal development can adversely affect marine mammals by increasing exposure to pollutants in stormwater runoff.

Destruction of habitat can also come in the form of wind turbines. The blades often affect bats directly when they collide with them or receive lung damage due to the pressure changes associated with the spinning turbines. One estimate suggests that the growing number of wind turbines of the Mid-Atlantic Highlands alone may cause the death of 33,000-111,000 bats annually by the year 2020 (USGS 2011 referencing Kunz et al. 2007).

Pollutants from a variety of sources can impact mammals. The mink occupies a niche at or near the top of the food chain; therefore, this species is especially vulnerable to environmental contamination, particularly from mercury and PCBs. Contamination in stormwater runoff can also pollute feeding grounds for marine mammals. Trash and litter pose challenges to both terrestrial and aquatic mammals. Small mammals can become trapped in bottles and other litter while foraging. Marine mammals can mistake plastic debris for food items; ingestion of this litter can result in death. One of the greatest challenges to marine mammals and manatees is boat strikes. An additional threat to these animals is entrapment in fishing gear, including hook and line as well as trawls.

Two diseases, raccoon roundworm and Sudden Oak Death (SOD), can adversely affect mammals in South Carolina. Raccoon roundworm can cross species boundaries to infect other mammals, resulting in death. It has been suspected in the decline of the Eastern woodrat in some states. The disease is undergoing a range expansion and may impact counties outside of the Appalachians in the near future. SOD attacks and destroys oak trees which are vital mast producers used as food sources by several mammals on South Carolina's Priority Species List including the Eastern woodrat. In addition, Hemlock Wooly Adelgid has defoliated and killed hemlocks in South Carolina, altering hemlock coves which are important to some small mammals such as masked and pygmy shrews.

Another emerging disease, WNS, affects bats. On February 21, 2013, a tri-colored bat was found dead at Table Rock State Park. Testing by the Southeastern Cooperative Wildlife Disease Study in Athens, GA confirmed that the bat had WNS, the first case in South Carolina. In April 2013, an Eastern small-footed myotis infected with the fungus was found in a more southerly portion of the same state park. The count continues. To date, 5.7 million bats have died from WNS nationwide (BCI 2012), with a decline of 70% in bat populations in the Northeast alone (USGS 2011). Bats provide pest control services to the agricultural industry in the United States, saving farmers approximately $3 billion a year (USGS 2011). For example, a single little brown bat can consume 4-8 g (0.14-0.28 oz.) of insects a night. With the threat of WNS, the US could stand to gain an additional 1,455 tons (1,320 metric tons) of insects in the Northeast alone if there are no

bats to eat them (USGS 2011). Then there are the myriad of forest insects that impact the timber industry; bats also eat these.

Introduced and non-native species can adversely affect South Carolina's mammals. Predation by domestic or feral cats and dogs can reduce population numbers. One study estimated that free-ranging domestic cats kill approximately 6.9-20.7 billion mammals each year in the United States (Loss et al. 2013). Feral hogs can destroy habitat for many species, particularly those found in wetland habitats. Gypsy moths, like SOD, can eliminate food sources for mammals by destroying important tree species. Thankfully, no gypsy moth outbreaks have been recorded in South Carolina to date although the species has been in the State since 1998.

Several species of mammals are regarded by humans as "pests;" this view can lead to persecution of these species. Examples include moles, mice, squirrels, skunks, raccoons, and bats. Black bears have increased in numbers in recent years in both the mountain and coastal population centers and they are expanding their home ranges as a result. However, this puts them in contact with people more frequently, sometimes leading to conflicts.

Finally, global warming could shift suitable high elevation habitat farther north and into higher elevations not found in South Carolina (W. Mark Ford, pers. comm.). This would affect the woodland jumping mouse and both species of moles on South Carolina's priority list.

Birds

As of 2011, 427 species of birds have been documented in South Carolina of which over 181 are classified as breeders (Cely 2003; CBC 2013), the newest being the Reddish Egret (Ferguson et al. 2005). This number may be higher due to the lack of coverage of the Breeding Bird Atlas to adequately survey the breeding distribution of colonial nesting wading birds and shorebirds. The total number of species present is comprised of resident and migrant birds with the majority of taxonomic orders of birds found in the United States being represented (Sibley 2000). South Carolina supports a high diversity of birds during breeding, wintering and migration likely due to the State's varied environments and habitats (Cely 2003). Figure 3-2 shows the bird richness in South Carolina. The National Audubon Society lists 45 sites in the State as Important Bird Areas (IBAs), 16 of which are recognized to be of global importance.

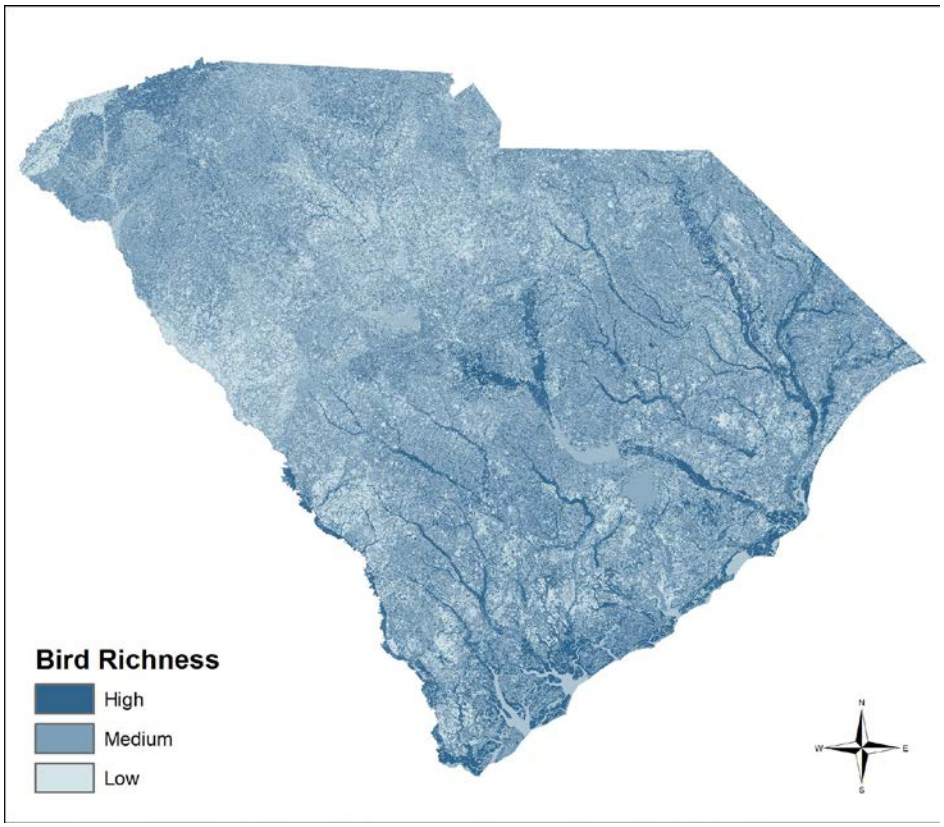


FIGURE 3-2: Bird richness in South Carolina

Three different Bird Conservation Regions (BCRs) transect South Carolina: the Southeastern Coastal Plain, Appalachian Mountains, and Piedmont. Bird Conservation Regions are a single application of a scale-flexible hierarchical framework of nested ecological units based upon the Commission for Environmental Cooperation. BCRs were adopted to provide a single map of biological units for all bird initiatives to use to attain a regional-based approach to bird conservation (US NABCI 2000). BCRs can be partitioned into smaller ecological units to facilitate finer scale planning and implementation or aggregated to facilitate greater cooperation and partnerships across political boundaries in order to recognize the migratory nature and vast annual ranges of some species.

The Appalachian Mountain BCR spans the Blue Ridge, the Ridge and Valley Region, the Cumberland Plateau, the Ohio Hills, and the Allegheny Plateau (US NABCI 2000). The Appalachian mountain BCR contains the headwaters of several major river systems (US NABCI 2000). A portion of the Blue Ridge transects three counties in the northwestern corner of South Carolina; this diverse temperate forest ecosystem supports habitats found nowhere else in the State (Barry 1980). A number of bird species are found in this portion of South Carolina that are not found elsewhere in the State including Peregrine Falcon, Ruffed Grouse, Common Raven, Red-breasted Nuthatch, Golden-crowned Kinglet, Black-throated Blue Warbler, Yellow Warbler, Chestnut-sided Warbler, Red Crossbill and Dark-eyed Junco (Cely 2003). This region also supports some of the highest breeding densities in the State of Scarlet Tanager, Louisiana Waterthrush, Worm-eating Warbler, and Black-throated Green Warbler (Cely 2003).

The Piedmont BCR is geographically part of Southern Appalachia and makes up the transitional area between the mountains and the flat coastal plain spanning from New Jersey to Alabama (US NABCI 2000). Approximately one-third of the State of South Carolina is comprised of this ecological unit (Cely 2003). This area is best characterized by oak-hickory dominated forests with associations of shortleaf and loblolly pine, black gum and sweetgum (Barry 1980). The once fertile and highly productive soils have been reduced due to past mismanagement, and the area is now subject to intensified agriculture and forest management practices (Barry 1980). The Piedmont is the main breeding area in South Carolina for several grassland and scrub/shrub birds such as Killdeer, House Wren, American Goldfinch, Song Sparrow, Field Sparrow and Grasshopper Sparrow (Cely 2003). Interior wetlands, reservoirs, and riverine systems provide migration and wintering habitat for waterfowl and some shorebirds (US NABCI 2000).

The Southeastern Coastal Plain is a huge area composed of both the South Atlantic Coastal Plain and the East Gulf Coastal Plain physiographic areas (Pashley et al. 2000). In South Carolina, the western boundary is at the Fall Line marking the edge of the hilly Piedmont; the eastern boundary is the Atlantic Ocean (Pashley et al. 2000). The major habitat types include longleaf and loblolly pine interspersed with Carolina bays and pocosins, bottomland hardwoods and maritime forests (Barry 1980). Priority species dependent upon pine habitats include Red-cockaded Woodpecker, Bachman's Sparrow, Brown-headed Nuthatch, Henslow's Sparrow and Painted Bunting (Pashley et al. 2000). Bottomland forests support high breeding densities of many Neotropical migrants including Acadian Flycatcher, White-eyed Vireo, Prothonotary Warbler, Hooded Warbler and Northern Parula (Cely 2003). The coastal intertidal habitats provide critical wintering and breeding areas for American Oystercatcher, important wintering and spring migration for Short-billed Dowitcher and Dunlin, and important fall staging areas for Red Knot (US NABCI 2000). Offshore islands and coastal areas provide important nesting and foraging habitats for Brown Pelicans, various ducks, terns, herons, egrets, ibis and other species (US NABCI 2000). Impounded wetlands (old rice fields) and backwaters are particularly important for nesting and foraging wading birds. Many impoundments are managed for waterfowl but also benefit wading birds and shorebirds. Most wading bird rookeries (excluding the Great Blue Heron) are located in the Coastal Plain, and wading birds utilize a variety of types of wetlands in this region.

In the past, the Eastern Wild Turkey would have been included in the SWAP had it not been for the efforts of the SCDNR and its partners. From 1951-2004, a total of 3,542 turkeys were restocked to 204 depauperate areas of the State under the "Turkey Project". Because all of the birds used in the program were not brought in from other states in order to accomplish this, the genetic integrity of the species was retained. Turkeys are now present in all 46 counties in South Carolina and all counties are open for hunting. This represents a great accomplishment for wildlife management in the State. [C. Ruth, pers. comm.]

Species Selection Process

The information about birds contained in the SWAP was mostly supplied by the expertise of several biologists who formed the Bird Taxonomic Committee. It was a relatively subjective review of current listings from various national plans, Partners in Flight data, and others. The members of that committee invested considerable time in the development of the SWAP and are

graciously thanked for their efforts; these individuals are listed in Table 3-2. Other sources of information included published literature and unpublished data from a variety of sources.

TABLE 3-2: BIRD TAXONOMIC COMMITTEE

(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
John Cely	South Carolina Department of Natural Resources
Elizabeth Ciuzio	Kentucky Dept for Natural Resources / US Fish and Wildlife Service
Nathan Dias	Cape Romain Bird Observatory
Billy Dukes	South Carolina Department of Natural Resources
Dennis Forsythe	The Citadel
John Gerwin	North Carolina Museum of Natural Sciences
Lex Glover	South Carolina Department of Natural Resources
Paige Grooms Koon	South Carolina Department of Natural Resources
Christy Hand	South Carolina Department of Natural Resources
Chris Hill	Coastal Carolina University
Anna Huckabee Smith	South Carolina Department of Natural Resources
Chuck Hunter	United States Fish and Wildlife Service
John Kilgo	United States Forest Service
Drew Lanham	Clemson University
Steve Lohr	United States Forest Service
Mary Catherine Martin	South Carolina Department of Natural Resources
Ken Meyers	Avian Research and Conservation Institute
Laurel Moore-Barnhill	South Carolina Department of Natural Resources
Tom Murphy	South Carolina Department of Natural Resources
Bob Perry	South Carolina Department of Natural Resources
Jamie Rader	South Carolina Department of Natural Resources
Jamie Rotenberg	University of North Carolina
Felicia Sanders	South Carolina Department of Natural Resources
Nick Wallover	South Carolina Department of Natural Resources
Craig Watson	United States Fish and Wildlife Service
Tim Jones	United States Fish and Wildlife Service
Dean Harrigal	South Carolina Department of Natural Resources

Species prioritization for birds in the first iteration of the SWAP relied heavily upon the Partners in Flight prioritization process. Partners in Flight (PIF) was initiated in the early 1990's and drew together many knowledgeable groups and individuals focused on "keeping common birds common" (Pashley et al. 2000). The first step in the PIF planning process was to set priorities (Pashley et al. 2000). The conservation assessment process evaluates species vulnerability and was developed based entirely on biological criteria (Hunter et al. 1993; Carter et al. 2000; Panjabi et al. 2001). The prioritization process is based upon 6 factors that measure aspects of vulnerability and the scores for each factor reflect the degree of each species' risk of significant population decline or range-wide extinction at the global level (Rich et al. 2004). In some cases, global assessment scores do not provide accurate prioritization lists at the bird conservation region or smaller ecological unit level. In order to accurately develop smaller scale priority lists; regional scores based on local data are needed (Hunter and Demarest 2005).

The PIF prioritization process allows species to be ranked into conservation tiers based upon combined scores. Species are also assigned a conservation action level that indicates the relative level and immediacy of conservation action based upon the sum of the assessment scores. For the purposes of this Plan, the majority of the species selected are Tier I species of high concern and

Tier II species needing additional stewardship with a conservation action level of immediate management or long-term planning and responsibility. Species selected that are in Tier III and IV represent species that are state or federally listed and/or are of local or regional interest.

Waterbird, shorebird and waterfowl conservation priority selections depended heavily on national and international conservation plans. Birds were chosen based on their continental priority listing as well as professional review of South Carolina's ecological role in the continued conservation of these birds. Plans consulted include the North American Bird Conservation Initiative (NABCI), South Atlantic Migratory Bird Initiative (SAMBI), North American Waterfowl Management Plan (NAWMP), North American Waterbird Conservation Plan (NAWCP) and the United States Shorebird Conservation Plan (USSCP). Thirty-year continental population trend data for waterfowl species was also obtained from the USFWS and professionally reviewed by committee to establish conservation priorities for migratory waterfowl. More detailed justifications for selections are included in species accounts for individuals and guilds of birds. In summary, 110 species of birds were selected for inclusion in the 2005 version of the SWAP.

The 2015 iteration of the SWAP took the original list of birds and reviewed their priority listings. In an attempt to standardize the selection process, the bird taxa committee decided to use pre-existing ranking methods of PIF, Waterbird and Shorebird Plans to reclassify the SWAP species in a comparable way. For landbirds, those with PIF categories of Critical Recovery (CR) or Immediate Management (IM) were recommended for the "highest priority" category under the SWAP. Management Attention (MA) species were put into the "high" category, and Planning and Responsibility (PR) designees went under "moderate priority" status. The database used for this purpose was the PIF species assessment for BCRs 27, 28, and 29.

Waterbirds were determined in this way: "highest priority" went to CR, IM, and MA species. "High priority" species included those in the Additional Stewardship (AS) category. "Moderate priority" species came from the listings for species that were of (1) Additional High National Responsibility and (2) Other Local or Regional Interest Species. The database used was Table 1 in the 2006 Southeast US Waterbird Conservation Plan. Shorebirds were scored based on the data in Table 1 of the 2004 US Shorebird Conservation Plan (High Priority Shorebirds section). Those of "highest" concern in the SWAP were those the Shorebird Plan considered Highly Imperiled or of High Concern. SWAP High concern species were from the Shorebird Moderate Concern list while the SWAP "moderate" listings were those of Low Concern in the Shorebird Plan.

Waterfowl ranks did not change much and roughly coincided with prioritizations by Waterfowl Conservation Region (WCR) in the North American Waterfowl Management Plan (ACJV Implementation Plan Revision, June 2005). Five ducks changed priority ranking in the 2015 iteration of the Plan.

After re-evaluation of the 2005 list of priority bird species, 48 new species were added (including subspecies) while 28 species underwent priority reassignments, including 5 ducks, 5 wading birds, 13 songbirds, and 5 miscellaneous species. The changes in priority ranking were due, in part, to the methodology change for species selection, but also new trends in populations for

these species have become available. Some species, like the Rosette Spoonbill and Reddish Egret, are becoming more common in South Carolina and thus deserve to be considered for prioritization. Mottled Ducks, though not a native species, have a large, self-sustaining population here in South Carolina and may possibly have become established here anyway as ranges expanded (D. Harrigal, pers. comm.).The total number of birds included in the 2015 edition of the SWAP is 164. Species/guild accounts are found in the Supplemental Volume, and habitat associations are in Appendix 1-A.

Challenges

One of the major challenges to birds in South Carolina is outright loss, fragmentation, and/or alteration of habitat. Land use changes and urban development are often to blame. Birds in this state depend upon varied habitats from the mountains to the coast; changes to habitats can result in loss of feeding or nesting habitat for these species. Wetland habitats, which are important to many members of this taxa have been destroyed by draining and filling throughout the State. Even small alterations to wetlands can make the habitat unsuitable for use by these species as water levels change and prey species disappear. Nesting habitat is also affected.

Conversion of prime habitat to agricultural fields poses another challenge to birds. For example, longleaf pine habitat has been greatly reduced both in extent and in quality; vast acreages of longleaf pine have been converted to agriculture and/or loblolly pine plantations in South Carolina. The loss or degradation of longleaf pine habitat results in the loss of key components necessary for success of the animals that live in that habitat.

Fire suppression contributes to habitat loss for bird species that require an understory with a diverse herbaceous plant layer that is maintained by routine burning. In recent years, the use of prescribed fire as a management tool has decreased in the State due to an increase in housing density. This has resulted in successional changes that render the habitat unsuitable for some animal species.

Human disturbance represents a significant challenge to birds in South Carolina. Nesting success of many birds can decrease when people frequent breeding bird congregation areas. Further, wakes from boats can destroy nests and interrupt feeding for many shorebirds. Because there are a limited number of islands that can be utilized for nesting purposes, disturbances are often profound since the birds cannot simply go somewhere else. In addition, pelicans, terns, and skimmers nest colonially so many nests can be affected each time the colony is disturbed.

Chemical contamination often threatens many carnivorous bird species, particularly those that consume fish and other aquatic organisms. Persistent organo-chlorine pesticides and heavy metals, such as lead and mercury, can result in poisoning. Barbiturate poisoning of Bald Eagles has also been an issue in South Carolina and elsewhere. Phenobarbital, which is used to euthanize animals, can be ingested by eagles that feed on carcasses that have been disposed of in landfills. The Center for Birds of Prey in Awendaw, SC has treated several Bald Eagles for such poisoning in the past. New regulations require disposal of euthanized animals in a dedicated section of landfills and then they are covered to a certain depth in order to minimize scavenger deaths.

Several diseases and parasites can affect bird populations directly. These include West Nile virus, Avian Vacuolar Myelinopathy, cholera, botulism, and soft tick infestation. Indirect effects on bird populations include disease outbreaks in important nesting substrates or forage plants. Examples include Sudden Oak Death (SOD) and Hemlock Wooly Adelgid infestations which greatly alter the characteristics of the forest type and therefore bird habitats.

Additionally, an over-population of white-tailed deer can be detrimental to bird habitat. In areas of high densities (greater than 7.9 deer/km^2), herbivores browse the understory such that nesting and foraging substrates are greatly reduced (NatureServe 2004).

Non-native predators can also decimate bird populations. In particular, predation by domestic and feral cats is problematic for songbirds. In 2013, researchers reported that an estimated 1.4-3.7 billion birds are killed each year in the United States (Loss et al. 2013.) Additionally, wind turbines kill or maim approximately half a million birds every year (ABC 2013). Nighttime migrants and raptors are especially vulnerable. It is estimated that by 2030, the total number of wind turbines in the US could grow to more than 100,000, essentially doubling the number of bird strikes (ABC 2013). Wind farms themselves also destroy habitat as vegetation is removed and towers are erected. By 2030, 20,000 $mi.^2$ of terrestrial habitat and 4,000 $mi.^2$ of marine habitat may be impacted.

Collisions with glass buildings claim around 300 million to 1 billion birds each year (ABC 2013). Communication tower strikes take an additional 7 million birds per year (ABC 2013). Nocturnal migrants often become confused by the red lights of communication towers and hit the guy wires or the towers themselves. In a report by the American Bird Conservancy (Shire et al. 2000), the number one species killed was the Ovenbird, followed closely by many other neotropical migrant songbird species.

Migratory species like songbirds, shorebirds, and waterfowl will be highly affected by climate change. Already researchers have noted that ducks migrating to their wintering grounds are leaving later and later while Canada geese are cutting short their trip south along the Central Flyway (BPC 2012). Migrations and breeding are timed to coincide with abundant prey. If the timing of spawning and/or insect hatching is decoupled from the arrival of the birds along the migration, routes, these birds could face higher mortality during migration and lower productivity on the breeding grounds. As droughts dry up critical stopover habitat, ducks are forced to overfly these dry pools in search of available water. Migration stress leads to more casualties along the way and lower numbers next year. Breeding grounds are also in trouble. The prairie pothole region could dry up, threatening 69% of the region's breeding ducks (BPC 2012). Although the northern boreal forests and parklands can provide additional breeding habitat, these areas are under threat as well from warming trends (D. Harrigal, SCDNR, pers. comm.).

Breeding bird ranges have begun to shift north as is evident by tropical species establishing themselves along the Gulf Coast. As temperatures increase, bird species in remnant boreal forests will have nowhere to go but up until the habitat runs out. In addition, sea level rise will destroy foraging habitat used by waterfowl and wading birds by changing salinity levels and

aquatic plant species composition. A multitude of nesting shorebirds will be affected by sea level rise as former nesting habitat is inundated.

Wading birds will be affected by drought conditions as prey abundance in nontidal wetlands diminishes. When wading birds are required to fly greater distances to find food, droughts can result in nesting failures or lower productivity (C. Hand, SCDNR, pers. comm.). In addition, lower water levels can make nests vulnerable to mammalian predators, especially when aquatic vegetation becomes established. Unusually high water levels, as seen during floods, can result in prey being dispersed. Heavy rainfall during the chick-rearing period is an issue for tactile foragers such as the Wood Stork, who require concentrated prey in shallow water to feed efficiently. Coastal areas, where both tidal and nontidal foraging areas can be utilized, will become increasingly important to wading birds if prey availability becomes diminished or unpredictable farther inland. Managing impounded wetlands near wood stork colonies to concentrate prey at critical times during the nesting season can counteract some of the negative effects of droughts and floods on prey availability and improve the survival rates of nestlings.

Herpetofauna: Amphibians and Reptiles

Currently, 144 species of amphibians and reptiles are known to occur in South Carolina. The State's rich herpetofaunal diversity is likely due to the diversity of habitat in our state. Though small in land area, South Carolina comprises portions of three major physiographic provinces: the Blue Ridge, Piedmont and Coastal Plain. Within each of these provinces, numerous sub-provinces or distinct ecological regions occur. A variety of unusual or rare habitats are found within these regions, and many support populations of unusual or rare amphibians and reptiles.

South Carolina is particularly important with regards to amphibian diversity. Salamander diversity in our state is very high in the Blue Ridge and Coastal Plain provinces. In fact, the Jocassee Gorges area in the Upstate contains the highest number of salamanders found anywhere on Earth. South Carolina' State Amphibian is the spotted salamander. One area of South Carolina's southern Coastal Plain supports more frog species (25) than any other place in North America (Duellman ed. 1999). See Figures 3-3 and 3-4.

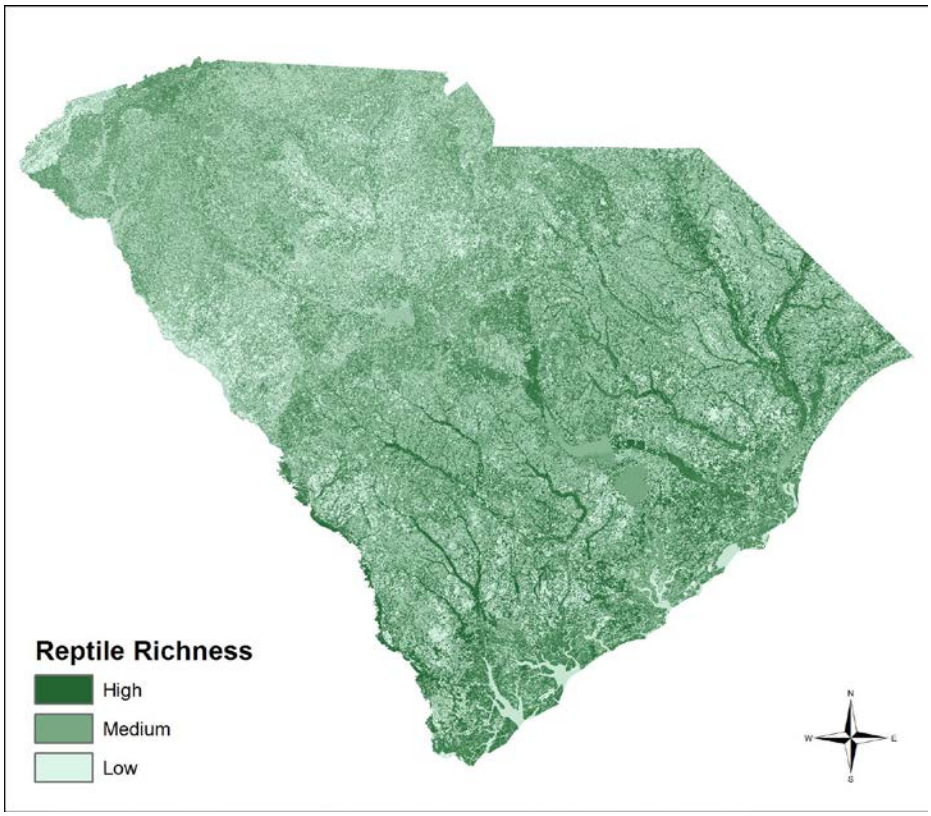


FIGURE 3-3: Reptile species richness in South Carolina

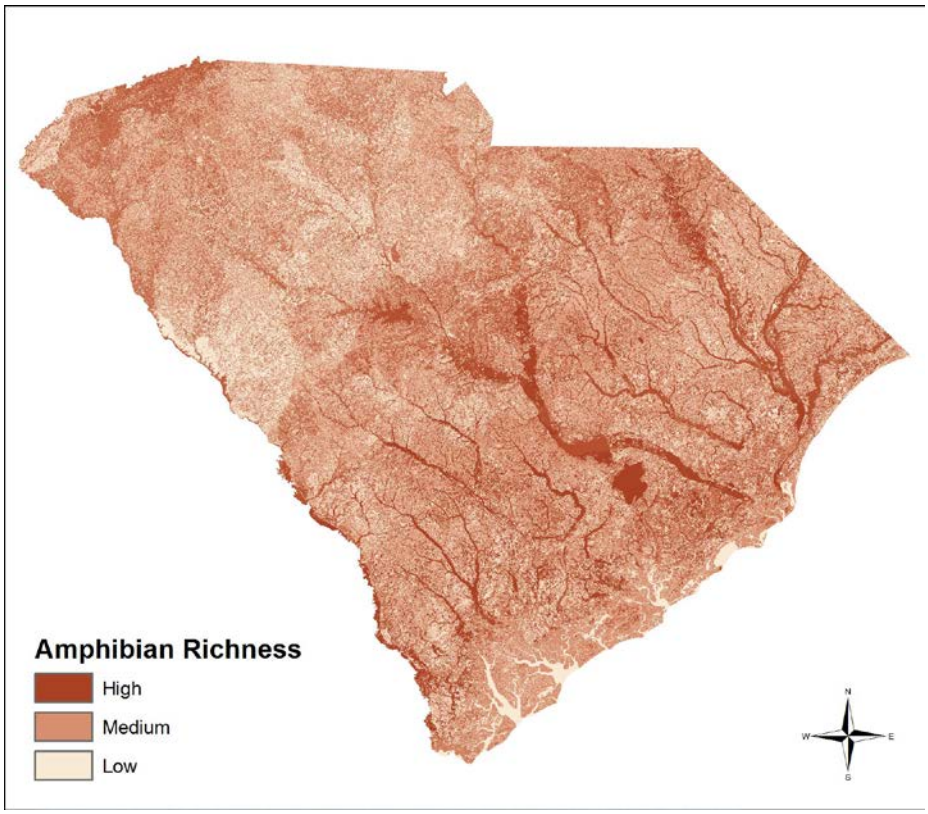
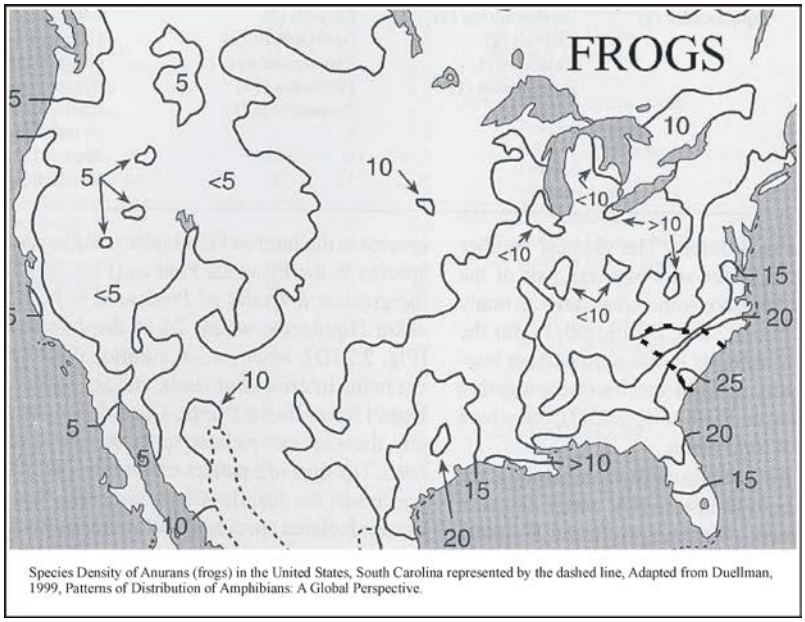
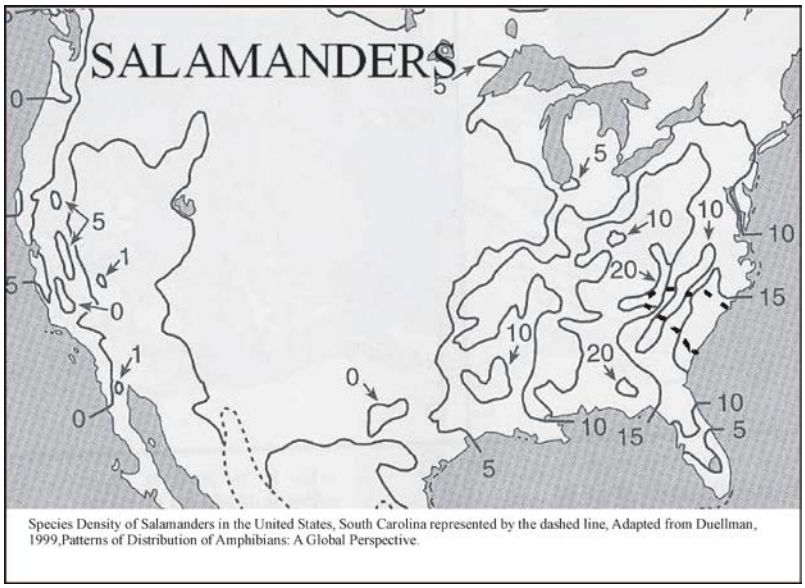


FIGURE 3-4: Amphibian species richness in South Carolina

The Blue Ridge, Upper Piedmont (referred to colloquially as the Foothills) and Coastal Plain are collectively rich in herpetofauna. Rock outcrops in the Blue Ridge and Upper Piedmont provide habitat for Jordan's salamander, the green salamander, and the timber rattlesnake. Bogs in this same region may provide habitat for the bog turtle**.** Several species of amphibians and reptiles found in South Carolina's Blue Ridge are peripheral to our state as the core of their geographic range is farther north.



The Piedmont of South Carolina is not as rich in herpetofauna as the other physiographic provinces, but there are areas of this province that are important. The Savannah River Valley, for instance, is home to the Webster's salamander, a rare species endemic to this region (at least in South Carolina). Numerous species that are found primarily in the Coastal Plain intrude into the Piedmont along the Savannah River. See Figures 3-6 and 3-7.



The Coastal Plain is a very important region overall for herpetofauna in South Carolina, with high species diversity, habitat diversity, and several rare, threatened and endangered species. Of the approximately 144 species of amphibians and reptiles found in the State, 112 occur in the Coastal Plain and 49 of these are endemic, or nearly endemic to this province (at least in South Carolina). See Table 2-5.

FIGURE 3-5: Maps of frog and salamander densities in the contiguous US.

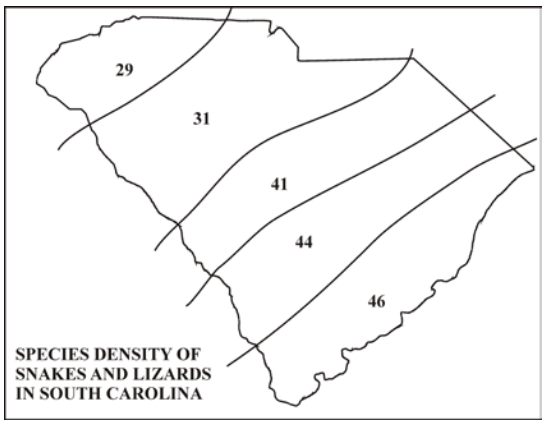


FIGURE 3-6: Species density of snakes and lizards in ecological regions of South Carolina

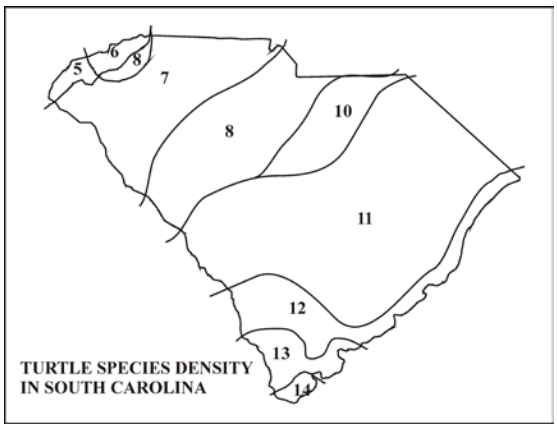


FIGURE 3-7: Species density of turtles in ecological regions of South Carolina

The diversity of reptiles in South Carolina is significantly higher in the Coastal Plain than in other areas of the State. Within this province, longleaf pine habitat plays a vital role in the life history of many species, including such rarities as the pine snake, southern hognose snake, and the gopher tortoise. Isolated, temporary wetlands such as Carolina bays, flatwoods, ponds, and limesinks provide breeding habitat for numerous amphibians, including the flatwoods salamander, tiger salamander, and gopher frog. Seeps and shrub bogs, embedded in xeric longleaf pine habitat in the Fall Line/Sandhills, are home to the pine barrens treefrog. Table 3-3 lists amphibians and reptiles that are endemic or nearly endemic to the South Carolina Coastal Plain.

TABLE 3-3: Herpetofauna endemic or nearly endemic to South Carolina's Coastal Plain

American alligator	Flatwoods salamander	Ornate chorus frog
Banded water snake	Florida cooter	Pig frog
Barking treefrog	Florida green water snake	Pine barrens treefrog
Bird-voiced treefrog	Florida softshell turtle	Pine woods snake
Black swamp snake	Glossy crayfish snake	Pine woods treefrog
Brimley's chorus frog	Gopher tortoise	Rainbow snake
Broad-striped dwarf siren	Greater siren	River frog
Carolina gopher frog	Green treefrog	Southern chorus frog
Carpenter frog	Island glass lizard	Southern cricket frog
Chicken turtle	Lesser siren	Southern hognose snake
Cottonmouth	Little grass frog	Southern toad
Diamondback terrapin	Mabee's salamander	Spotted turtle
Dwarf waterdog	Many-lined salamander	Squirrel treefrog
Eastern coral snake	Mimic glass lizard	Striped mud turtle
Eastern diamondback rattlesnake	Mole salamander	Two-toed amphiuma
Eastern glass lizard	Mud snake	
Eastern tiger salamander	Oak toad	

Species Selection Process

The amphibian and reptile portion of the SWAP has been written in a manner that incorporates a regional as well as species-specific and/or guild-specific approach. These priority species were identified by herpetological experts in the State. The members of that committee invested considerable time to the development of the SWAP and are graciously thanked for their efforts; these individuals are listed in Table 3-4.

TABLE 3-4: AMPHIBIAN AND REPTILE TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
C.L. Abercrombie	Wofford College
Ken Alfieri	Alligator Adventure
Kimberly Andrews	Savannah River Ecology Laboratory
Rob Baldwin	Clemson University
Dave Beamer	Nash Community College, NC
Jeff Beane	North Carolina Museum of Natural History
Steve Bennett	South Carolina Department of Natural Resources
Eric & Denise Billings	Charleston Turtle and Tortoise Society
Rick Blob	Clemson University
Alvin Braswell	North Carolina Museum of Natural History
Kurt Buhlmann	Savannah River Ecology Laboratory
Carlos Camp	Piedmont College, GA
Jeffrey Camper	Francis Marion University
Joshua Castleberry	University of South Carolina, Sumter
Heyward Clamp	Edisto Island Serpentarium
Mark Danaher	United States Forest Service
Mike Dorcas	Davidson College, NC
Mary Lang Edwards	Erskine College
Eric Fann	South Carolina Aquarium
John Fauth	Central Florida University
Roark Ferguson	Roark's Reptile Safari
Steve Fields	Cultural and History Museum
Barbara Foster	Greenville Zoo
Dr. J.W. Gibbons	Savannah River Ecology Laboratory
Julian R. Harrison	College of Charleston (ret.)
Hugh Hanlin	University of South Carolina, Aiken
Joey Holmes	Private consultant
Deborah Hutchinson	Coastal Carolina University
Jeff Humphries	North Carolina Wildlife Resources Commission
Austin Jenkins	University of South Carolina, Sumter
John Jenson	Georgia Department of Natural Resources
Wade Kalinowsky	South Carolina Department of Natural Resources
Eran Kilpatrick	University of South Carolina, Salkehatchie
Peter King	Francis Marion University
Sally Krebs	University of South Carolina, Beaufort
Mike Martin	University of South Carolina, Columbia
Kevin Messinger	North Carolina State University
Brian Metts	Savannah River Ecology Laboratory
Judy Greene	Savannah River Ecology Laboratory
Tony Mills	Spring Island Trust
Richard Montanucci	Clemson University (ret.)
Jeff Mohr	Macon State College, GA
Zach Orr	Randolf Rattlesnake Refuge and Research Center
Edwin Ott	South Carolina Department of Natural Resources
Gene Ott	South Carolina Amphibians and Reptiles webmaster
Scott Pfaff	Riverbanks Zoo

Melissa Pilgrim	University of South Carolina, Upstate
Corey Roelke	University of South Carolina graduate school
David Scott	Savannah River Ecology Laboratory
Sam Seashole	Alligator Adventure
Chuck Smith	Wofford University
Keith Taylor	Private consultant (dec.)
Tracey Tuberville	Savannah River Ecology Laboratory
Austin Trousdale	Lander College
Jayme Waldron	University of South Carolina, Columbia
Allison Welch	College of Charleston
John D. Willson	Savannah River Ecology Laboratory
Chris Winne	Savannah River Ecology Laboratory

These experts grouped many of the species into guilds (functional groupings) to indicate common habitat requirements, management needs, life history traits, threats, and/or other characteristics. Many of these groups align with provinces (e.g. Blue Ridge) or habitat regions (e.g. the historic distribution of longleaf pine) of the State. A number of species did not fit easily into a functional group and are addressed individually in the SWAP. All species, whether addressed individually or in a functional group, are related (within the SWAP) to a specific habitat type or several habitat types. Species/guild accounts can be found in the Supplemental Volume and habitat associations in Appendices 1-A (terrestrial), and 1-B (freshwater).

The species reports detail the amphibian and reptile priority species and provide information on their life history, status, threats they are facing, and detailed recommendations for conservation actions. Priority species are associated with key habitats, as well as specific descriptions of those habitats. The conservation needs of the species or functional groups are identified for the regions of the State and habitats in which the actions need to take place.

The first gathering of the herpetofauna taxa committee in 2005 began the selection process by compiling all available data and lists for herpetofauna in the State. The initial list of amphibians and reptiles designated as endangered, threatened, or species of concern was developed at the First South Carolina Endangered Species Symposium, held in 1976. As a result of this symposium 16 species of amphibians and 20 species of reptiles were proposed for listing under an appropriate category. Species recommended for endangered or threatened statuses were incorporated into the official list promulgated under South Carolina Regulation. The designation Threatened was changed to Species in Need of Management under the Act. A justification for listing was given for each species in the symposium volume.

The list of amphibian and reptile species that resulted from the 1976 symposium was also used to develop a list of "elements of concern" for the SCDNR's Heritage Trust Program. Listed species are "tracked" by this program through a computer database, developed initially by The Nature Conservancy. Occurrence records for these species are stored in this database. Archived data is very similar to that of a museum collection record and includes location, date, collector/observer, as well as other pertinent data.

The Heritage Trust Program, as part of its routine operation, established taxa review committees to periodically review the species lists and make recommendations for changes. The Amphibian and Reptile Taxa Review Committee met initially in 1983. Subsequent meetings of this group occurred in 1987, 1996, and 2004. A number of additions have been made to the original list as a

result of these meetings and several changes in nomenclature or taxonomy have occurred since the initial list was developed.

On January 30, 2004, SCDNR and Riverbanks Zoo in Columbia, SC sponsored the first annual South Carolina Herpetology Conference. The conference was open to both professional and amateur herpetologists with approximately 130 attendees. One presentation at the conference concerned the SWAP (or CWCS as it was referred to at that time) as it pertained to amphibians and reptiles. At the close of the meeting, SCDNR personnel distributed a packet of questionnaires concerning the status of amphibians and reptiles in South Carolina that was based on the matrix developed for the Strategy/Plan. Attendees who volunteered to fill out the questionnaires were asked to evaluate all of the amphibian and reptile species currently listed as either endangered, in need of management, or species of concern. In addition they were asked to evaluate 16 additional species that were selected based on suggestions from knowledgeable individuals, unknown status, or because the species were representative of habitats that are believed to be rare, uncommon, or potentially threatened. A total of 52 species of amphibians and reptiles in South Carolina were ultimately identified as priority species, representing 37% of the State's species. With the first listing, some mistakes were made and these were subsequently addressed in the 2015 revision of the SWAP.

During the second meeting of the taxa committee for the 2015 iteration of the SWAP, a total of 54 species of amphibians and reptiles in South Carolina were identified as priority species, representing approximately 35% of the State's species. While these 54 species have been identified as requiring immediate conservation attention, this is by no means an indication that the remaining species are stable and secure. All inventory projects originating as the result of this SWAP must take the full spectrum of South Carolina's amphibian and reptile fauna into account, documenting occurrences for all species.

Several changes to the 2015 priority herpetofauna list included upgrades to a higher priority listing or downgrades to a lower listing due to more available data on the species. There were also removals and deletions. The canebreak rattlesnake was removed from the list as it was not supposed to be included as a separate species of the timber rattlesnake in the 2005 edition. Painted turtle was added to the priority list as it had been inadvertently left off the first time while the Eastern box turtle was added due to concerns with losses to the pet trade. New species that were recently discovered included the patch-nosed salamander and dwarf black-bellied salamander, both of which earned a place on the list.

A recent project, funded by the State Wildlife Grants program, focused on the molecular phylogeny of salamanders in the genus Desmognathus, in particular the southern dusky salamander (*Desmognathus auriculatus*), which was identified as a conservation candidate under the 2005 iteration of the SWAP (CWCS). Results of this project indicate that this species does not occur in SC. Five Desmognathine lineages have been identified in SC, one of which is the currently recognized species, the spotted dusky salamander (*Desmognathus conanti*), which is the predominant species in the western portion of the State. The other 4 lineages are aligned with the northern dusky salamander (*Desmognathus fuscus*). Some of these lineages may warrant elevation to species level, but that is a work in progress. With the exception of one lineage, which only occurs in a small portion of SC, the other "*fuscus*" lineages are widespread and can

be relatively common to abundant. Based on this research, the southern dusky salamander has been removed from the SC list of Species in Need of Conservation as identified through the SWAP process.

The Hellbender (*Cryptobranchus alleganiensis*) has been removed from the original list of Species in Need of Conservation due to the lack of data supporting a self-sustaining population in South Carolina. There are two records for this species from the State, both from the area of Lake Tugaloo. Both animals were adults caught by fishermen, and it's been 30+ years since the last record. The hellbender does not occur "naturally" in Atlantic slope drainages, except for a small area in the extreme north of its range, in Massachusetts. Other than that small area this species is restricted to Gulf drainage streams. Surveys conducted by SCDNR staff and conservation partners have not resulted in any additional observations of this species in the State. It is likely that the two historic specimens taken in SC were introduced, escaped, or were from the bait trade and don't represent an established breeding population of hellbenders.

Eight species of freshwater turtles were identified as Species in Need of Conservation under the first version of the SWAP (the CWCS), based on concerns about their harvest for the Asian turtle (food) market. In 2009 South Carolina enacted a law prohibiting the removal of large numbers of these 8 species plus the Eastern box turtle, from the State for any purpose. The law created a permit for owners of private ponds such that they could harvest yellow-bellied and common snapping turtles. To date no one has applied for one of these permits. As such we are changing the status of the following species from high to moderate: spiny softshell turtle, painted turtle, chicken turtle, river cooter, and yellow-bellied turtle. No status change is recommended for the Florida softshell turtle as it is peripheral in SC and relatively uncommon. It is recommended that SCDNR continue to monitor the international trade in turtles and any impact that may have on our native turtle fauna.

The Eastern box turtle is being added to the list of Species in Need of Conservation in South Carolina. This species is relatively common in the State, but has become a target for the "wild-caught" pet trade. It was included in the list of turtles protected under the "turtle law" due to the concerns of researchers who have worked with the species for years. It is common for wild caught box turtles from South Carolina to show up frequently at reptile shows and on reptile websites. This species occurs in 30 states; it is listed as Endangered in one state, Maine, and has some type of regulatory protection in 13 states, including South Carolina. In addition, 18 states have identified it as a Species in Need of Conservation while 16 states allow take/harvest for personal use. Only one state, South Carolina, allows take for commercial purposes, though the number which can be removed from the State is limited under the new turtle law. The Eastern box turtle is being added to the list with a moderate priority with the sale of wild-caught box turtles as the primary conservation issue.

Challenges

As is the case with most wildlife species, amphibian and reptile populations are affected by habitat loss. In particular, the loss of rare, uncommon or vulnerable habitats, such as isolated freshwater wetlands, longleaf pine communities, and freshwater seepage wetlands is taking its toll on herpetofauna.

One of the major challenges to amphibians and reptiles in South Carolina is loss of habitat. Wetland habitats, which are important to many members of this taxa group, have been destroyed by draining and filling throughout the State. Even small alterations to wetlands can make the habitat inhospitable for reptiles and amphibians. Pond breeding amphibians are known to require adequate upland habitat around breeding ponds. Populations of amphibians may be extirpated by the elimination of adequate upland habitat despite the protection of the breeding pond. Conversely, the drainage or alteration of ponds in an otherwise unaltered forest may result in the extirpation of local amphibian populations. Many wetlands that still exist are now unsuitable for breeding because they have been left isolated in the landscape as a result of farming or timber operations.

Conversion of habitat to agricultural purposes represents a significant challenge to reptiles and amphibians. For example, longleaf pine habitat has been greatly reduced both in extent and in quality subsequent to European settlement of the southeast (Noss 1989). Vast acreages of longleaf pine have been converted to agriculture and/or loblolly pine plantations in South Carolina. The loss or degradation of longleaf pine habitat results in the loss of key components necessary for success of the animals that live in that habitat.

Habitat can also be lost to urban development. Nesting habitat for marine turtles is lost as coastal development expands. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites. Further, lighting in coastal areas can disorient turtles and result in nesting failure. Road mortality is also a significant threat as urban development requires that additional roadways. These roads are frequently constructed through amphibian and reptile habitat. Mortality occurs as animals attempt to migrate across roadways.

Fire suppression contributes to habitat loss for many amphibian and reptile species. Many species in this taxa group require an understory that contains a diverse herbaceous plant layer that is maintained by routine burning. However, in recent years, use of adequate fire management has decreased in the State, which has resulted in successional changes that render the habitat unsuitable for some animal species.

Emerging diseases can lead to severe population crashes or even extinctions. Chytridiomycosis is a fungal disease caused by *Batrachochytrium dendrobatidis* that affects the skin of amphibians, compromising water and electrolyte uptake. Because amphibians rely on their skin like we do our lungs, the hyperkeratosis caused by the fungus can also impact respiration. Another emerging disease we are watching in South Carolina is Ranavirus which causes hemorrhaging and ulcers.

A new threat that may begin to affect South Carolina's native snakes is Snake Fungal Disease (*Ophidiomyces ophiodiicola*) that causes swelling, scabs, and lesions. Copperheads, cottonmouths, water snakes, garter snakes, ribbon snakes, milk snakes, corn snakes, indigo snakes, and ring-necked snakes can be affected. In October 2013, an infected copperhead was found in Spartanburg County, SC, making it the first confirmed case in the State. Additional possible cases in kingsnakes from the same area are under investigation. The SCDNR will be watching this disease closely for its potential impact on both priority and currently secure species.

Another significant challenge to amphibians and reptiles is unregulated harvest. Currently, collection and/or harvest are regulated for only a few reptiles and amphibians in South Carolina. Collection of salamanders for the bait industry is a threat to some salamander species as collectors do not discriminate among species. Further, the salamander bait trade is unregulated. Generally, all salamander species collected are lumped together and referred to as "spring lizards." Several species of snakes in the State are collected for the pet trade; such collection is also unregulated.

Freshwater turtles can be adversely affected by many factors including habitat destruction and poor water quality. An additional challenge to these animals comes from unregulated harvest. Continuing unregulated harvest in South Carolina could result in drastic population declines for these turtles, which are currently common to abundant.

Introduced species, both plant and animal, can adversely affect South Carolina's reptiles. Beach vitex, an exotic introduced plant, has recently taken over areas in northern Georgetown and Horry Counties. Its aggressive growth and impenetrable roots quickly cover the dunes, making them unsuitable for turtle nesting (R. Westbrooks pers. com.). The Beach Vitex Task Force was established to combat this invasive species, and as of 2011, over 220 sites have been detected and cleaned. This amounts to 99% of the known populations of vitex.

The presence of nonnative fire ants throughout the Southeastern United States has been implicated as a potential reason for the apparent decline of the southern hognose snake (Tuberville and Jensen 2008). Fire ants may also be adversely affecting populations of other fossorial and egg-laying snakes. Further, fire ants are suspected to affect the probability of turtle hatchling survival.

Red-eared sliders (*Trachemys scripta elegans*) impact the population stability of yellowbelly turtles through hybridization. This nonnative species has been released in South Carolina resulting in concerns about the genetic integrity of the yellowbelly turtle as established red-eared sliders interbreed with this species, shifting the genetics of local populations.

Entrapment in fishing devices, including hook and line, trawls, and crab pots represents a significant challenge to turtle species throughout the State. Florida softshell and spiny softshell turtles are often captured incidentally on hook and line and are either killed to retrieve the tackle, or later die due to complications from the ingested hook. Major challenges to the diamondback terrapin in the marine environment include recreational, commercial and abandoned/ghost crab pots. Efforts have been made to educate crab fishermen about the importance of removing old pots and using turtle excluders over the openings. Incidental take of loggerhead turtles from boat strikes and commercial fishing operations also constitutes a major challenge to this species. In a 1990 study, the National Academy of Sciences estimated that between 5,000 and 50,000 loggerheads were killed annually by the shrimping fleet in the southeastern Atlantic and Gulf of Mexico (National Research Council 1990). In 1988, South Carolina was the first to enact Turtle Exclusion Devices (TEDs) on shrimp trawls to reduce incidental take of sea turtles. By 1991, TEDs were required everywhere by the National Marine Fisheries Service. The size of TEDs was adjusted in 2003 to accommodate leatherback sea turtles. The shark longline fishery, which operates all year long off the south Atlantic, may still impact loggerheads in the neritic

environment (Lewison et al. 2004). Turtles are still at risk from entanglement in longlines, float lines, and other ropes and cables (NMFS & USFWS 1991). In addition, sea turtles may mistake floating plastic for jellyfish and ingest it, causing gut obstructions or the absorption of toxic chemicals (NMFS & USFWS 1991).

A silent threat to some herpetofauna is the lack of knowledge about the species and thus the uncertainty of their status. There are a number of amphibian and reptils species in South Carolina for which adequate data on their status is lacking, but there is no immediate indication that they are threatened. Species such as the many-lined salamander (*Stereochilus marginatus*), southern Appalachian salamander (*Plethodon oconaluftee* [*teyahalee*]), mole kingsnake (*Lampropeltis calligaster*), and glossy crayfish snake (*Regina rigida*) are examples of species that are not well known in the State and that may be of future conservation concern.

Several groups of ecologically or taxonomically related species have been identified by SCDNR staff, colleagues and reviewers of the SWAP as problematic, and potentially in need of conservation in the future. These include glass lizards; small, fossorial snakes; and semi-aquatic snakes.

Of the four species of glass lizards found in SC only one, the Eastern glass lizard, appears to be common, even occurring in suburban and urban "habitat". The three remaining species were identified as priority species under the 2005 version of the SWAP. The slender glass lizard is uncommon while the island and mimic glass lizards are rare to extremely rare. Detection is a problem with these species and, to date no sampling or collection technique, such as coverboards or drift fences, has proven effective for them. Identification can be problematic; there are good diagrams in several guides, but there is also some degree of variability within species which may be ontogenetic.

One species, the pine woods snake, was identified as a priority species under the first version of the SWAP, but this may bear further thought as detection is obviously an issue with this species. Some species, such as the ring-necked snake, brown snake, and worm snake are common to abundant and these species also seem to be habitat generalists. Other species, such as the earth snakes and the Southeastern crowned snake may be uncommon and more habitat-restricted than the other species but also simply difficult to detect. All of these small snakes, especially those in the Coastal Plain, may be susceptible to impacts from imported red fire ants.

One species of semi-aquatic snake, the black swamp snake, was identified as a priority species under the first version of the SWAP, and two other species—the glossy crayfish snake and the rainbow snake—are reportedly uncommon in South Carolina. Detection is an issue with these species and any survey efforts aimed at them must use techniques that target them such as aquatic minnow traps or small hoop traps and coverboards at the edges of wetlands.

Continued controversy over the taxonomic status of certain species, or species complexes, results in a lack of certainty in giving a truly fixed number of species for the State. New species have been recently discovered or described, which results in a dynamic species list. Other taxonomic issues include the slimy salamander complex, the southern Appalachian salamander, and the milk snake/scarlet kingsnake relationship. An unidentified species of the genera *Desmognathus*

has been found in Jasper County, within the range of *Desmognathus auriculatus*, that more closely resembles either *Desmognathus apalachicolae* or *Desmognathus fuscus conanti*, neither of which has been documented for coastal South Carolina.

To emphasize the way in which the species list can change, consider the following recent additions. Within the past 30 years, the striped mud turtle (*Kinosternon baurii*), bog turtle (*Glyptemys muhlenbergii*), and seepage salamander (*Desmognathus aeneus*) have been verified as occurring in South Carolina. In addition, two newly described species, the mimic glass lizard (*Ophisaurus mimicus*) and Chamberlain's dwarf salamander (*Eurycea chamberlainii*), were added to the State's list of native herpetofauna in the past decade. Additionally, two more species, the patch-nosed salamander (*Urspelerpes brucei*) and the dwarf black-bellied salamander (*Desmognathus folkertsi*) were added as the SWAP was being revised.

Freshwater Fishes

South Carolina has an abundant and diverse aquatic community. There are 146 fish species that are known to inhabit the freshwaters of South Carolina or are seasonally dependent on freshwater habitats to complete their life cycle, such as shad and sturgeons. Several other fish taxa have not been scientifically described but may warrant species status review and would increase the number of species native to South Carolina. South Carolina's diverse fish fauna is largely due to the myriad of aquatic habitats that can be found throughout the State. Small, high-gradient Blue Ridge streams; large, fertile Piedmont rivers; and the "blackwater" streams and bays of the Coastal Plain are just a few of the aquatic habitats that contain numerous and diverse fish communities. South Carolina's freshwater fish fauna also boasts a relatively high degree of endemism with distributions of approximately 32 species, including the Carolina darter and the Sandhills chub, that are restricted to South Carolina, or more often, restricted to a few drainages that South Carolina shares with one or more of its neighboring states (Table 3-5).

TABLE 3-5: Freshwater fishes endemic to South Carolina and neighboring states in the South Atlantic region with indication of current conservation status.

Scientific Name	Common Name	Priority 2010-2015
Cottus sp. cf. *bairdii*	"Smoky" Sculpin	YES
Cyprinella chloristia	Greenfin Shiner	YES
Cyprinella labrosa	Thicklip Chub	YES
Cyprinella leedsi	Bannerfin Shiner	YES
Cyprinella pyrrhomelas	Fieryblack Shiner	YES
Cyprinella sp. cf. *zanema*	"Thinlip" Chub	YES
Cyprinella zanema	Santee Chub	YES
Elassoma boehlkei	Carolina Pygmy Sunfish	YES
Elassoma okatie	Bluebarred Pygmy Sunfish	YES
Etheostoma brevispinum	Carolina Fantail Darter	YES
Etheostoma collis	Carolina Darter	YES
Etheostoma fricksium	Savannah Darter	YES

Etheostoma hopkinsi	Christmas Darter	YES
Etheostoma inscriptum	Turquoise Darter	YES
Etheostoma mariae	Pinewoods Darter	YES
Etheostoma thalassinum	Seagreen Darter	YES
Hybopsis hypsinotus	Highback Chub	YES
Hybopsis rubrifrons	Rosyface Chub	YES
Micropterus sp. cf. *coosae*	"Bartram's" Bass	YES
Moxostoma pappillosum	V-lip Redhorse	YES
Moxostoma robustum	Robust Redhorse	YES
Moxostoma sp. cf. *erythrurum*	"Carolina" Redhorse	YES
Notropis alborus	Whitemouth Shiner	YES
Notropis chiliticus	Redlip Shiner	YES
Notropis chlorocephalus	Greenhead Shiner	NO
Notropis scepticus	Sandbar Shiner	YES
Noturus sp. cf. *leptacanthus*	"Broadtail" Madtom	YES
Percina crassa	Piedmont Darter	YES
Salvelinus fontinalis	S. Appalachian Brook Trout	YES
Scartomyzon rupiscartes	Striped Jumprock	NO
Scartomyzon sp.cf. *lachneri*	"Brassy" Jumprock	NO
Semotilus lumbee	Sandhills Chub	YES

Despite the Southeast's aquatic faunal diversity, some species are increasingly at risk of extinction. More than two decades ago, a fish assessment of the Southeastern US identified 85 fishes in peril (Deacon et al. 1979). A decade later, Williams et al. (1989) recognized 109 Southeastern fishes as in jeopardy. A published assessment focusing exclusively on Southeastern fishes (Warren et al. 2000) identified 187 taxa as extinct, endangered, threatened or vulnerable, which represents a 125% increase in imperiled fish taxa in only 21 years. Eighteen fish species that inhabit South Carolina were identified as endangered, threatened, or vulnerable to imperilment by Warren et al. (2000). An additional 38 fish species were determined to be of conservation concern in South Carolina in the first version of the SWAP (formerly the CWCS) (Kohlsaat et al. 2005). The third and latest published assessment of North American freshwater fishes reported that approximately 39% of described fish species on the continent are imperiled (Jelks et al. 2008). Compared to the 1989 assessment of Williams et al. (1989), Jelks et al. (2008) found that most taxa were the same or worse in conservation status; only 11% of those imperiled in 1989 had improved or been delisted. Our assessment currently places 57 freshwater fishes on South Carolina's Conservation Priority List. Although many of these species may not be in jeopardy globally, they warrant conservation concern if the goal is to maintain South Carolina's rich and diverse fish fauna. Future extinction rates of freshwater fish species in North America may approach 53 to 86 species by 2050; we have already lost 57 taxa since 1898 (Burkhead 2012).

Species Selection Process

The information about freshwater fishes contained in the SWAP was supplied by the expertise of the biologists who formed our Freshwater Fish Technical Team (FFTT). The members of that team invested considerable time in the development of the SWAP and are graciously thanked for their efforts; these individuals are listed in Table 3-6. Other sources of information included published literature and unpublished SCDNR and Clemson University data.

TABLE 3-6: FRESHWATER FISHES TECHNICAL TEAM
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Ron Ahle	South Carolina Department of Natural Resources
Tanya Darden	South Carolina Department of Natural Resources
Jeff Foltz	Furman University
Kevin Kubach	South Carolina Department of Natural Resources
Cathy Marion	South Carolina Department of Natural Resources
Joe Quattro	University of South Carolina
Fritz Rohde	North Carolina Division of Marine Fisheries
Mark Scott	South Carolina Department of Natural Resources
Dustin Smith	North American Native Fishes Association
Wayne Starnes	North Carolina State Museum of Natural Sciences
David Wilkins	South Carolina Aquarium

For the 2015 revision, the methods for determining priority ranking were based on a State Wildlife Grant-funded field survey of statewide streams, which marks the first objective, data-driven ranking of conservation need among South Carolina's diverse assemblage of freshwater fishes. The South Carolina Stream Assessment (SCSA) was initiated in 2006 and completed in 2011, data from which provided population density estimates of the State's freshwater fishes. We developed a quantitative and objective method using these data to rank conservation need among species. While the previous conservation priority designations for South Carolina freshwater fishes provided a useful framework for conservation planning and implementation, those rankings were based largely on qualitative observations such as expert-opinion that are useful in the absence of a robust data set. The availability of the SCSA data now allows us to objectively assess conservation need among species at the statewide scale. A quantitative index for assigning conservation priority for South Carolina stream fishes was created based on multiple attributes related to risk of imperilment including abundance, frequency of occurrence, range size and existing range-wide conservation status. The caveat to this treatment is that species whose preferred habitats are not wadeable streams are not well represented in the ranking, so other accommodations had to be incorporated.

Three hundred ninety-seven (397) randomly selected sites were sampled from 2006 - 2011 following SCSA Standard Operating Procedures for wadeable streams (Scott et al. 2009). Priority score was determined for each species by summing the three values for abundance, frequency of occurrence, and range size. Thus, a lower total score represented a higher conservation priority based on the rationale that species exhibiting low abundance, infrequent occurrence and/or a narrow overall distribution were most likely to decline due to anthropogenic alteration of habitats and ecosystems.

Regardless of status in South Carolina, species known to be declining or at high risk of decline in other portions of their ranges warranted concern. To account for existing conservation status,

scores were adjusted for species recognized as imperiled on a range-wide basis in a recent comprehensive assessment of North American fishes (Jelks et al. 2008). Scores for species listed in Jelks et al. (2008) were reduced by a percentage concordant with imperilment status: Endangered = 75% reduction; Threatened = 50%; Vulnerable = 25%. For the current conservation priority revision, any fish recognized as imperiled in Jelks et al. (2008) was assigned Priority status regardless of its priority index score. (For a complete discussion of the mathematical process, see the Assessment itself.)

The SCSA focused on wadeable freshwater streams draining watersheds between 2 to 58 $mi.^2$ (4-150 km^2). Although wadeable streams by length comprise about 90% of all stream and river habitats in South Carolina, they do not represent the primary habitat for certain species and therefore we excluded from the rankings species considered to occur principally outside of wadeable streams or otherwise beyond the scope of the SCSA. Species in the following categories were excluded from the rankings: (1) diadromous species except *Anguilla rostrata* (American Eel); (2) primarily estuarine species not collected in the SCSA; (3) non-native species not collected in the SCSA. Two species in this latter category, Banded Sunfish (*Etheostoma zonatum*) and Bluefin Killifish (*Lucania goodie*) were included in the previous SWAP but removed from consideration in this iteration. One additional species listed in the 2005 plan is omitted here: Saluda Darter (*Etheostoma saludae*) is considered conspecific with Carolina Darter (*Etheostoma collis*) (Rohde et al. 2009). South Carolina's form of what was formerly the Sailfin Shiner is now recognized as the Lowland Shiner (*Pteronotropis stonei*). The Lowland Shiner was a priority species in 2005 and remains one in the 2015 version of this Action Plan.

Prior to assigning final priority status, additional consideration was given to species known to occur primarily outside of wadeable streams, based on best available data and expertise of the Freshwater Fishes Technical Committee. Species falling within the priority range of the rankings yet known to be secure and stable in habitats other than wadeable streams were evaluated on a case-by-case basis by the FFTC. Examples included species occurring primarily in: (1) large (non-wadeable) streams and rivers, (2) lakes, and (3) swamps and wetlands.

Final rankings were computed for 130 fish species occurring in fresh waters of South Carolina. Conservation priority scores ranged from 0.50 ("Carolina" Redhorse, *Moxostoma sp. cf. erythrurum*,) to 156.77 (Redbreast Sunfish, *Lepomis auritus*) and the median score was 30.19, excluding the ubiquitous Eastern Mosquitofish (*Gambusia holbrooki*) at 609.45.

Based on the threshold in score distribution at 22.0 and consideration of status for species on either side of this score, we established a score of 22.0 as the cutoff for priority status (i.e. priority status if score $\leq$ 22.0). Fifty-four species exhibited scores less than 22.0 and were proposed for priority status. Of these, 43 species (80%) were previously designated as priority species in the SWAP (Kohlsaat et al. 2005).

Two additional species whose scores were outside of priority range were automatically assigned priority status due to range-wide imperilment recognition by Jelks et al. (2008): Ironcolor Shiner (*Notropis chalybaeus*) and Lowland Shiner (*Pteronotropis stonei*). All 54 species below the priority score cutoff value of 22.0 were evaluated by the FFTC prior to final assignment. Three proposed priority species were not added due to their secure status in habitats other than

wadeable streams: Brassy Jumprock (*Scartomyzon sp.*, abundant in larger rivers including the Broad River), Whitefin Shiner (*Cyprinella nivea*, abundant in larger rivers), and Lined Topminnow (*Fundulus lineolatus*, abundant in swamps and wetlands).

Nine species were assigned priority status for the first time, including *N. chalybaeus*. Ten previous priority freshwater species, from the 2005 Action Plan, scored beyond the priority cutoff and were proposed for removal from priority status. However, three of these species—White Catfish (*Ameiurus catus*), Highfin Carpsucker (*Carpiodes velifer*), and Quillback (*Carpiodes cyprinus*)—primarily occur in larger riverine habitats, and therefore this stream assessment did not provide sufficient grounds to remove priority status for these species. Five previously assigned priority species were removed from the list based on the ranks: Mud Sunfish, Pugnose Minnow, Longnose Dace, River Chub, and Greenhead Shiner. The above considerations resulted in the total of 57 species of freshwater fish listed in this revised Plan. Species/guild accounts can be found in the Supplemental Volume and habitat association in Appendix 1-B.

Challenges

One of the major challenges to freshwater fishes in South Carolina is degradation and loss of habitat. As urbanization through development occurs, waterbodies are altered in ways that change both the topography and hydrology of streams, rivers, wetlands, lakes and ponds. Removing riparian vegetation can result in siltation, increases in nutrient and pollutant loading, increases in velocity of flow both into and within the waterbody, and temperature increases.

Erosion from agriculture and silviculture (logging) can significantly lower water quality and cause drastic adverse reactions in aquatic life (Butler 1968). Runoff carries silt, chemicals and nutrients into wetlands that, acting alone or in combination, can be lethal to aquatic life, and particularly to larval forms (Matthews et al. 1980; Aust et al. 1997). Runoff can cause sedimentation while nutrients can encourage algal blooms, both leading to eutrophication and possible dissolved oxygen (DO) depletion (Matthews et al. 1980; Lockaby et al. 1997). Siltation can also cause an increase in water temperature (Aust and Lea 1991; Perison et al. 1993). Forestry Best Management Practices (BMPs) for bottomland forests are recommendations to landowners in order to conserve site productivity—primarily for silviculture—and are voluntary (SCFC 1998). When BMPs are not used, braided streams may be obstructed by plant material and disturbed soils; excessive ruts may channel eroded sediments into streams. Additionally, partially stagnated waters may become nutrient-rich and promote algal growth that can die under extended periods of cloud-cover (J.W. McCord, SCDNR, pers. obs.). These factors contribute to increased water temperature and reduced DO.

Rapid development in some parts of South Carolina also contributes to siltation in many ways. Impervious surfaces such as roads, buildings and parking lots increase erosion in adjacent areas and contribute to flooding. Clearing riparian vegetation also destabilizes stream and riverbanks allowing excessive siltation. Clear cutting in a substantial part of a watershed can also contribute to siltation even if a riparian buffer is maintained. In a study of several watersheds in the Georgia piedmont, streams in urban and agricultural watersheds had much higher nutrient and suspended sediment concentrations than watersheds that remained mostly forested. Suburban

watersheds had intermediate levels of nutrients and suspended sediments when compared with watersheds dominated by forested or urban and agricultural land use (Meyer and Couch 2000). The use of motor vehicles in streams and along banks can also degrade the stability of banks, stir up benthic sediments, and increase siltation. Factors that contribute to siltation can also change the topography of the stream or river by changing the slope of the bank and eliminating heterogeneity in the channel.

Siltation from agricultural, silvicultural and other land use practices can also reduce spawning success by causing mortality of eggs or by coating substrates needed for attachment of adhesive eggs (NMFS 1998). Pollution, runoff and siltation input contaminants and pollutants into sturgeon habitat that can cause lowered pH or lowered DO. This, in turn, can reduce survival of eggs, larvae or juveniles (Rogers and Weber 1995; NMFS 1998). Bioaccumulation of contaminants may reduce productivity or increase susceptibility to diseases or stress (Cooper 1989; Sindermann 1994; Varanasi 1992; NMFS 1998).

Hydrologic alterations to waterbodies can be detrimental to freshwater fishes. Dams prevent upstream migration of fish (ASMFC 1990; NMFS 1998; USFWS et al. 2001). Dams can block spawning migrations and severely restrict the availability of spawning and nursery habitat. In the event of a catastrophic event along a stream section, such as the diesel spill on a portion of the Reedy River in 1996, dams can make it very difficult for fishes and other aquatic animals to recolonize areas devastated by the catastrophe. Dewatering streams and rivers for anthropogenic purposes can result in reduced flows, elimination of critical habitats, and reduced water quality by concentrating non-point source pollution and increasing water temperature.

Nonnative fish species, particularly the nonnative Flathead Catfish (*Pylodictis olivaris*) and the Blue Catfish (*Ictalurus furcatus*), can severely impact native fish populations through competition for resources and predation. Flathead Catfish are voracious predators that have decimated ictalurid and other fish populations throughout the Southeastern United States (Guire et al. 1984; Jenkins and Burkhead 1994; Bart et al. 1994).

Climate is a primary force driving ecosystem dynamics, and aquatic systems are particularly susceptible to alterations in the hydrologic cycle. Our ability to predict the consequences of climate change is limited by uncertainty in climate predictions compounded by complexity in ecological system behavior. Climate will interact with a host of other ongoing system alterations—such as land use change—with which organisms must cope. Changes in precipitation timing and amount will affect water quantity and quality and timing of flows**.** Some of the unique characteristics of aquatic ecosystems in South Carolina that must be considered when planning for climate change impacts include:

- a high level of aquatic organism diversity and endemism.
- if migration of fishes is limited to within drainage networks, preventing natural migration across watershed boundaries.
- if barriers to connectivity within drainages are widespread, limiting natural migration upstream and downstream.

Data collected during the South Carolina Stream Assessment are being used to model potential consequences of climate change for streams in the State.

Diadromous Fishes

Diadromous fishes are species with complicated life histories, including partial growth and development in fresh and brackish and/or marine waters. These species are dependent on access to a wide diversity of habitats, particularly relative to water salinity or salt content, to most successfully complete their life cycle (McDowall 1988). There are several basic life history patterns within this group.

Anadromous fishes spawn in freshwater, but typically spend much of their developmental life in marine waters (McDowall 1988). In the Southeast, the classic anadromous life history is exemplified in the three alosine herrings or alosines (all members of the genus *Alosa* and the family Clupeidae): American Shad, Hickory Shad and Blueback Herring. The alosines are highly migratory species that occur along much of the Atlantic coast of North America and spawn in freshwater during late winter and spring. Genetically distinct populations occur in most coastal, freshwater drainage basins throughout the range of these species, including those in South Carolina (ASMFC 1985; ASMFC 1999). Because of similarities in life history, the alosines face similar threats and are often included in single, comprehensive management plans. These species are addressed in a guilded approach in the Supplemental Volume. Habitat associations can be found in Appendix 1-B.

Atlantic Sturgeon is the largest species of fish found in freshwaters of Eastern North America (Robins and Ray 1986). The Atlantic Sturgeon is also anadromous, but both juveniles and non-sexually-mature adults may move between fresh, brackish, and marine habitats during much of their lifespan (ASMFC 1990; McCord 2003). Atlantic Sturgeon may not occur in genetically segregated stocks to the extent as do alosines, but sturgeon are genetically dissimilar by Atlantic coastal region (North Atlantic, Mid-Atlantic and South Atlantic) (Wirgin et al. 2000). The extent of genetic mixing between drainage basin-specific populations or stocks is unknown.

The Shortnose Sturgeon displays a variant anadromous life cycle in southern populations (Dudley et al. 1977; Kynard 1997; McDowall 1988; NMFS 1998). Shortnose Sturgeons move into Atlantic Ocean coastal waters, though with much less frequency than do Atlantic sturgeons (NMFS 1998). Both species generally move between waters over a broad salinity range within particular drainage basins, and occasionally move into high salinity estuarine or nearshore marine waters (McDowall 1988; NMFS 1998). This semi-anadromous life cycle has been termed "freshwater amphidromous" (Kynard 1977; NMFS 1998). Such species typically occur in relatively unique genetic populations or population segments since there is limited opportunity for mixing between riverine populations (NMFS 1998). Genetic mixing between populations is likely rather limited. A potentially dam-locked population of Shortnose Sturgeon occurs in the Santee-Cooper lakes (Collins et al. 2003). Evidence to date indicates that this population is stressed, possibly because of lack of access to habitats with more appropriate food resources (Collins et al. 2003).

The Striped Bass is anadromous in basins along the North Atlantic and most of the Mid-Atlantic Coast, but is marginally anadromous, or freshwater amphidromous, in much of the Southeast (Dudley et al. 1977).

Catadromous fishes have a life history opposite that of anadromous fishes (McDowall 1988). This unusual life history strategy occurs in American eel (McDowall 1988; ASMFC 2000). The American Eel is distributed along much of the Atlantic Coast from Canada to South America in a single population (ASMFC 2000). Adults spawn in the Sargasso Sea, a region of the central North Atlantic, south of Bermuda and east of the Bahamas. Adults die after spawning; juveniles migrate across the Atlantic continental shelf and populate many estuarine and freshwater habitats where they remain until sexually mature (ASMFC 2000).

Ultimately, all seven diadromous fish species described here are included on South Carolina's Priority Species List. However, the Striped Bass is included on the list of freshwater fishes because the populations for which there is concern are located inland.

Since most diadromous species are highly migratory and use, or even require, a vast diversity of habitats, management of such species is much more problematic than for more habitat-specific species. Management is particularly complicated for species such as alosines and sturgeons that occur as individual populations (genetic races) by river basin, or even by major tributary within a basin (as has been indicated for American Shad). Most diadromous species are potentially impacted by threats both within and outside of a particular state's jurisdiction; for example, American Shad from South Carolina rivers occur in coastal bays of Canada during part of each year (Neves and Depres 1979). All portions of the life cycle are equally important for long-term sustainability of stocks. Accordingly, diadromous species generally require management through interstate or interjurisdictional plans.

Species Selection Process

The information about diadromous fishes contained in the Strategy was supplied by the expertise of biologists who formed our Diadromous Fishes Taxonomic Committee. The members of that committee invested considerable time in the development of the SWAP and are graciously thanked for their efforts; these individuals are listed in Table 3-7. Other sources of information included published literature and unpublished SCDNR data.

TABLE 3-7: DIADROMOUS FISHES TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Mel Bell	South Carolina Department of Natural Resources
Jason Bettinger	South Carolina Department of Natural Resources
Julia Byrd	South Carolina Department of Natural Resources
Mark Collins	South Carolina Department of Natural Resources
Doug Cooke	South Carolina Department of Natural Resources
Jarrett Gibbons	South Carolina Department of Natural Resources
Allan Hazel	South Carolina Department of Natural Resources
Billy McCord	South Carolina Department of Natural Resources
Elizabeth Miller	South Carolina Department of Natural Resources
Corbett Norwood	South Carolina Department of Natural Resources

Bill Post	South Carolina Department of Natural Resources
Brock Renkas	South Carolina Department of Natural Resources
David Whitaker	South Carolina Department of Natural Resources

The six diadromous species (American Shad, Hickory Shad, Blueback Herring, Atlantic Sturgeon, Shortnose Sturgeon, and American Eel) are considered to be highest priority species. All perform integral roles in the diverse habitats and ecosystems in which they reside during all portions of their complicated life cycles, and all have faced impacts that have caused stock declines, sometimes dramatic, in at least some river basins, both in South Carolina and across their broader ranges (ASMFC 1985; ASMFC 1990; ASMFC 1999; ASMFC 2000; NMFS 1998). The ecological functions of these species are described in detail within the species profiles. These species are all currently covered by dynamic management plans developed through the Atlantic States Marine Fisheries Commission (ASMFC) or the Natioanl Marine Fisheries Service (NMFS). Such management plans are primarily guidance documents that require action and cooperation by individual states. Several plans include mandates to the states that require specific monitoring or management actions. Unfortunately, funding associated with such plans and mandates has been insufficient to support actions necessary to collect information essential to assess and protect most basin-specific populations.

The Shortnose Sturgeon is a Federally Endangered species under the Endangered Species Act (ESA). However, individual basin-specific stocks of other anadromous species may be more imperiled than are many Shortnose Sturgeon stocks. All of the State's priority diadromous species are currently, or have been, targeted by commercial and/or recreational fisheries. Management of these species has generally been limited to control of fisheries. This is oftentimes based on limited data, perceived population levels, and regulatory actions presumed to produce desired positive effects. Currently, all take of Shortnose Sturgeon is prohibited because of its Endangered status. The Atlantic sturgeon is also under a fishery moratorium that began in 1985 and is to remain in effect for an undetermined period based on the ASMFC plan. In addition, the Atlantic Sturgeon are now listed as Federal and State Endangered. State law has closed commercial gear fisheries for alosines in several rivers and has limited such fisheries, as well as recreational creel limits, in other areas within the past decade. The Blueback Herring and American Eel have also been petitioned for listing under the Endangered Species Act by the National Marine Fisheries Service and the United States Fish and Wildlife Service, so further protection of these species may be on the horizon. However, prudent, effective, and responsive management of all of these species is dependent upon surveys and monitoring that can establish current distribution and stock status for all six priority diadromous species.

Challenges

There is a paucity of information on all species, particularly in regard to current population trends or distribution. For most of the priority diadromous species, information concerning presence or absence of these fishes is lacking for many state river basins. Also, the known or perceived status of individual populations for which there are data is variable, ranging from "secure" to "apparently depleted".

Dams that block or limit access of migratory fishes to historical habitats and prevent free movement both up- and downstream, have been indicated as major contributors to stock declines

for all diadromous species (ASMFC 1985; ASMFC 1990; ASMFC 1999; ASMFC 2000; NMFS 1998). Information on current distribution and stock status of all six high priority species is highly applicable to Federal Energy Regulatory Commission (FERC) relicensing considerations for dams and other water diversion facilities. Many dams on drainage basins within South Carolina are currently, or soon will be, undergoing the FERC-relicensing process. Both the NMFS and the USFWS have primary authority over fish passage and diadromous fish restoration issues related to FERC-relicensing (ASMFC 1985; ASMFC 1990; ASMFC 1999; ASMFC 2000; NMFS 1998). However, state natural resource agencies generally participate in such activities as well.

Because of the broad diversity of life history characteristics and habitat utilization displayed by diadromous species, and because of their complicated life cycles, survey and monitoring techniques must be diverse and performed for a decade or more to establish meaningful trends indicative of stock status. Most survey and monitoring to gather information on stock status of diadromous species in South Carolina over the past two decades or more has been funded by various federal grants. These studies have been primarily performed in response to mandates in ASMFC management plans. Funds have not been sufficient to allow for either comprehensive studies of all populations in South Carolina or for the accumulation of sufficient long-term data to provide for conclusive indications of stock status for even any single population.

Furthermore, mandated data collection is most extensive for American Shad, and such data collection is not required for all populations since participants in the ASMFC management plan development process understood (and currently understand) funding limitations. Generally, small rivers are not covered by mandates within the ASMFC plan for alosines (ASMFC 1999; ASMFC 2002). ASMFC management plans for the Atlantic sturgeon and the American eel include few mandates, but like all ASMFC plans, the National Marine Fisheries Services recovery plan for Shortnose Sturgeon (NMFS 1998) and other management plans, make numerous recommendations for data collection needs. These studies will help to establish population status and conservation actions needed to restore or enhance individual populations or population segments.

In many South Carolina river basins, basic surveys must be conducted to determine either presence or absence of these species. Population surveys in some rivers may be useful as indicators of probable stock trends in similar basins. Perhaps among the highest priorities should be the continuation or expansion of existing surveys (i.e. a survey of sturgeons in the Edisto River initiated in 1996) for sufficient duration to allow for characterization of stock status.

Modification of existing habitat poses a threat to all diadromous fishes. Changing the river's profile by deepening of the river channel or closing off existing corridors, can lead to lost habitat, differences in hydrologic features, and changes in water quality (i.e. salinity, dissolved oxygen, temperature, and pH). In addition, deforestation without proper buffers can lead to sedimentation and shoaling. These modifications to spawning habitat not only make once deep river reaches shallow, but affect areas upriver, causing siltation which makes it impossible for eggs to survive.

Climate change also has the potential to affect all diadromous fishes in one way or another. Long-term observations confirm that the climate is changing at a rapid rate. Over the 20th

century, the average annual US air temperature has risen by almost 0.6°C (1°F) and precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). These trends have been most apparent over the past few decades. Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project the Southeast to warm by the 2090s but at different rates (NAST 2000). Some of the major impacts to diadromous fishes will include loss of nursery habitat, loss of spawning habitat, and reduced flows. Expected consequences would be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000).

Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development—and this stress may be exacerbated by changes in climate—anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch et al. 2000). A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al. 2008). Consistently low stream flow can limit available spawning, thermal refugia, and foraging habitat.

Sea-level rise (SLR) is one of the more certain consequences of climate change; it has already had significant impacts on coastal areas, and these impacts are likely to increase. Since 1852 when the first topographic maps of the southeast region were prepared, high tidal flood elevations have increased approximately 30 cm (12 in.). During the 20th century, global sea level has increased between 15 and 20 cm (6 and 8 in.) (NAST 2000). Analyses attribute the coastal forest decline in the Southeast to salt water intrusion associated with sea level rise. Coastal forest losses will be even more severe if sea-level rise accelerates as is expected as a result of global warming. It is difficult to ascertain which impacts will occur and over what time period, but there is little doubt these impacts will affect diadromous fishes.

Other important issues in diadromous fish management include the determination of the extent of genetic isolation of populations or population segments using tributaries within larger drainage basins. For example, detailed and expensive genetics studies may be required to determine the relationships of alosines spawning within various tributaries of the greater Waccamaw-Pee Dee Basin. Similar relationships may exist for alosines in the ACE Basin rivers. Genetic relationships and the extent of genetic isolation of Atlantic sturgeon in riverine spawning populations are also poorly understood. Genetic implications are also very important with regard to the development of some fish passage and fish restoration programs when the integrity of genetically distinct populations may be negatively affected. For effective management of the Atlantic Coast American Eel population, it is of utmost importance to better understand the contribution of various riverine or regional sub-populations or population segments to the current and long-term productivity of the entire continental population.

Lastly, non-native, invasive species can impact populations of diadromous species. Blue Catfish and Flathead Catfish both are presumed to act as both competitors and predators to sturgeon, for example (NMFS 1998).

Crayfishes and Freshwater Shrimp

Crayfish are freshwater decapod crustaceans of the superfamily Astacoidea. Representatives of two of the three families, Astacidae and Cambaridae are found in North America. About 75% of the total known species of crayfish are endemic to North America (Lodge et al. 2000a). The Southeastern United States exhibits by far the greatest species diversity of any region (Taylor et al. 1996, 2007). South Carolina is the home to a diverse crayfish fauna of at least 38 native species. Nine of the known species appear to be endemic to the State; many others are found only in South Carolina and an adjacent state. Of the five species of the burrowing genus *Distocambarus*, four are South Carolina endemics. South Carolina freshwater shrimps belong to the family Palaemonidae (Caridea, Atyoidea), some of which live in both fresh and brackish water habitats.

Crayfish play several important ecological roles in aquatic habitats. These animals make up a large portion of the invertebrate biomass and the diet of several game fish species in some water bodies (Probst et al. 1984; Rabeni 1992; Roell and Orth 1993). Some South Carolina snakes also rely heavily on crayfish for food. Crayfish also have a drastic effect upon the biomass and species composition of aquatic macrophytes and snails (Lodge et al. 1994). Despite their abundance and importance in many North American freshwater habitats, both the taxonomy and natural history of many species of crayfish are poorly understood. New species are frequently being discovered and existing species are often reclassified. In fact, one of the species on our list is in the process of being described.

Commonly thought to inhabit strictly aquatic environments, crayfish can utilize a variety of aquatic, semi-aquatic, and terrestrial habitats. All species rely on water for reproduction, but many burrowers are terrestrial and either access the water table by digging deep enough or by constructing the burrow with compact soil around the walls, allowing it to retain moisture from rainfall and runoff. Some crayfish are obligate burrowers and rely on habitat such as farm fields, prairies and forests. Others inhabit streams, small lakes, or temporary ponds but may dig terrestrial burrows during dry periods. Still other species are restricted to aquatic habitats. The habitat requirements of many species, particularly primary burrowers, are not well understood.

Hobbs (1981) distinguished freshwater crayfish as primary, secondary, or tertiary burrowers. Primary burrowers spend almost their entire lives in the burrow. Secondary burrowers spend much of their lives in a burrow, but may move to open waters during rainy periods. Tertiary burrowers live primarily in open water but may move into a burrow to escape frost or drought and when brooding eggs.

Historically, the conservation of American crayfishes has received little attention by regulatory agencies; however, there has been some progress over the past decade. In 1996, the American Fisheries Society considered 65 species (19.2%) of North American crayfish as endangered, 45 (13.3%) as threatened, and 50 (14.8%) as special concern (Taylor et al. 1996). In 2007, updates

to the previous assessment resulted in nearly the same composition with 66 species (18.2%) of North American crayfish as endangered, 52 (14.3%) as threatened, and 54 (14.9%) as special concern (Taylor et al. 2007). Listing with the American Fisheries Society does not give species any protection. The US Fish and Wildlife service only lists 4 species as Federally Endangered, none of which are in South Carolina. No crayfish species are currently listed as Threatened by the US Fish and Wildlife Service. In 2011, however, 4 crayfish species that occur in South Carolina were proposed as candidates for listing as Federally Threatened or Endangered species (USFWS 2011).

Since the conservation plan for crayfishes of South Carolina was drafted, efforts have been made to survey crayfishes by the South Carolina Department of Natural Resources and contractors from universities. Additional distribution records across the State have accumulated as a result of these surveys. During the South Carolina Stream Assessment (2006–2011), crayfishes and shrimps were recorded at 364 of 397 random stream sites in 29 ecobasins across the State and at additional stream sites. These specimens are being identified as part of a State Wildlife Grant in progress.

Species Selection Process

The information about aquatic and terrestrial crayfish contained in the initial 2005 Plan was supplied by the expertise of 5 biologists (Kohlsaat et al., 2005). These people invested considerable time in the development of the Plan and are graciously thanked for their efforts; these individuals are listed in Table 3-8. Other sources of information included published literature, museum records, and reports.

TABLE 3-8: CRAYFISH & FRESHWATER SHRIMP TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
John Cooper	North Carolina Museum of Natural Sciences
Arnold Eversole	Clemson University
Daniel Jones	Clemson University
William Poly	South Carolina Department of Natural Resources
Jennifer Price	South Carolina Department of Natural Resources
Shane Welch	Clemson University

During December 2003, biologists were asked to review a list of 42 crayfish species and comment on the conservation status, conservation needs, and knowledge deficiencies of each species. Each reviewer was given an Excel data sheet with 18 questions accompanied by a set of criteria and instructions for conducting their review. Nine of the questions were multiple-choice and 9 were designed for comments. There were 2 categories of multiple-choice questions: those dealing with the current knowledge of a given species and those dealing with the species' conservation status. There were several species for which no one could provide any information. These species were retained on the conservation concern list due to lack of status information; data on these species was provided through museum records and publications. Ultimately, 23 crayfish species were included on South Carolina's Priority Species List for 2005. In 2011, updates to the status of each species was assessed using the previous assessment along with

recent SCDNR collection records, museum records, research reports, correspondence, and published literature.

In South Carolina's SWAP, crayfish are addressed in two groups. One is entitled "Primarily Aquatic Species Group;" in this group, all aquatic species are treated together, including secondary and tertiary burrowers, based upon our best knowledge. The second group is entitled "Terrestrial Burrowing Crayfish Group;" primary burrowers are addressed in this group since the challenges these species face may be somewhat different than those species inhabiting open water.

Changes to SC's SWAP crayfish list included the addition of 2 new species: the Carolina needlenose crayfish, an endemic, and *Cambarus* sp. "B" The latter species has yet to be described and fully understood so it is ranked as "highest priority" due to the lack of knowledge of the species. The Oconee stream crayfish was renamed the Chauga crayfish. Additionally, 10 other species received common names in this iteration of the SWAP. The latest stream surveys also indicated that the Pee Dee lotic crayfish and Carolina Sandhills crayfish (formerly simply called the Sandhills crayfish) were more abundant than first realized and were thus demoted to the "moderate priority" category. The Ohio River shrimp, first discussed in the 2005 version of the SWAP in the marine invertebrates section, was moved to the freshwater section because of its association with rivers. Species/guild accounts can be found in the Supplemental Volume while habitat associations are in Appendix 1-B.

Challenges

There are a number of potential challenges to crayfish. However, it is difficult to assess the degree to which each species is vulnerable to particular threats until the habitat associations, population trends, and distributions are better understood for each species. Genetic and taxonomic work is also very important where there are questions regarding classification because misidentification, or the lumping of species complexes, may obscure the presence of rare species in need of conservation. The case of *Cambarus* species "B," which was mistaken for an introduced species, is an excellent example. As of January 2012, this species remains undescribed, and most recently it has been treated as an introduced population of *C. longirostris* in South Carolina (McLaughlin et al. 2005; Taylor et al. 2007).

The arrival of introduced species is probably the greatest challenge to crayfish (Lodge et al. 2000a,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). In Europe, crayfish introduced from North America appear to be responsible for the spread of diseases to native species (Lodge et al. 2000a). Other potential mechanisms for the deleterious effects of invasive crayfish include predation upon natives, competition, and genetic hybridization with native species (Lodge et al. 2000a).

The red swamp crawfish, *Procambarus clarkii*, has been introduced from the Mississippi drainage into South Carolina (Hobbs et al. 1989). While few studies have documented the effects of the red swamp crawfish on native species, potential negative effects of its introduction include the spread of fungal diseases to other crayfish and the spread of human helminth parasites, for

which this species is an intermediate host (Hobbs et al. 1989). In South Carolina, *P. clarkii* has been collected at sites at which native crayfishes were present in some cases and absent in others (Poly 2007). The latter sites were channelized so lack of native crayfish species could be due either to habitat modification and/or presence of the non-native *P. clarkii*. Several sites in North Carolina that once had native species of crayfishes now have only *P. clarkii* (Cooper and Armstrong 2007), suggesting that *P. clarkii* has possibly displaced them.

Outside of its presumed native range that includes portions of Ohio, Indiana, and Kentucky, the rusty crayfish (*Orconectes rusticus*) has been widely introduced in the United States (Hobbs et al. 1989), although some records had been misidentifications (Wetzel et al. 2004). It is considered an non-native invasive species that usually becomes established where bait buckets have been dumped (A. Eversole, pers. comm.). The Rusty Crayfish has been reported from the upper Broad River drainage in North Carolina (Cooper and Armstrong 2007) and possibly could spread downstream into South Carolina. As of 2012 it has not been found in South Carolina, and the population in North Carolina doesn't appear to be spreading and might even have declined (Steve Fraley NCDENR pers. comm.). Several shipments of crayfishes to South Carolina schools for educational use have contained rusty crayfish (W. Poly pers. obs.).

Prevention of future introductions is most likely the only effective way to deal with the challenges caused by non-native 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. Other non-native crayfishes and shrimps have also been introduced into South Carolina. *Cherax quadricarinatus* and *Macrobrachium rosenbergii* were introduced to South Carolina for aquaculture (Smith et al. 1978, Brummett and Alon 1994) but do not appear to have become established in the wild.

Additionally, the "white list" approach should govern the species allowed for use in aquaculture. This approach restricts the sale of crayfish to only those species that have been extensively researched and demonstrated to pose minimal risk as potential invaders. We may not always be able to predict whether a species is likely to become invasive; even those thought to pose minimal risks should not be released.

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, such as *Cambarus* species "B", 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 1994). 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).

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.

Crayfish are fairly sensitive to pH (Hobbs and Hall 1974; Hobbs 1991). It appears that stream-dwelling species tend to have a lower tolerance for low pH than those from shallow lentic habitats (Hobbs and Hall 1974). Observations of diverse crayfish fauna at neutral pH (7.0) and the absence of crayfish at a high pH (11.4) in otherwise similar streams in Georgia suggest that crayfish may also be sensitive to high pH (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 more sensitive to water-borne pollution than adults; early instars are about three times more 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.

Freshwater Mussels

Freshwater mussels native to the United States are bivalve mollusks, belonging to the order Unionoida and superfamily Unionoidea. There are two families within Unionoidea: Unionidae and Margaritiferidae. All of South Carolina's species belong to the family Uniondiae. The Southeastern portion of the United States is the most diverse region in the world for freshwater mussels (Lydeard and Mayden 1995). The taxonomic identification of mussels to species can be difficult. More work is necessary to determine if species designations currently in use are correct.

The conservation of North American freshwater mussels has many broad implications beyond the survival of individual mussel species. As filter-feeders, mussels clean the water of suspended particles and can increase water clarity. They are also important food sources for fish, waterfowl, turtles, muskrats, raccoons, and river otters. Other invertebrates use mussels as hosts; two fish species are known to use mussels as brooding sites (Bogan 2001). Since mussels are sometimes found at densities as high as 200 to 400 per m^2 (19 to 37 per $ft.^2$), removing them from our rivers and streams can have drastic consequences for these ecosystems, particularly in terms of water filtration (Bogan 2001). The tolerance for pollution may differ somewhat between species, and

we have little information on reactions to specific pollutants by species, since most evidence is anecdotal. Laboratory toxicology studies have been conducted on a few species. In general, mussels are quite sensitive to pollutants and are recognized as indicator species; they are often the first to decline when streams and rivers become polluted. Protection and restoration of freshwater ecosystems to support a diverse mussel fauna will also result in improving the health of these ecosystems to the benefit of other aquatic organisms and humans.

Historically, mussels have been used for a variety of commercial purposes. In the mid- to late-1800s, harvesting mussels for pearls was common. From the 1890s until the 1950s, there were large commercial operations to harvest mussels for their shells which were used to make buttons. Today, there is still some demand for mussel shells for use in the cultured pearl industry and large-scale commercial harvesting still occurs in the US. However, no large-scale commercial harvesting currently occurs in South Carolina.

As a group, freshwater mussels are found in a variety of environments throughout South Carolina. A few species are widespread and found throughout the East Coast, but many are endemic to one or a few river drainages. Many species are endemic to only North and South Carolina or only to South Carolina and Georgia (Bogan and Alderman 2004, 2008).

Most freshwater mussels are dioecious (separate sexes), although a few species are hermaphroditic. After fertilization and hatching within the female, the larva—called glochidia—are expelled and must attach themselves to the skin, gills, or fins of a fish host, or in a few cases a salamander, in order to complete development. Some species will only parasitize a single host species, while others can develop within any of several species. Therefore, the presence of the required fish or salamander host at the appropriate time of the year represents an additional habitat requirement for most species. A few species, such as *Strophitus undulatus*, are able to complete larval development without the assistance of a host fish.

Freshwater mussels are among the most threatened groups of organisms in North America. There are nearly 300 recognized species and subspecies in the United States, and 189 of them are currently on the IUCN Red List (Lydeard et al. 2004). At least 30 species are presumed extinct. Many more may be functionally extinct; some long-lived individuals have survived, but their populations are not reproducing (Bogan 1997). In 1993, the American Fisheries Society evaluated the conservation status of freshwater mussels in the United States and Canada (Williams et al. 1993). They determined that 7.1% of mussel species were endangered and possibly extinct, 20.6% were endangered and extant, 14.5% were threatened, 24.2% were of special concern, and 4.7% had an undetermined status; only 23.6% of mussel species were determined to be stable. A panel of experts from the Southeast concluded that only three of 33 native mussel species in South Carolina are stable and abundant enough not to be included as conservation priority species. The earliest effort to establish a list of species of conservation concern in South Carolina was that of Fuller (1979).

Records from the mid- and early 1800s indicate that mussels were once plentiful in most North American rivers and streams (Parmalee and Bogan 1998). Mussels have completely disappeared from many bodies of water and rarely reach densities approaching those from historic times. Qualitative records of the decline of mussels are abundant, but there is little detailed quantitative

information to document the rate of decline of these species (Keferl 1993). While the Broad River mainstem in South Carolina continues to support a variety of mussel species (Price and Eads 2011), many of the tributary streams and rivers do not have any native mussels present (Keferl 1993; Scott et al. 2009).

Difficulty in identifying mussels has added to challenges quantifying their decline. Historic species identifications are often questioned, and the extent of a species' historic range is usually uncertain. Museum specimens are also especially lacking in South Carolina because there is no state natural history museum and collections are not in a centralized location. However, there are several natural history museums in the Eastern United States that contain mussel specimens from South Carolina. In addition, mussel specimens collected during the South Carolina Stream Assessment (2006–2011) were deposited in the North Carolina Museum of Natural Sciences for long-term storage and for use by mussel specialists. Temporal gaps in data exist because surveys have not been conducted at regular intervals. While there seems to be a growing interest in freshwater mussel conservation, conducting surveys is difficult due to (1) the lack of researchers skilled in mussel identification and taxonomy and (2) lack of funding to support surveys and other research, especially in South Carolina. Unresolved taxonomy of mussel species contributes further to the difficulty in making identifications. Taxonomic and systematic studies continue to be done on mussels in South Carolina, and over the next decade or two, additional species diversity likely will be known from the State as a result of these efforts.

Since the conservation plan for freshwater mussels of South Carolina was drafted over seven years ago, substantial efforts have been made to survey mussels in the State by a variety of organizations including The Nature Conservancy, the US Fish and Wildlife Service, the South Carolina Department of Natural Resources, and private consulting groups. Also, the Atlantic Slope Mussel Meetings and Workshops that have been held over the past 5 years have allowed mussel biologists and taxonomists to discuss their recent surveys and research projects. Many significant distribution records across the State have accumulated as a result of these surveys. During the South Carolina Stream Assessment (2006–2011), freshwater mussels were recorded at 77 of 397 random stream sites in 17 ecobasins across the State and at more than 50 additional stream sites. Although these records do not reflect the actual presence and abundances accurately because of the limited sampling for mussels, they do provide useful distribution information and museum specimens that will be used by mussel specialists to reassess the taxonomy and conservation status of various species.

Species Selection Process

The information about freshwater mussels contained in the SWAP was supplied by the expertise of biologists who formed our Freshwater Mussel Taxonomic Expertise Committee. The members of that committee invested considerable time in the development of the SWAP and are graciously thanked for their efforts; these individuals are listed in Table 3-9. Other sources of information included published literature and museum records.

TABLE 3-9: FRESHWATER MUSSELS TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
John Alderman	Alderman Environmental Services
Joseph Alderman	Alderman Environmental Services
Arthur E. Bogan	North Carolina Museum of Natural Sciences
Tom Dickinson	The Catena Group
David Eargle	South Carolina Department of Health and Environmental Control
John Fridell	United States Fish and Wildlife Service
Eugene Keferl	Coastal Georgia Community College
Eric Krueger	The Nature Conservancy
William Poly	South Carolina Department of Natural Resources
Jennifer Price	South Carolina Department of Natural Resources
Tim Savidge	The Catena Group
James Williams	United States Geological Survey
Morgan Wolf	United States Fish and Wildlife Service
Laura Zimmerman	United States Fish and Wildlife Service

The Freshwater Mussel Taxonomic Expertise Committee members met in August 2004 to review a list of potential priority species, make changes, and categorize the distribution and conservation needs of each mussel species. The committee reached consensus that 26 out of 29 of the species known to occur in South Carolina were rare and/or declining and in need of some conservation action (Kohlsaat et al. 2005). Each reviewer was given an Excel data sheet with 18 questions accompanied by a set of criteria and instructions for conducting their review. Nine of the questions were multiple-choice, and nine were designed for comments. There were two categories of multiple-choice questions: those dealing with the current knowledge of a given species and those dealing with the species' conservation status.

In 2011, biologists were asked to review a revised list of 36 mussel species and comment on the conservation status, conservation needs, and knowledge deficiencies of each species. Changes included the renaming of the Carolina Slabshell (*Elliptio canagarea*) as Carolina Elephantear. The reason for the change was due to the fact that the shell was not shaped like other typical slabshells. Likewise, the Southern Rainbow (*Villosa vibex*) was renamed the Eastern Rainbow (*V. modioliformis*). The Atlantic Spike moved up in priority ranking from "moderate" to "high" due to new information available on the status and distribution of the species. A new species this iteration is the Altamaha Arcmussel (*Alasmidonta arcula*). Eastern Lampmussel (formerly mislabeled in the text as Eastern Lampshell) and the Rayed Pink Fatmucket have been broken out into separate species, *Lampsilis radiata* and *L. splendita*, respectively. In 2011, 4 mussel species that occur in South Carolina were proposed as candidates for listing as Federally Threatened or Endangered species (USFWS 2011). All priority species are discussed in the Supplemental Volume, and habitat associations are provided in Appendix 1-B.

Challenges

Siltation appears to inhibit the reproduction of many mussels and the survival of juveniles (Ellis 1931). Siltation is usually considered the biggest challenge to the survival of freshwater mussels. Ellis (1936) found that silt accumulation on the substrate at a depth of 6 mm to 25 mm (0.25 to 1 in.) over several months caused mortality in several species of mussels in the laboratory, possibly

by reducing oxygen levels near the substrate and by silt build-up in the mantle cavity and gill chambers. Sediments suspended in the water column also harmed mussels by reducing the amount of time that they remained open for feeding (Ellis 1936).

Historically, siltation results from clearing land for farming, from mining operations, and by the construction of dams. Farming continues to be a challenge when too much bare soil is exposed, when sufficient riparian buffers are not maintained, and when cattle are allowed to enter streams. Feral pigs contribute to siltation by digging along streambanks and channels and uprooting vegetation in search of food. Rapid development in some parts of South Carolina also contributes to siltation in many ways. Impervious surfaces such as roads, buildings, and parking lots increase erosion in adjacent areas and contribute to flooding. Clearing riparian vegetation also destabilizes stream and riverbanks allowing excessive siltation. Clear-cutting in a substantial part of a watershed can also contribute to siltation, even if a riparian buffer is maintained. The use of motor vehicles in streams and along banks can also degrade the stability of banks, stir up benthic sediments, and increase siltation. Factors that contribute to siltation can also change the topography of the stream or river by changing the slope of the bank and eliminating heterogeneity in the channel. Eliminating structural heterogeneity may also slow the flow of water and reduce its oxygen content, therefore harming species that require highly oxygenated water. The rapid release of large amounts of sediment that has accumulated behind dams has no doubt had at least localized impacts on mussels occurring below dams.

Freshwater mussels have long been recognized as sensitive species that respond more quickly to pollution and siltation than other aquatic fauna. Ortmann (1909) recognized the rapid disappearance of mussels from streams polluted by coal mining, sewage, oil wells, oil refineries, and dam construction. Acidification appears to have drastic effects upon the survival and shell structure of mussels (Fuller 1974). Point source pollution from paper mills, dye factories, gasoline by-products, and chlorinated hydrocarbon pesticides are extremely toxic to mussels (Fuller 1974). Mercury appears to have significant negative effects on mussel growth (Beckvar et al. 2000). One review paper discussing the effects of ammonia concentration on ten species of mussels indicated that current EPA criteria maximum guidance concentrations for ammonia may be too high to offer protection to many mussels, particularly juveniles and glochidia (Augspurger et al. 2003).

Dam construction has caused the decline of mussels in many locations. Dams can slow the speed of water, thereby reducing the oxygen content and allowing the buildup of additional fine sediment. Dams may interfere with the reproduction of mussels by restricting the travel of host fish or by preventing the travel of sperm through the water to reach female mussels. Impoundments also result in habitat fragmentation and isolation of populations by preventing up- and downstream recruitment, making populations more vulnerable to extirpation from other environmental impacts.

Hydroelectric power plants also can harm mussels by causing sudden variation in water volumes which could leave shallow water mussels stranded. Peak flows can physically dislodge mussels which may later become stranded when flows suddenly recede. Rapid changes in water temperature may also occur and can cause additional stress on mussels. Some mussel species are

fairly tolerant of damming; mussel diversity may be reduced downstream of dams when a few tolerant species replace a previously diverse community of mussels.

Interbasin water transfer can also cause the degradation of streams and rivers and can be harmful to mussels. Such transfers can cause changes in the variability of flow, the speed of water through the channel, and the composition of the substrate. The effects of interbasin transfers on mussels are similar to those caused by dams and siltation.

The Asian clam (*Corbicula fluminea*) has been introduced and has spread throughout the United States. While it often co-occurs in large numbers with native mussels, it may sometimes contribute to their decline. During the South Carolina Stream Assessment (2006–2011), *Corbicula fluminea* was recorded at 68 of 397 random stream sites in 21 ecobasins and was distributed widely in all river basins of the State. In the St. John's River basin, Belanger et al. (1990) found that the density of *Corbicula* was inversely correlated with the density of native mussels. Further, mussels of the genus *Elliptio* experienced slower growth rates when they were among high densities of *Corbicula*. Unfortunately, there seems to be no pre-invasion data to assess impacts on native populations in systems such as Lake Marion where *Corbicula* overwhelmingly dominates the benthos (B. Taylor, pers. comm.).

The zebra mussel (*Dreissena polymorpha*) was introduced into the United States and has become well established in the Northeast and in the Great Lakes area. This is a much more problematic bivalve than *Corbicula*. The zebra mussel can cause the decline of native mussels by competing for food or by overcrowding. Overgrowth by zebra mussels may interfere with the feeding or locomotion of native mussels. It has invaded nearby parts of Tennessee and may eventually spread into South Carolina, although the risk of them becoming established has been assessed as low due to unsuitable water chemistry (de Kozlowski et al. 2002). As of 2012, zebra mussels have not been discovered in South Carolina or in any river drainages that flow into the State.

Feral hogs (*Sus scrofa*) have been roaming the Southeastern United States and have gradually become widespread throughout the Southeastern and South-Central United States and California. The species has become the most abundant free-ranging introduced ungulate in the United States (Sweeney et al. 2003). They are primarily found on floodplains along rivers, but occasionally populations will become established in other areas due to their capture and release for hunting purposes. In addition to contributing to siltation by uprooting streambank vegetation, feral hogs also directly consume mussels.

The identity of the host fishes for more than half of South Carolina's mussels is now known (Bogan and Alderman 2004, 2008), and research on suitable host fishes continues (Eads et al. 2010). Conservation of specific mussel species by protecting the host fishes can only be practiced efficiently if the identity of the host fishes is known. Conserving healthy aquatic environments will benefit both fishes and mussels.

Freshwater Snails

Mollusks of the class Gastropoda—commonly known as snails, slugs and limpets—are found in freshwater, terrestrial, and marine habitats. Terrestrial snails are not being included in the SWAP

at this time because little is known about the distribution and status of these organisms. Further, we have been unable to identify any regional experts who can provide substantial information about South Carolina's land snails. As with other invertebrate groups, the taxonomy of snails requires much additional research to sort out more precisely the species that occur in South Carolina and adjacent areas.

Since the conservation plan for freshwater mussels of South Carolina was drafted over seven years ago, efforts have been made to survey and identify snails in the State by Robert T. Dillon, Jr. (College of Charleston) and colleagues, private consulting groups, and the South Carolina Department of Natural Resources.

Surveys for snails in South Carolina were conducted in the 1980s-1990s (Dillon and Keferl 2000). Recently, the taxonomy of freshwater snails in South Carolina has received attention, resulting in the description of a new species, *Physa carolinae*, which occurs in Georgia, South Carolina, North Carolina, and Virginia (Wethington et al. 2009). Also a web-based Freshwater Gastropods of North America currently includes coverage for five states: Virginia, North Carolina, South Carolina, Georgia, and Tennessee. The South Carolina website includes a species gallery with color photographs of the shells of all species, a dichotomous key to species, and species accounts that discuss the distribution (with maps), biology, and taxonomy of each species (Dillon and Stewart 2010).

During the South Carolina Stream Assessment (2006–2011), freshwater gastropods were recorded at 50 of 397 stream sites in 11 ecobasins across the State. In addition, more collections were made as part of other research projects. Identifications were made possible with the kind assistance of Rob Dillon. *Campeloma decisum* was the snail collected most often and in greatest abundance. Although these records do not reflect the actual presence and abundances accurately because of the limited sampling for gastropods, they do provide useful distribution information and museum specimens that can be used for taxonomic or biological studies. All of the SCDNR snail records were provided to Robert Dillon for inclusion in the aforementioned web-based, Freshwater Gastropods of North America. Gastropod specimens from the South Carolina Stream Assessment were deposited in the North Carolina State Museum of Natural Sciences for long-term documentation and so that the specimens can be used for morphological and genetic research that will contribute a better understanding of the diversity of gastropods in South Carolina.

Species Selection Process

Robert Dillon of the College of Charleston and Paul Johnson of the Tennessee Aquarium were contacted regarding the species status of South Carolina's freshwater snails in November of 2003. At that time, the South Carolina Department of Natural Resources did not have a working list of the freshwater snails that occurred in South Carolina. A tentative list was provided by Paul Johnson and edited by Robert Dillon. Both biologists invested considerable time in the development of the 2005 Plan and are graciously thanked for their efforts. Other sources of information included published and unpublished literature. Ultimately, four freshwater snails were included on South Carolina's Priority Species List for the 2005 edition of the Plan (Kohlsaat et al. 2005). For the 2012 formal review process, Robert Dillon and Arthur E. Bogan

were asked to participate in a revision of the gastropods of conservation concern because of their active work on species in South Carolina and nearby states. See Table 3-10 which details all the experts consulted for freshwater snails.

TABLE 3-10: FRESHWATER SNAILS TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Arthur E. Bogan	North Carolina Museum of Natural Sciences
Jennifer Price	South Carolina Department of Natural Resources
Paul Johnson	Tennessee Aquarium
Robert Dillon	College of Charleston
William Poly	South Carolina Department of Natural Resources

Depending on the source, either 32 or 36 species of snails are present in South Carolina as of 2012 (Dillon and Stewart 2010, Johnson et al. in press). Only 3 species are considered to warrant conservation concern at this time (*Gillia altilis, Somatogyrus virginicus / S. spp.,* and *Lioplax subcarinata*). There will no doubt continue to be changes in the knowledge of the gastropod fauna of South Carolina, including new records of both native species and non-native species, along with information on their life histories. A few changes were made in the snail listings from 2005 to 2015. *Somatogyrus sp.* (a pebblesnail) was given a formal name, panhandle pebblesnail, and downgraded to "high priority" due to better knowledge of population estimates. The "*Physa* species A" mentioned in the previous (2005) version of the SWAP was formally described as *Physa carolinae* by Wethington, Wise, and Dillon in 2009. *Physa carolinae* is actually rather common, and does not merit any special conservation concern (R. Dillon, pers. comm.). Freshwater snails of greatest conservation need are discussed in the account found in the Supplemental Volume. Habitat associations are listed in Appendix 1-B.

Challenges

The lack of knowledge and information about life histories and habitat requirements for freshwater snails represents the most significant challenge to these species.

Siltation of streams and rivers through agricultural runoff and erosion of unstable streambanks appears to be the main threat to freshwater snails (Dillon and Keferl 2000). Historically, siltation has occurred due to land clearing for farming, residential development, forestry practices, mining operations, and construction of dams. Absence of sufficient riparian buffers significantly contributes to siltation (Moglen 2000). Clear-cutting a substantial part of a watershed can also contribute to siltation, even if a riparian buffer is maintained. Livestock and feral pigs degrade stream banks and bottoms as they drink and search for food. Impervious surfaces, such as roads, buildings, and parking lots increase erosion in adjacent areas and contribute to flooding (NCWRC 2002). The use of motor vehicles in streams and along banks can also disturb stream flow and increase siltation. All of these factors that contribute to siltation can also alter the topography of streams and rivers by changing the slope of the bank and eliminating heterogeneity in the channel.

Climate change will be a force that may affect mussels in the future. Since some mussels, such as the ridged lioplax, are at the southern edge of the species' presumed range, increasing temperatures may render current locations uninhabitable.

Freshwater, Marine, and Terrestrial Leeches

Leeches (Annelida: Hirudinida) occur in freshwater, marine, and terrestrial habitats. Some leeches are free-living predators on other invertebrates or on eggs, whereas others are primarily parasitic on vertebrate hosts. Some are parasitic, yet can be found off their hosts at times (Davies 1991, Hoffman 1999; Moser et al. 2005; Govedich et al. 2010). The leech fauna of South Carolina is relatively well known from past research on the group by Roy T. Sawyer and colleagues (Sawyer 1972; Sawyer and Pass 1972; Sawyer et al. 1975; Sawyer and Shelley 1976; Sawyer 1979). Leeches often go unnoticed until they become a problem to humans, such as when they attach to swimmers (Sawyer 1973).

Recent Biological and Conservation Efforts

Sawyer and Shelley (1976) surveyed for leeches and described several new species and subspecies occurring in North and South Carolina. Their list for South Carolina included 23 species of leeches, including 1 terrestrial, 19 freshwater, and 3 marine leeches. Since then, little work has been done; however, several recent reports have added species to the South Carolina fauna or corrected erroneous taxonomy (Light et al. 2005; Moser et al. 2011; Poly 2011). During the South Carolina Stream Assessment (2006–2011), freshwater leeches were collected at only a small number of stream sites across the State because this was not a group that was targeted. The most recently discovered species in South Carolina is *Macrobdella sestertia* (Poly 2011), which previously has been found infrequently in Massachusetts and Maine (Smith 1977, Smith and Hanlon 1997). With recent additions of taxa and taxonomic recommendations, the total number of leech species known from South Carolina is 25, including 1 terrestrial, 21 freshwater, and 3 marine.

Species Selection Process

Leeches were not included in the first edition of South Carolina's Priority Species List in 2005. Due to available literature on the group in South Carolina and invertebrate experience, a list of leech species occurring in South Carolina was able to be compiled by William Poly (SCDNR) for the 2015 revision. Sawyer's (1979) previous work on leeches of concern in South Carolina was a major source of information used to decide on the conservation status of leech species in the State. Based on Sawyer's (1979) earlier assessment, data from published literature, and recent collections, 4 species were considered to be species of conservation concern, including 1 terrestrial, 2 freshwater, and 1 marine species. The species of concern all have limited distributions within South Carolina and elsewhere, occurring in only 2 to 4 states, and are not distributed widely within those states. All priority leech species are discussed in the Supplemental Volume under a single guild while habitat associations are found in Appendices 1-A, 1-B, and 1-C.

Challenges

Any alteration of natural habitats can impact the aquatic and terrestrial fauna. Threats to the host animals of parasitic taxa will likewise threaten the existence of the leeches. Life history information is lacking for 2 of the species of conservation concern but is available for the other 2 (Shelley et al. 1979; Moser et al. 2005). Leech identifications can be challenging, and proper fixation and preservation of leeches is time consuming but important (Klemm 1982, 1995).

Marine Fishes and Invertebrates

Most marine fishes and invertebrate species have rather broad geographical distributions that extend outside of South Carolina's jurisdictional boundaries to the north or south and/or offshore, outside of the 3-mile (4.8 km) state territorial limit. Many species—particularly marine and diadromous fishes—are highly migratory, and some occur in state marine waters only during portions of the calendar year or during portions of their life cycle. Efficient and effective management of migratory species and species with complicated life cycles is dependent upon management plans that have coverage outside of any individual state's jurisdiction.

Many marine fish species and some invertebrate species—particularly those of recreational and commercial fishery importance—are currently addressed by state and/or federal or regional plans, laws and/or regulations. However, the population status of most species remains poorly understood. For most species, the genetic relationships of stocks or sub-populations throughout their distribution are also poorly understood. Understanding such relationships is of utmost importance in the identification of individual management units. In general, existing management does not identify individual management units, but attempts to establish a framework for managing commercial and recreational harvest as a surrogate to population management to prevent excessive directed fishing mortality over a broad geographic range. Many management plans identify potential threats and conservation actions to mitigate such threats, but plans do not include sufficient links to funding needed to provide comprehensive population-based management by specific stocks or management units.

The numbers of marine species, both fishes and invertebrates that can be found in the boundaries and/or jurisdiction of South Carolina, is vast. Prior to the beginning the process of preparing South Carolina's Strategy, lists for these taxonomic groups did not exist. Development of completed species lists for these taxa represent a major accomplishment for the SCDNR.

Species Selection Process

In 2005, the initial species selected for review included all marine fishes and invertebrates identified on computer code species lists that are maintained by SCDNR's Marine Resources Division (MRD). A total of 1,059 species were included in the initial list: 256 fishes and 803 invertebrates. The first step was to remove species that had not been recorded in cumulative surveys conducted within South Carolina's marine waters from tidal, brackish river reaches to the 4.8 km. (3 mi.) territorial jurisdictional limit of the Atlantic continental shelf.

The information about marine and brackish fishes and marine invertebrates contained in the SWAP was supplied by the expertise of biologists who formed the Marine Taxonomic Committees. The members of these committees invested considerable time in the development of the SWAP and are graciously thanked for their efforts. These individuals are listed in Table 3-11 and Table 3-12. Other sources of information included published literature and unpublished data from various sources.

TABLE 3-11: MARINE FISH TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
William Anderson	College of Charleston
Steve Arnott	South Carolina Department of Natural Resources
Joey Ballenger	South Carolina Department of Natural Resources
Mel Bell	South Carolina Department of Natural Resources
Mark Collins	South Carolina Department of Natural Resources
Tanya Darden	South Carolina Department of Natural Resources
Mike Denson	South Carolina Department of Natural Resources
Don Hammond	South Carolina Department of Natural Resources
Erin Levesque	South Carolina Department of Natural Resources
Phil Maier	South Carolina Department of Natural Resources
Bob Martore	South Carolina Department of Natural Resources
Billy McCord	South Carolina Department of Natural Resources
John McGovern	National Oceanic and Atmospheric Administration
Charles Moore	South Carolina Department of Natural Resources
Marcel Reichert	South Carolina Department of Natural Resources
Fred Rohde	NC Division of Marine Fisheries
Bill Roumillat	South Carolina Department of Natural Resources
George Sedberry	South Carolina Department of Natural Resources
Dustin Smith	Native fish enthusiast
Glenn Ulrich	South Carolina Department of Natural Resources
Pearse Webster	South Carolina Department of Natural Resources
David Whitaker	South Carolina Department of Natural Resources

TABLE 3-12: MARINE INVERTEBRATES TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Dennis Allen	University of South Carolina – Baurch Institute
Bill Anderson	South Carolina Department of Natural Resources
Loren Coen	South Carolina Department of Natural Resources
Stacie Crowe	South Carolina Department of Natural Resources
Larry Delancey	South Carolina Department of Natural Resources
Arnie Eversole	Clemson University
Nancy Hadley	South Carolina Department of Natural Resources
Pam Jutte	South Carolina Department of Natural Resources
Peter Kingsley-Smith	South Carolina Department of Natural Resources
David Knott	South Carolina Department of Natural Resources
Marty Levisen	South Carolina Department of Natural Resources
Billy McCord	South Carolina Department of Natural Resources
Steve Stancyk	University of South Carolina
Elizabeth Wenner	South Carolina Department of Natural Resources
David Whitaker	South Carolina Department of Natural Resources
Bob Van Dolah	South Carolina Department of Natural Resources

It was clear early in this process that data and knowledge available for most marine species in South Carolina were largely qualitative or of limited scope. In 2005, MRD staff suggested that most reviewers would have difficulty supplying input related to stock or population status for most species of fish and certainly for most invertebrates. Regardless, all identified experts were to be contacted for their input via an Excel data sheet or matrix with 18 questions. Nine of the questions were multiple-choice and nine questions were designed for comments. There were two categories of multiple-choice questions: questions dealing with knowledge of a given species and questions dealing with the species' conservation status. Initial trimming of the lists was facilitated by asking reviewers to eliminate species that did not warrant special conservation concern in South Carolina. A species was eliminated from the list if at least two of the reviewers suggested elimination and none of the other reviewers provided information for that species.

Experts suggested that marine fishes would be best protected by managing essential habitats for species or species groupings as the marine fishes group was a poor fit for the matrix treatment. Accordingly, all core (non-peripheral) marine fish species found in South Carolina marine and brackish water were retained on South Carolina's Priority Species List. Many of these species may be monitored as indicators of habitat health or as indicators of population health for other species associated with similar habitats. The final list of marine and brackish fishes included 163 species for the 2005 version of the SWAP.

The marine invertebrate grouping was more problematic, as there is generally very limited information available relative to population status of practically all species in South Carolina. The 2005 invertebrate list was revised by MRD staff using similar methodologies as were used for developing a marine fish 'list of concern.' Input was solicited via email from several identified marine invertebrate experts. The final list of marine and brackish invertebrates for the 2005 SWAP included 775 species, or better, types. The classification of some "species" remained in question.

In 2013, the marine fish taxa team reconvened to review the old list and make any necessary revisions. A matrix was designed whereby reviewers could place notations in columns that corresponded to factors that would help them determine if various species fit the criteria to be included on the list. Because the first taxa committee (2005) decided to err on the side of caution and list species or types that had no data on them, the list of priority species grew too big to be useful. This time around, the team was able to utilize new data and risk assessments to reduce the number of species on the list to 37 marine fish and 54 marine invertebrates. Many of the species removed from the list were determined to have stable populations or were so understudied that a guess as to their true status could not be determined at this time. If, at any time, any of the "culled" species are found to be in need of priority status, they will be relisted. The taxa committee went a step further and ranked the remaining species into priority categories of highest, high, moderate, or not ranked. All species are highlighted in a species or guild account in the Supplemental Volume while habitat associations are listed in Appendix 1-C.

Challenges

There are a number of potential challenges to marine fishes and invertebrates. However, it is difficult to assess the degree to which each species is vulnerable until habitat associations,

population trends, and distributions are better understood for each species. In some cases, regional management organizations (South Atlantic Fisheries Management Council, Atlantic States Marine Fisheries Commission) are currently conducting stock assessments to determine the health of the populations.

One of the major challenges to marine organisms in South Carolina is the degeneration and loss of habitat. As development and urbanization occurs along the coast, beaches and water bodies are altered in ways that change both topography and hydrology of coastal systems. Removing riparian vegetation can result in siltation and increases in nutrient and pollutant loading.

Habitat loss can affect all life stages of marine organisms. Salt marsh is an extremely productive habitat and is often used by larval forms of both fishes and invertebrates. Degradation of this habitat would be especially detrimental to marine organisms. Coastal development continues to encroach upon salt marshes in South Carolina.

Habitat alterations in marine waters also include damage resulting from trawling, dredging and dredge disposal. These types of habitat alterations are particularly detrimental to benthic fishes and invertebrates.

All marine organisms are affected to some degree by water quality. Industrial and municipal sewage discharge along with runoff from agriculture, golf courses, and suburban developments negatively affect Tarpon and other estuarine fishes. Stormwater runoff from developed areas contains sediment, nutrients and contaminants. These substances can substantially degrade water quality. Sedimentation can impair the ability of many marine organisms to feed. Nutrification can result in harmful algal blooms that substantially reduce dissolved oxygen in the water. Chemical pollution (PCBs, mercury, etc.) can be detrimental to all species; but can be particularly detrimental to benthic species, even in small amounts. Some species, such as fiddler crabs have been shown to bioaccumulate contaminants; bioaccumulation can result in contamination being passed up the food chain. Another species also affected by benthic contaminants is the Southern Flounder, a bottom-dweller.

Several marine fishes may be adversely affected by fishing pressure. Many marine fishes are not managed as either commercial or recreational species, but are targeted by recreational fishermen. If unchecked, such fishing pressure can reduce populations. Also, many species, both fish and invertebrate, are harvested as by-catch in commercial fishing operations. Even if alive when discovered and released, many animals can die due to stress or physical damage sustained during harvest. Some of South Carolina's priority species, such as the Atlantic Spadefish and Sheepshead, are often caught as by-catch.

Unregulated harvest threatens some marine species. For example, South Carolina does not currently regulate a commercial cannonball jellyfish fishery. This species is a major component of endangered sea turtles' diets. However, this fishery does exist in other portions of the cannonball's range. Asian countries are developing fisheries management plans to conserve jellyfish because populations are unstable or declining due to pollution, overfishing, or climate change. Consequently, dealers are looking for new sources of jellyfish (Hsieh et al. 2001). Interest in cannonball jellyfish from the United States increased recently because of high

consumer demand in Asia (Hsieh et al. 2001). Rising demand in Japan and Southeast Asia may create an international market for cannonball jellyfish from South Carolina coastal waters. Likewise, some marine species are collected for the aquarium trade; many of these collections are also unregulated.

Non-native invasive species also have the potential to negatively affect native populations of marine finfish and invertebrates either directly (through predation or the transmission of disease), or indirectly (through competition for resources, such as food and space). On an ecosystem level, the introduction of non-native species is one of the major causes of decreased biodiversity (e.g. Molnar et al. 2008). Examples of introduced marine organisms include the Indo-Pacific Lionfish, Eastern Pacific barnacle, and spiny hands crab (SC Aquatic Invasive Species Task Force and SCDNR 2008).

As the climate changes and becomes warmer, oceans may also warm and become more acidic. Stressed by these environmental conditions, marine fish and invertebrates may experience decreases in reproductive success. Additionally, parasite loads on fish may increase.

Insects

The crafters of the first edition of this document noted many unique challenges to incorporating insects into a conservations strategy. Over a half-decade later, these challenges remain and likely will always be present. As noted previously, one of the greatest challenges is that insects and their kin are species rich and relatively poorly known compared to many other groups. Their small size often renders them inconspicuous and generally unremarkable to the casual observer. Yet their presence on this planet has a profound influence on all other life forms. Additionally, their complex life cycles and seemingly endless diversity have afforded lifetimes of study for many naturalists.

The actual number of insect species is unknown. Of the current 1.5 million named species, approximately 1 million are insects (Foottit and Adler 2009). Other remarkable statistics are that "social insects"—such as ants and termites—could make up 20% of the total animal biomass on the planet. Erwin (1983), through work conducted in tropical forests, estimated that at any one time there are approximately 10 quadrillion (10,000,000,000,000,000) individual insects alive. A recent analysis of taxonomic data estimated there are 8.74 million species of all life forms on Earth (Mora et al. 2011). However, some other estimates suggest between 30 and 50 million species of insects alone could occupy the planet (Erwin 1988, 1997; Odegaard 2000). There are debates about what estimate is correct, but most experts agree that insects are the single largest component of world biodiversity and biomass.

Species Selection Process

With these many challenges, the group of taxonomic insect specialists took to the task of selecting species from the Palmetto State that conformed to the spirit and intent of the SWAP's 8 Required Elements. The size and diversity of the taxonomic group necessitated a large committee, mostly composed of individuals who have devoted many years to their area of expertise. Ten biologically distinct groups were selected for the first edition of this document and

these were here retained. Some experts have retired or no longer could participate and so the taxa presented in the 2005 edition were carried forward while expanding on others. Those who participated then and now have devoted much time to this endeavor and their efforts are acknowledge and greatly appreciated.

The insect taxa committee did not develop a comprehensive list of priority insects in South Carolina because the number of species of insects in this state is not known. As a starting point, the taxa committee completed their work by developing a table indicating the number of species within each insect order in South Carolina.

Table 3-13 presents a summary of the groups that were analyzed, along with specialists who contributed to this project. With some notable exceptions, the paucity of knowledge concerning life histories and insect diversity has not changed significantly since the first edition of the SWAP in 2005. There have been additions to state species records along with new species descriptions, and this will likely continue as more research occurs. It is important to note that this table is far from comprehensive and major groups have not been included. Because of the relative lack of knowledge of numerous species and their distribution, the experts chose again not to include "S" rankings for all groups. However, where knowledge was sufficient, based on the opinions of the various experts, this was included for certain groups. Nevertheless, even for these better-known taxa, this ranking should be considered a rough approximation. Another point of change from the original effort was the inclusion of more species than the 15 selected in the first edition. This again was based on efforts and opinions of various taxonomic experts who served on the committee. The number of priority insects for the State totaled 32. In addition, a list of South Carolina's 158 species of dragonflies and damselflies (order Odonata) are listed in a table in the Insects section of the Supplemental Volume. Taxa team members have made an attempt to assign S-ranks to them for the first time. This exercise may one day result in some of them being included in a future iteration of the SWAP. None of the insects in this Plan can be ranked into categories of "highest", "high", or "moderate" at this time. Select species/guild accounts for the 32 priority species can be found in the Supplemental Volume. The total known insect species reported to occur in South Carolina stands at 6,511 and covers approximately 23 families/groups.

TABLE 3-13: INSECT TAXONOMIC COMMITTEE
(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Taxa Group	Family Or Groups	Expert	Affiliation	Reported Species 2012
Odonata	Dragonflies	*Chris Hill* Wade Worthen	Coastal Carolina University Furman University	157
		Lynn Smith	Columbia University	
Plecoptera	Stoneflies	**Boris Kondraieff**	Colorado State University	85
Hemiptera	Lace Bugs	Al Wheeler	Clemson University	38
Lepidoptera	Butterflies	**Brian Scholtens**	College of Charleston	158
	Moths	**John Snyder**	Furman University	1,927
Ephemeroptera	Mayflies	*Luke Jacobus* Pat McCafferty	Indiana University Purdue University Columbus Purdue University	185
Trichoptera	Caddisflies	**John Morse** *James Glover* Bradley Goettle	Clemson University SCDHEC Clemson University	270
Diptera	Mosquitoes	*Chris Evans* Bill Willis	SCDHEC Clemson University	62
	Midge Flies	**John Epler**	Private Researcher	392
	Long-legged Flies	Harold Robinson	Smithsonian Institution	91
	Fruit Flies	**Allen Norrbom**	Smithsonian Institution	16
	Black Flies	**Peter Adler**	Clemson University	54
	Horseflies	**Bruce Ezell**	UNC Pembroke	113
	Net-winged Midges	**Greg Courtney**	Iowa State University	12
Coleoptera	Ground and Tiger Beetles	**Janet Ciegler**	Private Researcher	415
	Scarab Beetles	**Phil Harpootlian**	Private Researcher	290
	Bark Beetles	Don Bright	Agriculture Canada	64
	Fireflies Aquatic Beetles Leaf Beetles Tenebrionoid Weevils	Jim Lloyd *Janet Ciegler* *Janet Ciegler* *Janet Ciegler* *Janet Ciegler*	University of Florida Private Researcher Private Researcher Private Researcher Private researcher	37 331 441 339 447
Hymenoptera	Sawflies	David Smith	Smithsonian Institution	52
	Ants	Tim Davis	Clemson University	103
Araneae	Spiders	Robert Wolff	Private Researcher	432
Total Number of Reported Species				**6,511**

Challenges

Some of the challenges for insect conservation are the same faced by many species of plants and animals. Landuse changes, exotic and invasive species introductions, urban sprawl, and hydrologic modification such as dredging and dam construction can be catastrophic to many species of animals. If predictions of global climate change are correct, all biota, including insects, will be negatively affected in ways impossible to predict. However, one way in which

insect conservation differs from conservation of vertebrates and some marine invertebrates is that direct "take" by humans generally has no measurable effect on populations. While there are rare exceptions, such as tropical butterflies where commercial harvest may be profitable, these practices do not exist in South Carolina. The increased scientific collection of insects will almost certainly benefit the conservation of this diverse but understudied group of animals.

Possibly one of the greatest challenges is that the professional entomologist is also becoming rare and endangered. Robert May (2010) noted that while invertebrates comprise at least 90% of named species, only one-third of professional taxonomists specialize in invertebrates. Thus, the fundamental task of describing and naming insect species, or even being able to identify them, is lacking and probably will be for the foreseeable future. May (2010) noted that funding agencies around the world view basic systematics and taxonomy simplistically, and because much of the work does not conform to the commonly limited notion of falsifiable hypothesis testing, proper funding is not made available. This is a trend not unique to the study of insects. It is hoped that documents such as the SWAP can provide incentive for academic institutions and funding agencies to support high quality training for individuals who devote their careers to describing and naming species, exploring their evolutionary relationships, and studying their life histories. The awareness of the concepts of biodiversity and conservation is likely greater now than in recent memory. However, unless there is a resolve to train the next generation of professional taxonomists, future editions of the SWAP will be comprehensive in name only.

Finally, there have been some very positive trends in recent years that allow for a better understanding of insect diversity. The advancement of computer technology now enables the cataloguing and sharing of data with much greater efficiency. Even if global species richness is closer to 10 million as suggested by Mora et al. (2011) than the 50 million or more proposed by Erwin (1982), the ability to store and share this volume of data would have been unthinkable in the recent past. Numerous agencies have made use of this technology and have attempted to store and make public biotic data from regional and state data.

Geographic Information Systems (GIS) are now sufficiently mature that even user-friendly interactive maps and queries can be built from large datasets and viewed from a desktop computer anywhere in the world. Another advancement is the ability to diagnose species identities using their genetic material (Hebert et al. 2003) with initiatives underway to catalogue the genetic "bar-code" of the world's biota. This initiative has begun to attract interests from various agencies including those within applied fields (Pilgrim et al. 2011). While this tool will likely give rise to a better understanding of insect diversity and a clearer picture of the truly rare and endangered animals that exist within South Carolina, it will do so only with the aid of experienced taxonomists who have the training and years of experience necessary to identify the voucher specimens from which the genes are sequenced. These experts seldom are the ones physically doing the barcoding, but are generally volunteers who are more or less donating their time and effort. Without them, the barcoding would be valuable only for recognizing diversity of haplotype clusters. There is something much more intimate about a recognizable name—or list of names—than indices of haplotype cluster diversity that helps us to understand and comprehend the magnificence of the natural world around us.

Plants

South Carolina, a state with a temperate climate, boasts 2,795 native vascular plant species and perhaps several hundred lichens, algae, mosses, and liverworts (USDA/NRCS 2013). Of the vascular plants known to exist in South Carolina, about 15% are considered at risk (USDA/NRCS 2013). In fact, over half of all federally listed species (i.e. those listed under the US Endangered Species Act of 1973, as amended) nationwide are plants. Currently, the federal guidelines for the State Wildlife Grants Program exclude plants from funding. This is most likely due to the fact that plants are harder to protect on private lands because laws protect plants only if they occur on federal property or if a federal activity on private lands would harm them. There is also the precedent set forth during colonial days that suggests that animals fall under the jurisdiction of the Crown and plants belong to the people (Stein and Gravuer 2008). However, 31 states have created Acts or state ESA requirements that do cover plants along with animals (Stein and Gravuer 2008).

The SCDNR recognizes that plants are an important component of the landscape and therefore is being proactive in the discussion of plant species of concern in this iteration of the SWAP. It has been suggested that the recovery costs for plants may be less than those for vertebrates so perhaps it is time to start considering their inclusion. [Stein and Gravuer 2008]

In addition, some of SC's SWAP priority insects depend upon some of the State's plants of conservation concern for some part of their life cycle. For example, the Argos Skipper utilizes Pine Barrens Reed Grass (*Calamovilfa brevipilis*) while the Two Spotted Skipper uses Tussock Sedge (*Carex stricta*). There are many more plant species that are not in peril themselves but should be maintained for the sake of the insects and other animals that rely on them for survival. For example, monarchs and other migratory butterflies are highly dependent on *Baccharis halimifolia* as a nectar plant (B. McCord, pers. obs.). Maintaining associations such as this is just one more way to ward off population declines and the need for listing species.

Species Selection Process

In October 2004, plant experts convened to revise the South Carolina Heritage Trust database. Reviewers were asked to consider the same types of criteria (e.g. endemism, distribution, population size and trends, threats, knowledge of the species, existing state rank and protection status) as the faunal taxa groups when determining what species to include on their list. The current list of plants tracked by the Heritage Trust Program is divided into priority rankings of highest (those that are federally listed), high (global ranks of G1-G3), and moderate (state ranked S1-S3). This list was further refined to only include G1-G3 and S1 species. These were then split into thirds to derive at the final "highest", "high", and "moderate" SWAP categories.

In ArcMap 10.1, an intersect with the county boundaries layer and ecoregions layer was run, and the resulting table was imported into the University of South Carolina's A. C. Moore Herbarium (USCH) Specify6 database. The list of target species was also imported into the herbarium's database. With these two tables, a query was run against all herbarium specimens matching target species, and details were displayed for habitat information along with their corresponding ecoregion based on the county in which the specimens were collected.

The members of the plant taxonomic committee invested considerable time in the development of the list and are graciously thanked for their efforts; these individuals are listed in Table 3-14. No species/guild accounts have been written for the 333 priority plant species listed in the SWAP. However, habitat associations are listed in Appendix 1-D.

TABLE 3-14: PLANT TAXONOMIC COMMITTEE

(Committee members – 2005 only; *2015 only*; **2005 & 2015**)

Name	Affiliation
Albert B. Pittman, Ph.D.	South Carolina Department of Natural Resources
Katherine Boyle	South Carolina Department of Natural Resources
Julie Holling	South Carolina Department of Natural Resources
Herrick Brown	South Carolina Department of Natural Resources / University of SC

Challenges

Plant species constitute the base of the food chain and are one of the defining characteristics of habitat. From a human perspective, plants are essential for shelter, food, fiber, medicine, filtering runoff to protect water quality, controlling erosion, and providing carbon sequestration services. In addition, many plants are aesthetically pleasing with their foliage colors, patterns, growth habits, and floral components. There are even what some refer to as "game species" in the botanical world—those wild specimens harvested for human use such as American ginseng and black cohosh. [Stein and Gravuer 2008]

Unfortunately, it is some of these highly sought-after properties that have put certain plant species at risk from overharvesting and poaching (Stein and Gravuer 2008). Other threats, potentially even more serious, include habitat destruction or alteration and climate shifts. Long life-spans and lack of mobility mean plants may be affected by climate change earlier and initially more profoundly than animal species. Management can alleviate some of these effects, but management tools often benefit some species at the expense of others. For instance, dormant versus growing season burns in pine forests have markedly different outcomes in regard to understory composition (Roth and Franklin 2009).

Other challenges to plant management include staffing and funding limitations; the difficulties of plant species identification, and the demands of protecting highly localized populations, dependent on specific soils and microclimate (Stein and Gravuer 2008). With a majority of the State in private ownership, long-term land protection is lacking. SCDNR has acquired title to 268,516 acres and protected an additional 22,906 acres with conservation easements. These figures do not include federal lands or NGO holdings. Despite these impressive numbers, many more critical areas are still left to protect across South Carolina's 32,000 mi.^{2}.

In the foreseeable future, climate change will alter the plant communities of South Carolina in ways regarded by many as both positive and negative. As the climate continues to warm while the amount of atmospheric carbon dioxide ($CO_{2)}$ increases, forests will expand and trees will grow more in a given year due to an extended growing season (SCFC 2010). The increased atmospheric CO_2 will benefit some plant species but not others due to the way it is absorbed (C3

versus C4 plants). Palatability and nutritional content of crops and native plants will decline as a result of the increased CO_2 uptake (SCFC 2010).

Looking further into the future, drought and increased heat will take its toll, turning forests into open savannahs or grasslands. With increases in temperature (and therefore milder winters) come the threat of invasion of more non-native exotic plants, timber and crop pests, and emerging diseases (SCFC 2010). Together with increased drought, these stresses are likely to accelerate tree death. As dead and dying trees contribute to a buildup of the litter layer, this material will act as mulch to help retain ground moisture but also serve as potential fuel and thus increase the risk of wildfire.

One Southern pine species that is being called the "wonder tree" due to its ability to take the heat is longleaf pine. Not only is it a prime candidate in the Southeast for carbon sequestration efforts, but it is more tolerant to drought, overly wet conditions, fire, beetle infestations, forest pathogens, and hurricane-force winds.

CHAPTER 5: STATEWIDE CONSERVATION STRATEGIES

Through the SWAP prioritization process, 496 animal species were identified in this iteration of the Plan. Each species or guild had specific threats unique to them or their taxa, but most had the same overarching challenges. Although each species is discussed in detail in the **Supplemental Volume: Priority Species Accounts**, the common issues affecting all priority species can be compiled into nine broad needs or themes that translate into "Conservation Action Areas" (CCAs). These CAAs are presented in Box 5-1.

BOX 5-1: NINE CONSERVATION ACTION AREAS (CAAS)

- Education and Outreach
- Habitat Protection
- Invasive and Non-native Species Control
- Private Land Cooperation
- Public Land Management
- Regulatory Actions
- Survey and Research Needs
- Urban and Developing Lands
- Climate Change [NEW]

Within each CAA, conservation actions were condensed from the recommendations prepared for each animal on South Carolina's Priority Species List. Some of the actions identified will affect all species included in the SWAP, while others may affect only a few species. Within each of the nine CAAs, specific strategies were prioritized as "highest", "high", or "moderate" based on the most immediate needs. Therefore, the priority of each action is identified in brackets beside it. Some specific activities are repeated in several sections where appropriate.

In the first iteration of the Plan in 2005, Conservation Action Committees were deemed necessary to address each CAA and determine how to prioritize the specific strategies therein. Experts on the various topics ranged from Department staff to partners from educational institutions, federal agencies, industries, and organizations. Six criteria were to be used to determine the priority status of the various conservation actions. Box 5-2 summarizes these. Two Conservation Action Committees—those for Education and Outreach and Urban and

BOX 5-2: SIX CRITERIA USED FOR DETERMINATION OF PRIORITY CONSERVATION STRATEGIES

- **Feasibility:** Challenges can be mitigated; solutions are apparent. SCDNR can feasibly staff and implement the actions needed and the results will be beneficial.
- **Opportunity**: SCDNR is able to implement the conservation action (i.e., opportunities exist; SCDNR has the authority to carry out the action).
- **Benefit**: Implementation of the action will result in benefits to the natural diversity of South Carolina. Benefits are considered in terms of unit of effort to achieve those benefits; that is, implementation results in multiple benefits to a given species or multiple species are benefited by a single action.
- **Proactive**: Implementation will result in proactive changes to address challenges; actions are more than reactive responses to ongoing challenges.
- **Partnerships**: Partnership opportunities exist for implementation which provides the ability to leverage other resources.
- **Funding**: Implementation is eligible for SWG funding and/or matching funds exist.

Developing Lands—were convened prior to the completion of the Plan in 2005; the resulting conservation strategies are outlined within this chapter. Some of their suggestions were already ongoing actions of the Department; others have recently been implemented; and still others have simply been proposed. Additional committee meetings will be held as needed for the remaining CAAs as the SWAP continues to be implemented. Resulting conservation strategies will be included in future revisions of the South Carolina SWAP.

CONSERVATION ACTION AREA 1: Education and Outreach

Education and outreach programs positively affect conservation activities by involving the broader community in these activities. As such, education and outreach programs are critical to successful wildlife and habitat conservation. In times of budgetary crises, when funding, personnel and resources become limited, education and outreach programs are often supplanted by more imminent needs associated with species and habitat protection. However, it may be most critical during such times to ensure that education and outreach programs are functioning; such programs can produce an informed public that can assist in achieving the goals of environmental conservation.

Each division within the SCDNR has its own education and outreach programs. Of special note, Outreach and Support Services Division (OSS) in the Columbia office manages Camp Wildwood. Box 5-3 outlines current programs that are based in the SCDNR or programs for which SCDNR is a major contributor or partner.

BOX 5-3: SCDNR EDUCATION AND OUTREACH PROGRAMS

EDUCATION PROGRAMS

- **Alligator Seminars:** These seminars are provided intermittently and cover topics such as the current year's applicant statistics, capture and handling techniques, hunting regulations, allowable hunting equipment, processing, and other helpful information about this priority species.
- **Boater Education Program:** This program teaches basic boating safety including proper safety equipment, navigation rules, boat trailering, and preventative routine boat maintenance.
- **Camp Wildwood**: A week-long camp designed for high school students to encourage leadership skills and increase their knowledge and experience with natural resources management.
- **Carolina Coastal Discovery Program**: A cruise is conducted within the Coastal Zone aboard SCDNR's educational vessel, *Discovery*. Passengers learn about immediate areas of concern within the coastal and inland regions of South Carolina such as water quality, endangered species, and threatened habitats. When the trawl drags in an array of marine species, groups have the opportunity to discuss the biology of estuarine animals and plants with hands-on learning.
- **Certified DNR Fishing Instructor Program:** A volunteer opportunity for individuals to become trained fishing instructors to conduct Family Fishing Clinics for the agency.
- **Envirothon**: A hands-on learning experience in the form of a team competition to stimulate high school students and provide incentive to learn about their role in nature. Winners receive scholarships.

BOX 5-3: SCDNR EDUCATION AND OUTREACH PROGRAMS (CONTINUED)

EDUCATION PROGRAMS (CONTINUED)

- **Family Fishing Clinics:** SCDNR hosts an introductory class on fishing where skills such as how to tie fishing knots, how to rig a rod and reel, and casting are taught. Participants get to actually fish.
- **Graduate Student Guidance and Training**: This program provides logistical and staff support to state colleges and universities for graduate and undergraduate training of natural resource students.
- **Hunter Education Program**: This program provides instruction in hunter safety and techniques. Students also learn about hunting ethics, hunter/landowner relations and basic conservation and wildlife management principles.
- **Master Naturalist Program:** This program recruits volunteer citizen scientists by training them in the basics of geology, ecology, species-specific needs, and human impacts on the landscape within their ecoregion. Certification requires completion of a 12-week course plus 30 hours of volunteer service which includes 8 hours of advanced training. Housed within Clemson Extension, these courses rely on SCDNR biologists to teach parts of the courses. Copies of the SWAP are distributed to participants as the class textbook.
- **Master Wildlifer Course:** This is a Clemson Extension course designed for landowners, land managers, and wildlife enthusiasts who are interested in integrating wildlife considerations into their current land use and management activities. The latest research and management information is presented by instructors who are experts in their field. Game species are emphasized but multi-species management is discussed. SCDNR is a partner in this program.
- **Minorities in Marine and Environmental Sciences (MIMES):** This is a 12 week internship program hosted by the SCDNR Marine Resources Division on James Island, SC and funded by the National Science Foundation. The focus of this research experience for undergraduates (REU) program is to increase minority participation in marine and environmental science disciplines, in which minority candidates are underrepresented. Students engage with scientific mentors to design and complete their own rigorous individual research project, take classes, participate in field work, present their work to peers, and have the chance to meet successful minority scientists.
- **OSHER Lifelong Learning Program:** Clemson University, in partnership with SCDNR, provides a series of lectures and field trips on the natural history and status of SC habitats and species.
- **Reel Art**: Students from kindergarten through 12th grade in private, public and home schools learn about aquatic habitats and their inhabitants in an art contest held annually by SCDNR.
- **South Carolina Institute for Natural Resource Conservation**: This workshop provides hands-on studies in topics such as soils, forestry, land and water management, reclamation, wildlife, conservation leadership and career opportunities.
- **South Carolina Oyster Restoration and Enhancement Program (SCORE):** This program provides hands-on/living classroom lessons to school groups and interested citizens. The program also offers lectures and conducts workshops at coastal education centers.
- **Trapper Education Program**: This program provides information on furbearer biology, history of the fur trade, wildlife management principles, fur harvest regulations and ethical conduct.
- **Trout in the Classroom**: A partnership program with Trout Unlimited, teachers are trained on how to rear trout from eyed eggs in the classroom allowing students to explore the importance of healthy watersheds and learn about trout habitat and biology.
- **Wild Quail Management Seminar**: This 3-day seminar presents information on the latest research about quail natural history, biology, diseases and parasites, predation and other factors affecting populations. Speakers include wildlife and forestry professionals from state and federal agencies. Field demonstrations and classroom instruction will focus on habitat practices.

BOX 5-3: SCDNR EDUCATION AND OUTREACH PROGRAMS (CONTINUED)

OUTREACH PROGRAMS (CONTINUED)

- **SC's National Archery in the Schools Program:** This program promotes student education, physical education and participation in the life-long sport of archery (Junior Olympic style).
- **Take One Make One Program**: An outdoor education and mentoring program aimed at developing South Carolina's youth and young adults into lifetime participants in conservation, hunting, angling and shooting sports activities through conservation education and adult mentoring.
- **Youth Bass Fishing Clubs:** The South Carolina Department of Natural Resources has partnered with The Bass Federation and B.A.S. S. to encourage middle and high schools to start Youth Fishing Clubs. The agency provides an overall Youth Bass Fishing Championship each year.
- **Youth Hunts**: These hunts allow youth to have an educational hands-on experience in hunter safety and hunting techniques and exposes youth to basic wildlife management practices and hunting ethics.

ONLINE RESOURCES

- **Climatology (Climate for Kids):** This resource provides weather facts and summaries from past seasons as well as games and activities.
- **Geology for Teachers:** This is an earth science education series covering topics such as earthquakes, erosion, minerals, rock types and cycles, landforms, topography, geomorphology, and plate tectonics.
- **South Carolina Oyster Restoration and Enhancement Program (SCORE):** Information, lesson plans, and an online tutorial are available on the project website.

OUTREACH EVENTS

SCDNR participates in many events throughout the state that disseminate information and program materials that are centered around the agency's mission including the following:

Boat shows (Law Enforcement and Clean Vessel Act)
Legislative Reception
National Hunting and Fishing Day
Pee Dee Deer Classic
Shooting Range Field Day
Palmetto Sportsmen's Classic
Southeastern Wildlife Exposition (SEWE)

PUBLICATIONS

SCDNR provides many publications around all programs which includes the following:

Brochures
Books
In-depth Reports
Magazine: *South Carolina Wildlife*
Manuals
Newsletters (printed and emailed)
Websites

MEDIA

DNR YouTube channel
Facebook
RSS feed
Radio: SCDNR hosts a radio show called **"Your Day"** once a month on NPR/SCETV where SCDNR staff members are on hand to discuss DNR related topics such as deer hunting, the Palmetto Sportsman's classic, Boater Safety, and species-specific information. Listeners are encouraged to call in with their questions.
Twitter
Educational videos

BOX 5-3: SCDNR EDUCATION AND OUTREACH PROGRAMS (CONTINUED)

OUTREACH PROGRAMS

- **Audio/Visual Programs**: All programs within the SCDNR have representatives available to provide audio/visual presentations about the goals and objectives of those programs at the request of partners, educational facilities and private citizen groups.
- **Beach Sweep/River Sweep**: In partnership with the South Carolina Sea Grant Consortium, SCDNR coordinates an annual, nationwide, one-day cleanup of inland and coastal waterways.
- **Coastal Training Program**: The CTP aims to provide science-based training to coastal decision-makers and to increase collaborative networking opportunities within the coastal area. By offering scientific information and skill-building training sessions, the CTP ensures that coastal decision-makers have the knowledge and tools they need to address resource management issues concerning local communities.
- **Fishing Rodeos**: Youth fishing rodeo events are designed to provide youth with opportunities to catch fish.
- **Fishing Tackle Loaner Program:** Several tackle loaner sites are set up around the state at various state and county parks to provide an opportunity for adults, kids, and families to try their hand at fishing.
- **Jr. Duck Stamp Contest**: This contest enables students in grades K-12 to express their feelings of natural resources through their art and increases awareness of environmental concerns in an artistic manner. There is an adult version of the contest as well (SC Migratory Waterfowl Stamp Contest).
- **Monofilament Recovery and Recycling Program**: Volunteers put up and maintain monofilament collection bins and mail the contents in for recycling.
- **Shotgun Shooting Sports:** This program promotes all three regimens of clay target shooting: sporting clays, trap, and skeet. The SCDNR has assisted this growing program by off-setting costs for shot shells and targets, as well as providing training for coaches and students in firearms safety and hunter education.

Although education and outreach may not directly contribute to the management of natural resources, these programs can assist in garnering support for environmental programs. Public support can assist in ensuring the outstanding natural resources of South Carolina are conserved for future generations. In 2005, when public meetings were held throughout the State, SCDNR discovered that the public would genuinely like to assist in protecting natural resources but that they were unsure what they could do to help. Additionally, the goals and mission of the SCDNR were unknown to some segments of South Carolina's population. Discovery of this information underscores the need for natural resource education and outreach programs throughout South Carolina. Therefore, since these meetings, the SCNDR has been attempting to improve its method of information delivery to the public through a public awareness campaign including an Open House at the Marine Resources Center in 2008 that was attended by over 1,500 citizens.

What follows are a compilation of the comments from the public meeting as well as those from the 31 participants of the two Education and Outreach Conservation Action Committee meetings that were held in 2005 with invited partners. Examples of accomplishments have been noted in italics after each Specific Conservation Action but are not exhaustive lists of what has been done by the SCDNR or its partners. Each year, the SCDNR and its partners consistently reach well over 40,000 kids and adults through the various education and outreach programs. Efforts are ongoing and future measures of success might include: the number of web-products developed or updated; number of media/outreach products developed/updated; number of reports/publications developed and distributed; number of audiences reached; number of programs given; number of

partnerships created/supported; number of programs/products produced by partners; number of in-kind support hours received; and the number of participants/volunteers reached plus the number of new volunteers attracted.

Specific Conservation Strategies for Education and Outreach

1) Develop and enhance education and outreach programs that highlight the importance and value of the species on South Carolina's Priority Species List and their contribution to the unique natural resource diversity of this state. [Highest priority]

   In 2007, the SCDNR in conjunction with SC Educational Television, produced a major video on sea turtles. Also, when biologists wanted to attract nesting seabirds to the newly protected Bird Key island, they purchased decoys and had Horry County school children paint them as part of an education program on SC's priority seabirds. These decoys were used in other projects to successfully attract nesting seabirds and continued to be part of an educational program for school groups.

   Professional development programs have attracted 152 teachers over the past 6 years, exposing these participants to the importance of diversity for ecosystem function. Examples of coastal programs include: ACE Basin Adventure Workshop, Seeds to Shorelines Workshop, Estuaries 101, and vessel-based training. In addition, presentations by the Wading Bird Project, for example, attracted a total of 265 attendees. Three field trips were made to an active Wood Stork rookery. In addition, the importance of conserving habitat for the following priority species was also discussed: Black-crowned Night Heron, Glossy Ibis, Little Blue Heron, Snowy Egret, Tri-colored Heron, White Ibis, Yellow-crowned Night Heron. The Shorebird Project has highlighted the interaction between priority migratory shorebird species (e.g. Red Knot) and Atlantic horseshoe crabs. A workshop entitled, "Raising Awareness of Shorebirds in South Carolina" (2012) was one such venue.

2) Develop and enhance education and outreach programs that encourage land stewardship values, particularly to private landowners in priority habitats. [Highest priority]

   The Safe Harbor Program has been, and continues to be, very successful in SC as a tool to protect and manage for the Red-cockaded Woodpecker and other habitat-related species.

   Based on the outcomes of a SWG grant, a 76-page booklet entitled, "Best Management Practices for Wildlife in Maritime Forest Developments" was published in November 2009. This document reviewed the animal species of the maritime forest with emphasis on habitat requirements for each, and special emphasis was given to species of concern. This was followed by detailed descriptions of Best Management Practices (BMPs) at the community, neighborhood, and individual home levels. Immediately after printing, 225 copies were distributed to planners and other officials of coastal communities, the Office of Coastal Resources, Coastal Conservation Association, SC Forestry Commission,

various DNR staff, SC Sea Grant office, SC Wildlife Federation, Coastal Conservation Association, and a number of private citizens.

3) Develop and enhance education and outreach programs that inform the public about the importance of prescribed burning to benefit wildlife species. [Highest priority]

   The Wild Quail Management Seminar as well as most other management workshops produced by SCDNR or its partner, the SCFC, incorporate prescribed burning benefits into the discussion. A variety of habitat management techniques for Bobwhite Quail and other priority shrub-scrub birds are discussed in detail.

4) Ensure that accurate information about priority species and their habitats is made available, both within the SCDNR and to any interested parties outside of the department. Interested parties can include state and federal agencies, academic institutions, private landowners, local municipalities, organizations and industry. [Highest priority]

   Printed copies and CDs of the SWAP are sent to academic institutions around the State as well as to our partners and anyone else requesting one. Graduate students are encouraged to review the list of "conservation recommendations" contained within each species' account and use this as a guide when choosing a project. The Master Naturalist course participants are given a printed copy of the SWAP as part of the studied text of the program.

5) In consultation with SCDNR biologists, identify "poster species" that will highlight conservation messages in each ecoregion of South Carolina. Enhance existing education and outreach programs in SCDNR to include priority species and their habitats. [Highest priority]

   A new segment in SC Wildlife Magazine will include the highlighting of "poster species" by ecoregion. A handful of priority species from each taxa will receive coverage. In addition, a new display has been created for use at various venues around the State highlighting the SWAP and State Wildlife Grants. "Poster species" that dwell in unique habitats across the five ecoregions are highlighted.

6) Ensure that all SCDNR employees are working to provide education and outreach information to partners and citizens of South Carolina by doing the following: [Highest priority]

   a. Dissemination of information to partners;

      One step in this direction is the closer working relationship the SCDNR has with the USFWS based on a renewed MOU. Information sharing has been a priority with the SWG Coordinator assisting with the Mega-petition species review process as many of these species are also listed in the SC SWAP.

   b. Cataloguing education and outreach programs in the State;

Completed; see item 16.

c. Updating the website catalogue annually; and

Updates are done on a regular basis.

d. Coordinating priority species education and outreach efforts throughout the State.

7) Promote partnerships, both in development and implementation of education and outreach programs. [High priority]

The approach utilized in the SWG grant, "Landscape Planning for Priority Wildlife Species on Agricultural Lands (T-10-P)," was to employ three technical guidance biologists to partner with USDA staff to engage in landscape level planning for priority wildlife species on private agricultural lands. Over the course of the grant period, 248 conservation plans potentially affecting 170,359 acres in 23 South Carolina counties were written. Technical guidance biologists also delivered 47 programs for a combined audience of 2,511 people. Nine news releases promoting habitat conservation for priority wildlife species were written and submitted, 6 technical brochures on various aspects of wildlife conservation were developed, and 22 fact sheets on threatened and endangered species were completed.

8) Promote volunteer participation, both in education and outreach programs as well as in data collection. [High priority]

Citizen Science programs are always popular in our state. For example, SC citizens participate in the Clemson firefly survey, Great Backyard Bird Count, Christmas Bird Count, Project Feeder Watch, Nest Watch, Celebrate Urban Birds, Yard Map, and Swallow-tailed Kite Surveys. Additionally, SCDNR has a reliable source of volunteers for our shorebird nest counts, wading bird/rookery counts, sea turtle volunteer network, and fish tagging. SCORE program (oyster reef restoration) volunteers number over17,000 and have attracted 173 partnerships. Volunteers that contributed to the Carolina Herp Atlas amassed a total of 16,958 occurrence records online for the Carolinas! Additionally, various links on the SCDNR's website direct people to reporting forms for Florida manatees and bat colonies.

The SCDNR is seeking help from anglers targeting cobia to collect DNA samples of fish caught in 2014 for ongoing research projects. These DNA samples will be used to identify hatchery released cobia and characterize the population structure of cobia captured along our coast. Fin clip collection kits can be ordered online or anglers can donate filleted carcasses to the freezer collection program. Four drop-off locations are available.

Another successful volunteer effort involving voluntary participation involves 20 high-rise owners allowing Least Terns to use their pea gravel rooftops for nesting. The

SCDNR staff has worked tirelessly to teach owners and tenants the importance of this manmade nest substrate substitute to this priority bird species. A new brochure explaining about the birds and their habits was created for businesses with appropriate rooftops and was distributed to 25 businesses and a number of patrons. A sign was made for the windows of the buildings explaining the importance of the site.

A SWG grant entitled, "Using Citizen Science in the Study and Conservation of Breeding Painted Buntings" assessed the effectiveness of this technique on a priority species of concern. A total of 1,379 Painted Buntings were captured and banded in South Carolina. An internet-based reporting system for the reporting of sighted birds was developed, and reporters were recruited using workshops, short newspaper articles, word of mouth, and through the website. Volunteers were encouraged to report sightings of birds—banded and un-banded—to the website. Following banding, 34,705 reports of Painted Buntings, banded and un-banded, were received at the website, demonstrating a high rate of interest in the process.

9) Create a map that identifies locations of South Carolina's priority species and their habitats and distribute the map to all natural resource education and conservation entities. [High priority]

The revealing of specific locations of some species of concern is sometimes problematic as there is often a threat of vandalism to den sites, caves, or other habitat features required by these species. Sometimes the species themselves are in danger of being collected. In some cases, element of occurrence records are unavailable for some species, especially plants. In an effort to provide useful information on the potential location of priority species and habitats, GAP analysis was used to create maps of each ecoregion (see Chapter 4). An associated spreadsheet listing all of the species of concern and their potential habitats provides the best approximation of their occurrence. In addition, each species is discussed in detail in a species or guild account found in the Supplemental Volume: Priority Species, and range maps or specific locations are often included. Also, Chapter 4 contains a focus area map of where the SCDNR is focusing its efforts on priority habitats and species throughout the State. An interactive map is in production for the SWAP website.

10) Create a database that contains available data and information for the species on our priority list and their habitats. Ensure that this database is available through the SCDNR website. [High priority]

The current biological database system has been evaluated and is being revised. Much depends on the new computer program we hope to acquire. In addition, the SCDNR will implement a requirement that recipients of any SWG funding must submit a copy of their data (shapefiles, point locations, etc.) to the main database for storage and querying as needed by approved users. Sensitive data will be protected as needed. Chapter 6 of this SWAP discusses database needs as it relates to the SCDNR Monitoring Program.

SCDNR also has a GIS Data Clearinghouse. In addition, we participate in/link to the USGS Bat Population Database for the United States and Trust Territories.

In addition, a SWG grant allowed for the creation of a novel web-based South Carolina Stream Conservation Planning Tool that enables a spatially explicit understanding of how human activities affect the biological condition of wadeable streams, intended to support decisions about aquatic conservation actions. The Oracle-based system is composed of a searchable database for data input, editing, and analysis.

11) Develop and enhance education and outreach programs that inform the public about the detrimental impacts of litter on priority species. [Moderate priority]

The annual River/Beach Sweep sees between 6,000 and 3,000 volunteers per year. SCDNR staff members also visit schools to do presentations on the dangers of litter to both terrestrial and aquatic wildlife and their habitats. The fishing line recycling program has been heavily promoted as well. Most workshops include the topic of the impacts of litter on wildlife and habitats.

An outreach program was initiated as part of SWG grant T-56-R to inform the public and fishermen about the risks of abandoned crab traps to marine life such as SWAP priority fish, blue crabs, and diamondback terrapins. An online survey was created so that the public could report abandoned crab traps to aide in their removal from coastal waterways. The reef systems created from the old refurbished traps have become demonstration areas for the public with documented use by at least 46 marine species, 18 of which are listed within the SWAP (or former CWCS) as a priority.

The SWG Coordinator presented a PowerPoint presentation to kindergarteners at Laurel Hill Primary School in Mt. Pleasant, SC on the American alligator, a priority species, as well as other related reptile species. A lesson on litter impacts on wildlife was incorporated into the discussion.

12) Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails. [Moderate priority]

13) Develop and enhance programs that educate fishermen about employing correct techniques for capture and release of marine mammals, fish, and invertebrates and programs that emphasize the importance of reporting ship strikes and entanglements to authorities. [Moderate priority]

In 2008, the SCDNR successfully implemented a stakeholder process to acquire public input, build public support, develop legislative recommendations, and implement regulation changes to protect, enhance, and recover the Santee Cooper Striped Bass population.

The SCDNR Marine Division developed a campaign including a brochure on how to catch, handle and release large fish, like tarpon, to improve their chances of survival.

Staff assisted crab fishermen on new rules related to weak-link releases for their buoy lines to facilitate escape of entangled marine mammals. A campaign was begun to encourage hook and line fishermen to use "circle hooks" to reduce mortality of caught and released fish. Training was conducted for recreational fishermen who voluntarily catch and tag fish. This included methods for handling fish with minimal damage. SCDNR continues to promote "cull in place" for both commercial and recreational oyster harvesters. This minimizes unnecessary loss of oyster shell from the natural habitat. The Division has conducted research and provided information on the use of turtle excluder devices in crab traps to prevent capture of diamondback terrapins. The Division also headed up a program to recycle fishing line that otherwise might have been discarded into the water to potentially entangle animals.

14) Utilize a variety of methods for information dissemination including: [Moderate priority]

a. Printed materials

The SWAP is available as a printed document, a CD, and an online pdf file. The South Carolina Wildlife Magazine regularly publishes articles on priority species and their habitats. The SWAP is also distributed to participants in the Master Naturalist program as the accompanying textbook. The Freshwater Fisheries section developed and printed the Fish Species of Concern Coloring Book (2009) which can also be found online at http://www.dnr.sc.gov/aquaticed/pdf/SCFishesofConcernColoringBook.pdf.

Various feature articles in South Carolina Wildlife Magazine have introduced some of the State's species of concern to over 50,000 subscribers as a way of informing the public about the threats faced by these species and their habitat requirements. Examples include diamondback terrapins (May-June 2009), Swallow-tailed Kites (May-June 2011), freshwater aquatic species (September-October 2011), and diamondback rattlesnakes (September-October 2012). A short article in the magazine's Roundtable section (May-June 2004) highlighted the importance of the Plan and its present status, while another article (May-June 2012) on bat roosting towers demonstrated how SWG funding was used to provide habitat for state endangered Rafinesque's big-eared bats. A special magazine supplement entitled, "Treasure Our Wildlife—Plan to Keep Them" (September-October 2005) came out after completion of the first edition of the Plan and explained its purpose and highlighted species that would benefit from future SWG funding.

In an effort to better inform the public about the various roles of SCDNR's divisions, the South Carolina Wildlife Magazine began running a series highlighting each division and important aspects of the jobs housed in each. For example, the magazine started with the Law Enforcement Division and has since rotated through Marine, Freshwater Fisheries, Wildlife Management, and other divisions. This will become a standard feature of the magazine from this point

forward as we try to inform South Carolina's citizens about the nature of the Agency and the work that we do to protect and manage species and their habitats.

In the 2005 version of the SWAP (CWCS), we recommended the creation of a Wildlife Initiative Newsletter. We have decided to incorporate this idea into the existing South Carolina Wildlife Magazine as a new bi-monthly feature that will highlight a species of concern and what the public can do to help mitigate threats to the species. This "What you can do to implement the Plan" feature will help engage the public in the management process.

Other printed material distributions include brochures and bumper stickers. For example, over 500 of these materials were distributed in 2013 for the SCORE program alone.

SCDNR strives to not only inform the public about conservation issues but also motivate them to get involved with resolving conflicts. At the 30th Annual Palmetto Sportsman's Classic, a one-page flyer entitled "What You Can Do to Help Implement South Carolina's State Wildlife Action Plan" was distributed at the SWAP booth that listed specific actions citizens could take that would improve the welfare of both priority species and their habitats. Annually, the Classic hosts over 35,000 visitors.

b. Websites; social media

The SCDNR posts stories and news releases to its website and Facebook page as well as its Twitter account. The SWAP is web-enabled and can be found online as a single PDF file or by chapters. The Supplemental Volume is also available in pdf format for each species/guild account. Information on the State Wildlife Grants Program and related documents are also housed on this site. The link can be found at http://www.dnr.sc.gov/cwcs/index.html.

The Freshwater Fisheries section compiled information and photographs for nongame fish description web pages which are currently in development. Also, the Blackwater River Guide and associated interactive Powerpoint were created: http://www.dnr.sc.gov/education/pdf/BlackwaterInteractivePoster.pdf and http://www.dnr.sc.gov/education/pdf/BlackwaterRivEdGuide.pdf.

We have added a link to our website for the Battle For Bats video produced by USFWS and USFS (through Ravenswood Media) highlighting WNS. See http://www.dnr.sc.gov/wildlife/batswns.html.

c. Formal or informal education/outreach programs

Although some popular programs were dissolved due to budget cuts, new ones have taken their place. For example, the Trout in the Classroom program deals directly with the Brook Trout, a species of concern in SC, and has 36 schools now participating. The Trapper Education Program has been held 6 times since 2006

with a total attendance of 95. Priority species such as the mink and spotted skunk were discussed. In addition, 18 Alligator Seminars have been conducted since 2008 attracting 1,385 total attendees.

d. Updates to existing education curricula

Updates that include the latest scientific information can be found at such sites as the Climatology website, Geology for Teachers, and the SCORE program module.

e. Demonstration sites

SCDNR continues to work with Clemson University to create demonstration sites within Clemson Experimental Forest for habitat enhancement. Landowner tours are often given here. All Wildlife Management Areas are "outdoor classrooms" where hunters and other wildlife enthusiasts can see effective management techniques in action. The Marine Center also did a demonstration project where they installed a rainwater recovery cistern and irrigation system. Artificial reefs created through refurbishing crab pots are considered demonstration areas for the public.

f. Landowner workshops

The Wild Quail Management Seminar focuses on providing habitat for Bobwhite Quail, a priority species, as well as a myriad of other shrub-scrub and grassland species. Since 2005, over 100 participants have gone through the program.

g. Media

The September 2013 e-newsletter for the Southeastern Section of The Wildlife Society released a status report on the revision process for South Carolina's SWAP. This informative newsletter reaches a vast majority of our partners across the State and nation.

A new radio talk show, "Your Day" airs on National Public Radio once a month and conservation topics are discussed. Listeners are encouraged to call in with their questions. Often, the topic of priority species and the SWAP is raised (e.g. Stream Team's freshwater fish surveys, bear hair snare DNA research, etc.).

15) Develop and enhance education and outreach programs that discourage stocking, release, and transplanting non-native animal and plant species throughout South Carolina. [Moderate priority]

16) Develop a catalogue of all natural resources education and outreach programs offered in South Carolina, including educational curricula. This catalogue will include a description of program/curricula content and contact information for the person(s) responsible for

program development and implementation. The catalogue should be updated annually and made available on the SCDNR website. [Moderate priority]

Users of the SCDNR website have more than tripled since 2002 with annual increases still occurring. In an effort to reduce printing costs and since many people now look first to the Internet for information, an online version of the catalogue described above has been created and can be accessed at http://www.dnr.sc.gov/education/contacted.html. A second tab on the website directs the user to a more detailed description of each program: http://www.dnr.sc.gov/education/environed.html.

CONSERVATION ACTION AREA 2: Habitat Protection

Habitat protection has been identified as one of the most important actions to assist in the protection of South Carolina's priority species by SCDNR biologists, species experts, and attendees at the public information meetings held throughout the State (for a thorough discussion of these meetings, see Chapter 7). The importance that the SCDNR places on habitat protection for the benefit of South Carolina's wildlife is evident in the many programs currently in place at the SCDNR and in the partnerships SCDNR has forged with other state and federal agencies, organizations, academic institutions, and industries. A list of the SCDNR habitat protection programs and partnerships is presented in Box 5-4.

Historically, species conservation and management efforts have been employed to address single species to the exclusion of others occurring in the same habitat. The SCDNR, however, has recognized the importance of employing habitat- or ecosystem-based conservation. By focusing on whole habitats or ecosystems, we are able to protect several species in a more cost-effective manner. Since 2005, the SCDNR has gained an additional six properties totaling 1,338 ha (2,306 ac.) of property which is under wildlife management. Loss and fragmentation of habitat have been identified as major threats to many of the species included in South Carolina's SWAP.

BOX 5-4: SCDNR HABITAT PROTECTION PROGRAMS

- **The Heritage Trust Program**: The purpose of this program is to inventory, evaluate, and protect the elements considered the most outstanding representatives of South Carolina's natural and cultural heritage.
- **Forest Legacy Program**: The purpose of this program is to identify and protect environmentally important forest land from conversion to non-forest uses through the use of conservation easements and fee-simple purchases.
- **Focus Area Program**: The purpose of this program is to conduct landscape-level conservation efforts that include private lands. There are 12 habitat conservation focus area task forces in South Carolina; these are operated through the Atlantic Coast Joint Venture. Further description of the Focus Area Program is provided below in the discussion of the ACE Basin Project.
- **ACE Basin Project**: The first of the SCDNR's Focus Areas, the ACE Basin Project is a unique partnership of state and federal governmental representatives, nonprofit conservation organizations, and private landowners that works to maintain the natural character of the Basin by promoting wise resource management and continuing traditional uses with improved public access. While encouraging traditional land uses such as agriculture, timber production, hunting, and fishing, the overall management goal is to maintain the area's ambiance while restricting industrial and resort development. To date, well over 660,191 acres in the Basin have been protected through conservation easements, management agreements, and fee-simple purchases by the SCDNR and its partners.
- **Scenic Rivers Program**: The goal of this program is the conservation of South Carolina's river heritage through the proper management of the natural and cultural character of the State's river corridors. This program has the purpose of protecting "unique or outstanding scenic, recreational, geologic, botanical, fish, wildlife, historic or cultural values" of selected rivers or river segments in the State.
- **The South Carolina Conservation Bank Act**: This act preserves the most significant natural and historic lands in our state by either purchasing the land outright or buying conservation easements from willing sellers. Dedicated funding is provided for the protection of wildlife habitat, parks, greenways, prime farmlands, historic sites, wildlife habitat, and other biologically sensitive areas in the State. Funds come from a percentage of South Carolina's deed-recording fees, which are collected when real estate is sold in the State. A volunteer board made up of conservationists, sportsmen, scientists, and business leaders from across the State oversee the disbursement of grants to protect land. The SCDNR acts as an advisor to this Board.
- **National Estuarine Research Reserve System**: In partnership with the National Oceanic and Atmospheric Administration, the SCDNR helps communities develop strategies to deal successfully with coastal resource issues including habitat restoration.
- **South Carolina Land Trust Network**: The SCDNR is a member of this network which facilitates the preservation of the natural and cultural character of South Carolina through the exchange of information among land trusts. The network creates awareness and seeks support of the general public to conserve natural resources of the State.
- **Beach Sweep/River Sweep**: In partnership with the South Carolina Sea Grant Consortium, the SCDNR coordinates an annual, nationwide cleanup of inland and coastal waterways.

There are many ways to prevent habitat loss and reduce the effects of past losses and fragmentation. One of the most expensive conservation tools is land acquisition; further land acquisition is frequently driven by land availability, not by what is required for high priority species. Acquiring land, however, is likely the most beneficial method of ensuring wildlife and habitat protection. Conservation easements are also extremely beneficial for habitat protection. It is imperative that the SCDNR continue to partner with other agencies and organizations to acquire and manage lands that are available for conservation.

Statewide acreages in conservation now total 469,392 acres state-owned, 990,443 federal, 671,900 private (land trusts and other organizations), and 91,235 military. By ecoregion, this equates to 57% of the Blue Ridge being of conservation status, 6% of the Piedmont, 14% of the Sandhills, 10% of the Coastal Plain(s), and 29% of the Coastal Zone. This equals 11% of the total ~2,219,777 conservation acres.

Even if the SCDNR or its partners do not own lands, there are ways of protecting habitats. Coordination of wildlife goals and strategies during land planning processes and the ability of SCDNR to review development and environmental impact plans for relevance to priority species can also assist in protecting habitats. An ever-present theme throughout the SWAP, education and outreach is imperative in the protection of the State's habitats.

Some of the following recommendations are ongoing within the Department while others have recently been implemented; still others have simply been proposed. Future measures of success might include: the number of acres acquired or protected across the State by SCDNR and its partners; number of long-term cooperative habitat protection projects; number of completed site inventories; number of acres or sites restored and species/population response to the restoration; improvements in measures of diversity/species composition; number of acres prescribe burned; number of miles of streams restored; percent decrease in non-native invasive species; measures of water quality improvements; number of BMPs developed; percentage of recommendations implemented; number of plans or permits commented on; number of site visits; number of threats mitigated; percent increase in priority species and habitats; amount of technical guidance given; number of data exchanges; percentage of a watershed in protection; percentage of a given ecoregion or habitat type protected; number of programs developed; and the number of individuals trained.

Specific Conservation Strategies for Habitat Protection

1) Acquire property for the protection of priority species and to ensure habitat linkage through fee-simple acquisition and conservation easements covering all priority terrestrial, freshwater aquatic, estuarine, and marine habitats outlined in Chapter 4 of this Plan.
   [Highest priority]

   The SC Forest Legacy Program is used extensively to provide funding for land purchases. Many corridor projects such as along the Catawba River have been made possible through a commitment to purchase riparian habitats of high conservation value for priority species. A wide variety of priority habitats have been protected across the

State from hammock islands along the coast to rock outcrops in the mountains, totaling 75,866 acres to date. Relevant to the SWAP, the purchase of Belfast Plantation Phase II was made possible in part through a SWG grant meant to protect priority habitats and their associated species.

2) Continue to partner with private entities and other state and federal agencies to acquire land for habitat protection. Develop additional partnerships for land acquisition. [Highest priority]

   Appendix 3 lists the over 480 partners of the SCDNR. Many of these are active partners in the protection of lands within our focus areas which often overlap with theirs.

3) Restore and enhance impaired habitat, where feasible and cost-effective. Habitat enhancements include:
   a. Encourage nest/roost site retention/restoration
   b. Employ prescribed burning
   c. Restore natural stream courses and flows
   d. Eliminate or reduce invasive and non-native species from habitats
   e. Replant native plants
   f. Wetland restoration

   [Highest priority]

   Restoring and enhancing priority habitats across the State are ongoing tasks of the SCDNR and its partners. Recent projects of note include the SWG grant entitled, "Restoration of Longleaf Pine Forests on State-Owned Lands" (T-11-1-R), whose objective was to restore longleaf pine forests and associated herbaceous species on a minimum of 1,000 acres of state-owned lands using prescribed burning, selective herbicide treatments, and the planting of longleaf pine. The total longleaf habitat improvement ended up totaling 1,510 acres with new longleaf pine stands established on 1,135 acres. Several other grants have also been used to fund prescribed burns throughout the State as well as habitat restoration. Several thousand acres of upland habitats, such as grasslands, pine savannahs, and pine woodlands, were restored at Lewis Ocean Bay Heritage Preserve thanks to another SWG grant.

   Prescribed burning in the mountains has resulted in better habitat for priority species and a 20% increase in their numbers (mainly birds).

   Habitat restoration and enhancement efforts have also been conducted on North and South Williman Islands where tidal estuarine marshland and interspersed hammocks predominate. Feral goats (100) and Chinese tallowtree (~5,000) were removed while wood duck boxes were erected and native sweetgrass planted to enhance the native habitat. Other coastal areas have undergone marsh restoration through volunteers helping SCDNR biologists plant Spartina.

   Bird Key was designated as a Seabird Sanctuary in March 2006 because of its importance as a seabird nesting island and the need to protect it from human

disturbance. Additional nesting islands have been protected from disturbance since that time. Islands that had become too overgrown for seabird nesting have been cleared. This includes 2 recent site restorations covering 5 acres.

Islands where Brown Pelicans nest often become infested with avian ticks. Spraying has been used to improve colony health (2004-2011). Targeted trapping of seabird predators such as mink has been utilized as well.

In 2007, the Indian Creek Wildlife Habitat Restoration Initiative was formed and involves the SCDNR, other governmental agencies, conservation organizations, and private landowners to restore and improve grassland habitats on approximately 16,000 acres statewide.

Over the last 5 years, the Oyster Shell Recycling program has collected an annual average of 21,000 bushels of recycled oyster shells for use in new oyster reef construction. During the same period, SCDNR replanted an average of 75,000 bushels of shells each year along SC's intertidal shorelines. These reefs provide structure and habitat for 26 priority species and a myriad of other marine species. Other types of artificial reefs are constructed along SC's coast at the average rate of 14 per year. The SCORE program received the Captain Pride award in 2013 from Charleston County's Community Pride, Inc. This award is given to the top 10 individuals, businesses, governments, or civic organizations that have undertaken tasks that have significantly improved the environment.

The SCDNR, in consultation with the NPS and SC Audubon Chapter, has been retrofitting Ft. Sumter and Ft. Moultrie with native plants for butterflies, which are important pollinators for priority plant species and members of the food web for many priority vertebrate species.

4) Promote the importance of habitat protection and participation in conservation easement programs through education and outreach presentations. [Highest priority]

   SCDNR holds easements on over 23,000 acres across the State. However, many more tracts are in conservation easements through partners and private landowners. The Agency encourages all landowners of significant land holdings to consider long-term protection of the resources therein.

5) Partner with other state and federal agencies, to promote habitat protection and provide technical support to private landowners. [Highest priority]

   Farm Bill programs are advertised and promoted by SCDNR staff for the Natural Resource Conservation Service (NRCS) to fund and implement the SWAP as well as benefit common species.

6) Develop and implement protective Best Management Practices (BMPs) for habitats and land uses throughout South Carolina. [Highest priority]

Best Management Practices were developed for sustaining wildlife in the Maritime Zone of South Carolina. This was accomplished through a SWG grant and resulted in a 76-page booklet that reviewed the animal species of the Maritime Forest with emphasis on habitat requirements for each, and special emphasis was given to species of concern. This was followed by detailed descriptions of BMPs at the community, neighborhood, and individual home levels. This document was given to local costal community planners and officers, the SC Forestry Commission, non-governmental conservation organizations, and several private citizens.

The marine division partnered with private businesses in a non-regulatory program to encourage Best Management Practices at marinas and boat yards. Bathrooms and pump-out facilities were also provided to protect water quality.

7) Participate in development and review of environmental plans (including FERC relicensing projects) to ensure appropriate habitat protection. [Highest priority]

SCDNR routinely provides an average of 80 comprehensive environmental reviews per year to a variety of entities. These include environmental impact statement reviews, FERC relicensing projects, and others. SCDNR also assisted with the completion of the SC State Water Assessment, 2nd ed.

Two research projects undertaken by the Freshwater Fisheries section include "Twelve-mile Creek Monitoring of Dam Removal Effects" as well as "Developing Guidelines for the Effects of Sediment in the Broad River Basin."

The Marine Resources Department of SCDNR wrote an assessment of wind energy, military maneuvers, and other human activity on sensitive maritime species and habitats (2011).

8) Mitigate habitat threats that are caused by human practices such as entanglement in fishing gear, by-catch, boat strikes, dredging, chemical exposure, tower strikes, powerline strikes, nest disturbance, boat wakes, artificial light sources, and dewatering of streams. [Highest priority]

South Carolina has had Turtle Excluder Devices (TEDs) on its shrimp fleets for many years. By-catch Reduction Devices (BRDs) are also used. Diamondback terrapin excluders are now being tested for use on crab pots to limit accidental drownings.

One mitigation accomplishment at Donnelley WMA was getting SCANA line crews to widen the power line conductors and install bird diverter devices so that wading birds like the Wood Stork could not get electrocuted. Since these changes have been implemented, no more fatalities have occurred.

Every year the SCDNR ropes off 10 beaches that are shorebird and seabird nesting hotspots and posts signs to keep dogs and people off the beaches. Three nesting islands have subsequently been given "sanctuary" status.

In addition to the shorebird nest site protection programs, the coastal "Lights Out for Loggerheads" initiative to protect hatchling sea turtles is still going strong, and bumper stickers can be seen on many coastal vehicles. Local ordinances have been put into effect to limit light pollution and obstructions on the beach. A list of these ordinances can be seen at http://www.dnr.sc.gov/seaturtle/volres/ordinances.pdf.

Another mitigation measure involves diadromous fish passages for American Eels, American Shad, and Blueback Herring as well as spawning and restocking programs for Striped Bass, Robust Redhorse, American Shad, and Red Drum.

Abandoned (ghost) crab trap recycling has been successful in repurposing these traps as structures used in oyster habitat enhancement efforts.

9) Encourage city, county and state planning entities to consider habitat protection in all development projects. [Highest priority]

Many local beach communities have consulted with SCDNR staff to minimize development impacts on native wildlife species. (See also BMPs for Maritime Zone mentioned in item 6.)

10) Where possible, manage wildlife species and promote habitat protection on an ecoregions-wide and/or watershed-wide scale. [High priority]

Already, 49.41% of the State's basins are protected. The breakdown is as follows:

River Basins	Basin Area (ac.)	Basin Area (ha)	Conservation Area (ac.)	Conservation Area (ha)	% conserved
ACE	5,239,572	2,120,379	660,191	267,170	12.6
Pee Dee	5,027,500	2,034,557	347,032	140,439	6.9
Savannah	2,942,779	1,190,901	624,064	252,550	21.21
Santee	6,770,046	2,739,740	589,108	238,404	8.7

As new suitable habitat is located on public and private lands, some relocations have been conducted for the following priority species: Red-cockaded Woodpecker, mink, gopher tortoise, and Eastern diamondback rattlesnake. A new initiative to restore diamondback terrapins to vacant habitat is also being evaluated through a new SWG grant.

GIS modeling is being done for landscape-scale restoration projects and corridor creation. One study in particular looked at satellite images that revealed past alterations of the habitat to anticipate what restoration efforts would accomplish when the landscape was returned to its unaltered state.

11) Continue to partner with private entities, private landowners, and other state and federal agencies to protect riparian areas from degradation. [High priority]

Whenever SCDNR is involved in Forest Stewardship Plans, Streamside Management Zone recommendations are wider than those commonly used by the timber industry. The result has been more private and corporate landowners understanding the value of wider buffers for aquatic and terrestrial life forms.

12) Continue SCDNR participation in Emergency Response training programs to ensure that the SCDNR has the most current information on planning logistics and technology for dealing with coastal oil and hazardous material releases, as well as the most effective program to deal with the aftermath. [Moderate priority]

SCDNR coastal staff took an oil spill assessment course in 2010. Additional courses will be conducted as needed in conjunction with DHEC and the US Coast Guard. SCDNR's role in responding to spills is defined in the Oil and Hazardous Materials (HAZMAT) Spill Guidance document.

CONSERVATION ACTION AREA 3: Invasive and Non-Native Species

There are an estimated 50,000 non-native species in the US (Pimentel et al. 2005), although of that 4,300 are considered invasive (Corn et al. 1999), and the number is steadily increasing. Many of these represent serious threats to agriculture, horticulture, or forestry. Other non-native species are more likely to impact natural communities and individual populations of native wildlife species. Some estimates suggest that 90% of introduced species have resulted in detrimental effects on native wildlife (Hutchins 2011). Approximately 42% of the species listed as Endangered or Threatened under the federal Endangered Species Act are significantly impacted by invasive exotic species (Pimentel et al. 2005). On a national basis, the economic losses and environmental damage caused by exotic species total approximately $120 billion per year (Pimentel et al. 2005). One survey of managers of 430 national wildlife refuges indicated that 80% of the refuges recognized problems with invasive exotic organisms. Refuge managers reported more than 790 invasive organisms, including 507 non-native plants, 208 non-native animals, and 76 plant and animal diseases (Simonson et al. 2004).

Invasive and non-native species constitute a significant threat to South Carolina's biological diversity. Many native species are declining due to increasing competition or habitat degradation from invasive and non-native species of plants, animals, and pathogens. A list of those known to be located in South Carolina and making a marked impact is presented in Box 5-5. Additional terrestrial and aquatic plant species are listed in Appendices 5 and 6. Some species are still being assessed for their impact severity to South Carolina's ecosystems and include English ivy, mimosa, the Asian jumping worm (*Amynthas agrestis*), Green Sunfish, South American cactus moth, kudzu bug, Chinese mystery snail, nine-banded armadillo, Mediterranean gecko, Ranavirus, Snake Fungal Disease (*Ophidiomyces ophiodiicola*), Chytridiomycosis in frogs (no records in SC yet), black gill disease in shrimp, and Lymphoproliferative Disease Virus (LPDV) in turkeys. Sometimes the origins of an invasive are unknown as in the case of the pathogens that cause Oak Wilt, LPDV, and Amphibian Chytrid Fungus (Chytridiomycosis); they could be naturally occurring or introduced from abroad.

In addition, native plants and pathogens can become a nuisance when their populations increase above normal levels. Examples include native varieties of *Baccharis* sp. (plant) clogging coastal landscapes and the raccoon roundworm crossing the species boundary to infect the Eastern woodrat, a priority species in SC. Additional species—both native and non-native—affecting forest health in South Carolina can be found on the SC Forestry Commission website at http://www.state.sc.us/forest/fra-pro.htm.

BOX 5-5: INVASIVE AND/OR NON-NATIVE SPECIES KNOWN TO THREATEN SOUTH CAROLINA'S NATIVE WILDLIFE & HABITATS

ANIMALS

- Aquarium/Ornamental Fish
- Asian Clams
- Asian Tiger Shrimp
- Blue Catfish
- Cactus Moth
- Charrua Mussel
- Common Carp
- Feral Cats
- Feral Dogs
- Feral Hogs
- Flathead Catfish
- Green Mussel
- Gypsy Moth
- Green Porcelain Crab
- Hemlock Wooly Adelgid
- Indo-Pacific Lionfish
- Island Apple Snail
- Red Bay Ambrosia Beetle
- Red Imported Fire Ant
- Red Swamp Crayfish
- Rapana Whelk
- Zebra Mussel

DISEASES

- *Anguillicoloides crassus* (eel swimbladder parasite)
- Avian Vacuolar Myelinopathy (AVM)
- *Bonamia* spp. (in oysters)
- Chestnut Blight
- Dutch Elm Disease
- Laurel Wilt Disease (via Red Bay Ambrosia Beetle)
- Sudden Oak Death (SOD)
- West Nile Virus (WNV)
- White Nose Syndrome (WNS)

AQUATIC PLANTS

- Alligatorweed
- Brazilian Elodea
- Common Reed (Phragmites)
- Crested Floating Heart
- Giant Salvinia
- Hydrilla
- Invasive Red Alga
- Mediterranean Clone
- Water Hyacinth
- Water Lettuce
- Water Primrose

TERRESTRIAL PLANTS

- Autumn Olive
- Asian Wisteria
- Beach Vitex
- Chinaberry
- Chinese Privet
- Chinese Tallowtree
- Chinese Wisteria
- Cogongrass
- Japanese Honeysuckle
- Japanese Privet
- Japanese Stilt Grass
- Kudzu
- Multiflora Rose
- Russian Olive
- Thorny Olive
- Wart Removing Herb

Invasive and non-native species that do not directly harm wildlife species can do so indirectly by reducing or eliminating food sources for those species. For example, gypsy moths can eliminate mast for birds and mammals. An exotic forest pest in the Blue Ridge Ecoregion of South Carolina, the hemlock wooly adelgid, is causing the decline of hemlock populations; loss of

streamside hemlocks can result in water temperature increases which negatively affect such priority species as Eastern Brook Trout. Feral cats kill wildlife such as songbirds, small mammals, and herpetofauna directly and kill indirectly by passing toxoplasmosis on to humans and wildlife (Hutchins 2011). Feral pigs disturb sensitive habitats with their wallowing and rooting behavior and compete directly with native wildlife for food resources.

As the climate changes, so too will species ranges, making it more difficult to determine what was introduced versus what arrived here on its own. The definition of "exotic" may evolve over time to encompass these new arrivals as they become part of the local ecosystem. [Hutchins 2011]

Impacts from non-native invasive species have been documented in South Carolina, and control measures have been implemented to address these impacts. SCDNR is currently working to control invasive aquatic plant species in lakes and rivers throughout the State. Further, SCDNR has partnered with other organizations to investigate ways to reduce invasive and non-native species in South Carolina. Future measures of success may include: the percentage of non-native/invasive species populations decreased or eliminated; number of areas surveyed; number of species/populations located; number of individuals removed; identification of causal factors in population change; number of species protocols established; number of media/outreach products on the subject created and distributed; number of programs given; number of audiences reached; number of volunteers utilized; number of partnerships developed; and number of MOUs developed.

Specific Conservation Strategies for Controlling Invasive and Non-native Species

1) Prevent the spread of existing invasive and non-native species, eliminating them, where possible. [Highest priority]

   SCDNR staff and partners actively search for non-native, invasive species on select properties. For example, since 2005, 328 small coastal islands have been surveyed for invasive species.

   Every year, SCDNR practices aquatic weed control on approximately 2,700 acres of management lands. Santee Cooper sprays an additional 2,500 acres, especially for crested floating heart. SCDNR utilizes triploid (sterile) grass carp in Lake Greenwood and elsewhere for hydrilla control. An average of 455 state acres per year is treated for phragmites.

   As was previously mentioned in the Habitat Protection section above, 100% of feral goats and 90-95% of Chinese tallowtree infestations have been removed from several hammock islands in the North Williman Island complex in Beaufort County, SC.

   According to Clemson University, South Carolina has scattered populations of cogongrass, 9 of which are active and 8 are inactive but monitored. The Cogongrass Task Force is an integral partner in monitoring and eradicating this highly invasive species.

In the mountain ecoregion, native rhododendron and other off-site species have taken over some sensitive habitats. With a determined effort by the SCDNR, 4,000 acres have been converted to more appropriate covertypes within our Wildlife Management Areas. Kudzu and royal pawlonia (tree of heaven) have been eradicated from 6 sites. A protocol was developed for hemlocks, and 2 large stands of Carolina hemlock and 4 stands of Eastern hemlock were chemically treated for hemlock wooly adelgids. Predatory beetles (40,000), both Sasjiscynmus tsugae and Laricobius nigrinus, were used at 30 other sites as a biological control agent on a landscape level, but they were not as effective as the chemical treatments.

Along SC's beaches, the SCDNR's partner, the Beach Vitex Task Force, has been able to successfully contain 99% of the known population of this invasive dune species and has helped local municipalities draft ordinances to keep it from being replanted. Educational videos, signs, and pamphlets have been distributed to reach a wide audience. Two site visits per year are conducted by SCDNR staff to monitor for vitex re-infestations.

In 2008, the SCDNR provided early detection and rapid response strategies that were used in a cooperative effort to successfully control the spread of the highly invasive Island Apple Snail in Horry County and a toxic algae problem in Aiken County.

2) Determine the impacts of invasive and non-native species on South Carolina's priority species and habitats used by those species. [Moderate priority]

We know from past research the harmful effects of pasture grasses like fescue on rabbit fecundity when consumed by females as well as the mat it forms thus hindering quail chicks as they try to move through it. Sea turtle hatchlings can get tangled in beach vitex, while Chinese tallowtrees can become a monoculture that deters native songbirds from nesting in these habitats. Research on coastal islands in SC has proven that feral hogs can destroy over 90% of sea turtle nests in one season and destroy sensitive habitats with their rooting behavior. We are also aware how detrimental the importation of species can be in the transmission of diseases to native populations. One control method, for example, has been the certification of shellfish to reduce the risk of Bonamia spp. infections. Continued research will reveal even more interactions and lead us to make better cases for the removal of invasive species across the landscape.

The SCDNR collaborates with the Southeastern Cooperative Wildlife Disease Study (SCWDS) on periodic updates for feral swine population distribution and/or density as well as with the Animal and Plant Health Inspection Service (APHIS) on feral swine disease profiles.

3) Strive to prevent the importation of additional invasive and non-native species to South Carolina. [Moderate priority]

Already, some plants are illegal to import and sell in SC such as the popular red cultivars of cogongrass, Japanese Blood Grass and Red Baron, as they can revert back to the green wild type. In addition, SC law states that it is unlawful for a person to import,

possess, or transport for the purpose of release or to introduce or bring into this State any live wildlife from a long list of species. A new law passed in 2012 prohibits the intentional release any aquatic species, regardless of the stage of its life cycle, into the waters of this State without a permit from the department.

It is also unlawful to use any non-indigenous fish as bait that is not already established in the water body being fished except for a short list of minnow species specified in the law. A person may not possess, sell, offer for sale, import, bring, or cause to be brought or imported into this State or release anywhere in this State detrimental species (e.g. piranhas and freshwater electric eels). Beneficial triploid grass carp stocked in public lakes are protected from take as they are used in the eradication of noxious aquatic weeds.

4) Develop and conduct an education and outreach campaign to raise awareness of the impacts of introducing non-native species into South Carolina. [Moderate priority]

The SCDNR partnered with the University of South Carolina and NRCS (USDA) to produce a video on the environmental impacts of Chinese tallowtree and appropriate eradication techniques. Additionally, an article on Chinese tallowtree appeared in South Carolina Wildlife Magazine in 2012, explaining its negative impacts on wildlife and habitats within the State. The SCDNR and its partners hosted a Chinese tallowtree workshop in 2008 at Nemours Plantation to educate landowners and land managers about this invasive species and eradication techniques.

5) Develop partnerships with other entities in South Carolina to address impacts associated with invasive and non-native species. [Moderate priority]

A Cooperative Agreement with the USFWS allowed for the follow-up treatment of Chinese tallowtree on "Goat Island" as well as the restoration of isolated wetlands on site. Agreements with Santee Cooper also have proven beneficial in the control of invasive aquatic plant species.

The SCDNR participates in multiple partnerships that address non-native, invasive species control. Some of these include the USFWS, Vitex Task Force, and Clemson University.

CONSERVATION ACTION AREA 4: Private Land Cooperation

Currently, 77% of the land in South Carolina is under private ownership (SCFC 2010). As such, SCDNR has little authority over habitat conservation and wildlife management on those lands. Therefore, it is important that SCDNR enlist the cooperation of private landowners to protect priority species and their habitats. Encouragingly, many citizens in South Carolina recognize the importance of natural resources and the value of these resources for our quality of life. A number of programs are currently available to landowners through the SCDNR as well as other state and federal agencies and public and private entities. A list of the private land programs provided by SCDNR, both independently and with partners is presented in Box 5-6.

Despite the number of programs available in South Carolina, the changing urban landscape mandates that other programs are likely necessary. Further, many private landowners are not aware of the current programs available to them. Future measures of success may include: the number of partnerships developed; number of MOUs developed; number of conservation programs implemented; number of participants in programs; number of volunteers recruited; number of outreach programs put on for the public; and the number of positive/negative comments received from the public.

BOX 5-6: SCDNR PRIVATE LAND PROGRAMS

- **Wildlife Program**: SCDNR Wildlife Biologists conduct site visits and formal consultations with landowners and assist with management plan preparation and technical guidance for all species found therein.
- **Conservation District Program**: SCDNR personnel provide technical assistance and cost-share for farmland improvements, including water quality and erosion management as well as wildlife habitat improvement.
- **Red-cockaded Woodpecker Safe Harbor Program**: This program allows for the formal enrollment of qualifying private lands in a management program to enhance red-cockaded woodpecker populations.
- **Farm Bill Technical Support Program**: As an official member of the NRCS State Technical Committee, SCDNR participates in policy development and Farm Bill program priority setting. Additionally, SCDNR Wildlife Biologists provide technical guidance on Farm Bill program plans.
- **Landowner Incentive Program**: SCDNR directs federal cost share funds to qualifying lands for management practices benefiting red-cockaded woodpeckers and other "species at risk."
- **US Fish and Wildlife Service Partners for Fish and Wildlife Program**: SCDNR works with this federal program on various habitat restoration projects on private lands (example: Partners for Trout in South Carolina's Upstate).
- **Focus Area Program**: The purpose of this program is to conduct landscape-level conservation efforts that include private lands conservation. There are 12 habitat conservation focus area task forces in South Carolina which are operated through the Atlantic Coast Joint Venture (example: ACE Basin Project).

Specific Conservation Strategies for Private Lands

1) Develop or expand partnerships with other entities to provide landowner assistance programs that focus on the conservation of priority species and their habitats. [Highest priority]

   Currently, SCDNR staff provides consultations with an average of 3,000 private landowners a year. General requests for technical assistance with aquatic and terrestrial habitat recommendations number around 800 per year. The SCDNR partners with NRCS to promote Farm Bill incentive programs to private landowners. Priority habitats that are commonly advocated for include longleaf pine ecosystems and native grasslands.

2) Conduct outreach efforts to private landowners to:
   a. Explain to the public the ecological importance of protecting natural resources on private lands and the benefits of protecting those resources for all citizens of South Carolina.
   b. Encourage voluntary participation in natural resource conservation activities.

c. Encourage natural resource stewardship by utilizing Best Management Practices (BMPs) on private lands.
d. Explain the mission of the SCDNR and the programs conducted by the department.

[High priority]

Since its introduction in 1998, the Red-cockaded Woodpecker (RCW) Safe Harbor Program has grown to include 140 enrollees and 299 RCW groups. This program has ensured habitat maintenance and enhancement for nearly 300 groups of Red-cockaded Woodpeckers on private lands. This program has helped facilitate widespread reintroduction of fire to the landscape, thus maintaining and restoring critically imperiled longleaf pine habitat. It has also improved relationships between the private sector and government organizations, producing a cooperative effort toward conservation.

In addition, habitat improvement efforts at Wood Storks rookeries (and other priority wading bird rookeries) on private lands has lead to the increase in the number of active rookeries in South Carolina.

3) Develop or modify landowner education and outreach programs to include information about South Carolina's priority species and habitats. [High priority]

The 2013 Longleaf Pine Alliance meeting featured a presentation on SC's SWAP priority species found in this habitat type.

The SCDNR staff has instructed many private landowners and Home Owners Associations (HOAs) on how to better manage rookeries found on site for priority wading birds including Wood Storks.

CONSERVATION ACTION AREA 5: Public Land Management

Only 7% of the land in South Carolina is in public ownership by federal, state and local governmental agencies (SCFC 2010). Much of that land is not directly managed by the SCDNR; however, these lands provide critical protection for the State's priority species and their habitats. Agencies who manage ecologically important public lands in South Carolina—including the SCDNR; SC Forestry Commission; SC Parks, Recreation and Tourism; US Fish and Wildlife Service; National Park Service; and the US Forest Service—are mandated to conserve native wildlife species and their habitats. Additionally, other public agencies, such as the US Department of Defense, US Department of Energy, and some city and county park facilities manage ecologically important lands for the protection of wildlife and their habitats.

The SCDNR has an excellent working relationship with other public land managers throughout the State. The conservation goals of these separate agencies may differ slightly, resulting in different conservation strategies and efforts. In order to provide the most efficient management of our priority species and their habitats, it is important to continue and enhance partnerships between the SCDNR and other agencies. Future measures of success may include: the number of

education efforts, number of recommendations implemented on public lands, number of partnerships formed, number of in-kind services conducted by partners on public lands, number of recommendations implemented on SCDNR lands, and the number of management plans influenced.

Specific Conservation Strategies for Public Lands

1) Provide key information about management requirements for priority species and habitats in South Carolina to partners responsible for public land management. [Highest priority]

   A statewide Conservation Plan for the Gopher Tortoise in South Carolina was developed to help aid land managers with giving conservation considerations to this priority species. In addition, a management plan for 3 rare burrowing crayfish was also developed.

   The SCDNR is in regular communication with partners such as SC Audubon, Ducks Unlimited, The Nature Conservancy (TNC), various land trusts, the Lowcountry Biodiversity Foundation, and the USFWS regarding proper management techniques on sensitive habitats (e.g. hammock islands). For example, SCDNR staff assisted TNC and the USFWS in writing the shorebird monitoring protocol for oyster reef restoration.

   For our partners in the private sector, SCDNR produces brochures on new regulations and habitat protection recommendations to hand out to patrons For example, kayak companies conducting ecotours near barrier islands receive the latest on shorebird nestings. Boat ramps and marinas are also targeted for outreach efforts.

2) Continue to work with partners to manage and protect priority species and their habitats in South Carolina through other agencies' funding programs. [Highest priority]

   SCDNR has partnered with several parks to address protecting bat roosts from disturbance. In addition, SCDNR partners with the USFWS in shorebird/seabird surveys and the associated data sharing for over 25 miles of shoreline in the Cape Romain NWR area.

3) Ensure that priority species and their habitats on SCDNR lands are managed in accordance with the conservation actions provided in the SWAP. [Highest priority]

   For example, in the Wood Stork species account in the Supplemental Volume of this SWAP, it discusses the need to apply herbicides to control aquatic vegetation that is degrading the open-water habitat under the rookeries. In response, 40 acres of rookery habitat was sprayed, including 2 tracts on private land.

   In accordance with action items put forth in the various aquatic species' accounts, 6 miles of mountain streams were restored/improved and the faunal response is under different levels of evaluation. Isolated wetlands along the coast have also been restored

by damming old drainage ditches (e.g. North Williman Island and Old Combahee Island, Beaufort County).

CONSERVATION ACTION AREA 6: Regulatory Actions

Within South Carolina, there are several state and federal entities with regulatory authority over certain aspects of wildlife and habitat conservation. State and federal regulations in South Carolina govern the conservation of rare, threatened, and endangered species; protection of natural areas and specific natural habitats; take of game and nongame wildlife species; monitoring and protection of water and air quality; review and permitting of mining, dam construction, surface water discharge, and groundwater withdrawal; dock and pier construction; and other project developments.

As SCDNR biologists and other experts prepared species accounts, they identified areas where existing laws and regulations may need to be changed in order to protect priority species and habitats. They also identified areas for which no laws or regulatory authority exists to protect these species. Future measures of success may include: the number of calls/responses to priority species concerns; number of proposed recommendations implemented; number of plans developed; number of regulation change proposals; number of regulation changes that enhance or protect wildlife or habitat; number of species protected from unregulated use or impact; and the amount of habitat protected/affected.

In addition, our Law Enforcement Division undergoes basic wildlife management training as it relates to their job. Course instruction covers: upland game and fish rules and regulations as well as non-game regulatory authority; wildlife diseases; snake, tree, and grain identification; depredation permitting; trapper education; marine regulations (i.e. TEDs for shrimp trawl nets); and why certain practices are illegal as well as the biological basis behind our Title 50 laws. In 2013, a new class of recruits was briefed on the importance of the SWAP to the people of South Carolina and how law enforcement actions help protect these priority species as well as traditional game species.

Specific Conservation Strategies for Regulatory Actions

1) Enhance SCDNR Law Enforcement capability to address priority wildlife species law enforcement needs. [Highest priority]

   In 2006, Act 84 was passed which dealt with the regulation of non-hunting violations on leased WMA properties and SCDNR owned properties.

2) Continue to develop State of the Resource Reports for marine species that are not currently targeted in commercial or recreational fisheries and for species that are targeted, but for which no plan currently exists. [Highest priority]

   As of 2013, 17 finfish species and 3 invertebrates have undergone a stock assessment and a State of the Resource Report generated for each. These reports give an index of abundance that shows population trends over time. Modifications of management

strategies can be made quickly and efficiently as new data dictates. SWAP priority species, in particular, that are now being tracked in more detail include the mummichog, weakfish, sheepshead, king mackerel, Spanish mackerel, southern flounder, spot, Southern kingfish, black drum, blue crab, and Eastern oyster. In addition, a moratorium on the retention of saltwater catfish was instated.

In 2007, Act 85 was passed which established new finfish bag and size limits. An additional regulation passed in 2013 which reduced the limit of flounder taken in response to a decline in the population seen through surveys, especially for the priority species Southern flounder. Regulations for black drum (bag and size limit) and weakfish (size limit) were also modified.

3) Investigate the need to amend existing SCDNR regulations and/or develop additional SCDNR regulations to address the conservation status of South Carolina's priority species. [High priority]

Act 251 was passed in 2005 which allowed bonds to be issued for land acquisition guaranteed with Heritage Trust funds. This subsequently allowed SCDNR to purchase 2 tracts of land totaling ~39,000 acres for priority species habitat protection.

The SCDNR is also able to offer an endangered species specialty license plate portraying our state reptile, the loggerhead sea turtle, as well as a SWAP priority species—the Painted Bunting. The tag advertises the importance of endangered species conservation in South Carolina, and revenue from the sale of the license plates is used by SCDNR for fish and wildlife management and conservation programs as authorized by SC law.

Cormorants have increased in population to the point where they are impacting fisheries in South Carolina. The Cormorant Removal Program on Santee Cooper Lakes will allow for hunting of this species in order to protect sportfish and SWAP priority species. The effects of migrant Double-crested Cormorants that winter on the Santee Cooper Lakes include competition with the resident fish population for clupeid (herrings, shads, menhaden, etc.) forage, direct predation on out-migrating anadromous juvenile shad and herring, direct predation on returning anadromous adults while crowded below the System's dams, and direct predation on juvenile game fish and catfish. In addition, cormorant harassment has been linked to significant winter kills of adult Redear Sunfish too large to swallow. Permanent damage to flooded bald cypress and tupelo trees used for roosts has also been documented. The first year the SCDNR initiated a citizen-lead reduction effort, 11,653 cormorants were removed from the Santee Cooper Lakes.

4) Investigate the need to amend existing SCDNR regulations and/or develop additional SCDNR regulations to address the effects of collecting and/or harvesting South Carolina's priority species. [Moderate priority]

The "turtle law" that was passed in 2006 protects several priority species of freshwater turtles plus the Eastern box turtle from overharvesting for commercial purposes such as Asian food markets and the pet trade. More laws such as this are being developed.

CONSERVATION ACTION AREA 7: Survey and Research Needs

When preparation of South Carolina's first SWAP was initiated, it quickly became apparent that SCDNR and other entities in South Carolina were lacking data for many of the priority species and their habitats. Historically, research and survey activities have focused on managed species, federally or state listed species, and activities funded through grants and private dollars. In order to adequately manage for priority species in South Carolina, it is imperative that baseline research be conducted for these species.

Within this iteration of the SWAP, Chapter 6: South Carolina Comprehensive Monitoring Program specifically addresses survey and research needs as they apply to the priority species. The conservation actions here are presented to illustrate the type of information that needs to be gathered. Future measures of success may include: the number of areas surveyed; number of new survey sites; number of species/populations located; number of new monitoring sites or species protocols; number of new trend estimates; number of species for which population targets can now be assigned; amount of new data on a species compiled; number of genetic analyses conducted; and the number of taxonomic issues resolved.

Specific Conservation Strategies for Survey and Research Needs

1) Conduct surveys to determine the presence and extent of priority species populations and their habitat. [Highest priority]

   The SCDNR, along with its partners and volunteer network, utilizes a variety of methods to survey and monitor priority species including: aerial transect plots (wading birds); helicopter passes to map intertidal oyster reefs and monitor sea turtles; photo identification (cetaceans); trammel netting (fish); electroshocking (fish); drop net sampling (fish, crustaceans); hydrophonic transmitters (Shortnose Sturgeon); pit tagging (rattlesnakes); mist-netting (songbirds); point counts (birds); nest checks (songbirds, Red-cockaded Woodpecker, Bald Eagle); radio telemetry (birds and reptiles); spotlight surveys (deer); camera censuses (deer, gopher tortoise, etc.); rocket/cannon netting (waterfowl and Red Knots); track boards (mink); scent stations (furbearers); scent lures/hair snares (black bear); and butterfly tagging (monarch).

   The recent Stream Assessment (2006-2011) answered a lot of questions as to the range and population size of many of SC's priority freshwater fish. In addition, a recent SWG grant is cataloging the species of crayfish that were collected at the same time.

   The marine species known as the weakfish is being tagged to examine its migration. Atlantic blue crabs and gag grouper are undergoing genetic studies to determine the extent of and health of their populations along the South Carolina coast.

   Heritage Preserves, WMAs, hammock islands, and accreted lands are routinely surveyed by staff and partners to identify potentially new populations of priority species as well as

document the occurrence of invasive exotics for removal. These site visits include Carolina Vegetative Survey "pulse" exercises.

2) Monitor the condition of priority species populations and their choice habitat, once discovered. [Highest priority]

Life history studies have been conducted for at least 4 priority crayfish species. The SCDNR actively monitors many of the State's priority species through bird banding programs, snake pit tagging, freshwater fish fin clipping and radio telemetry studies, and marine fish tagging.

Yearly surveys of over 200 sites and 20 seabird colonies are conducted along the coast for high priority bird species.

Addendum 1 to the Interstate Fishery Management Plan, approved in 2012, established a coast-wide sampling program to improve the quality of information available for use in future bluefish stock assessments. The intent of this coast-wide biological sampling program is to address uncertainties existing within the current age-structured assessment model used to monitor the status of the bluefish population. Specifically, the goal is to develop aging techniques that can be used to perform a coast-wide age structure analysis of the bluefish stock in an effort to increase the validity of stock assessment results.

A multi-species stock assessment model was developed by the ASMFC to move fisheries management away from individual species assessments to ecosystem-based fishery management. Members of the ASMFC Multispecies Technical Committee and others have worked to develop a multispecies Virtual Population Analysis (MSVPA) model to explore important predator-prey interactions among key ASMFC-managed species, including Atlantic menhaden as the primary forage fish and striped bass, bluefish, and weakfish as predators. The most recent update was in 2012.

3) Determine the impacts of contaminants (including thermal discharges) on South Carolina's priority species. [Highest priority]

4) Conduct research to identify the habitat requirements for South Carolina's priority species and determine whether existing habitats meet those requirements. [High priority]

Habitat modeling for 4 priority crayfish species has been done, and statistically significant preferences for specific plant assemblages and habitat features were found. Swainson's Warbler has undergone extensive habitat evaluation. Several other priority species are currently under review such as McGillivray's Seaside Sparrow.

5) Determine genetic relationships of new species and those species with questionable taxonomic designations. [Moderate priority]

A molecular phylogeny study of seepage slope salamanders determined that the Southern dusky salamander does not actually occur in South Carolina. Thus, it was removed from

the list of SC's priority species. In addition, a recent crayfish study found that the Edisto crayfish (Procambarus echinatus) needs to be re-examined as there may be 2 separate species involved. Multiple distinct genetic populations of Cobia have been discovered along the Southeast coast, thus affecting species management strategies in SC and elsewhere. A new species of shark, the Carolina hammerhead, is being studied to determine how to distinguish it from the scalloped hammerhead.

6) Determine the effects of plant and animal invasive and non-native species (including diseases) on South Carolina's priority species and their habitats. [Moderate priority]

As previously stated, feral hogs have demonstrated their ability to cause severe predation on sea turtle nests and destroy fragile habitats with their rooting behavior. In addition, coyotes have been having an impact on white-tailed deer fawn recruitment. Armadillos have moved into the State, causing additional alterations to sensitive habitats with their burrowing habits and fondness for ground nesting birds' eggs. Studies addressing the extent of their influence on SC's priority species have yet to be determined.
A possible new marine threat includes the recent reports by commercial shrimp fisherman of captures of the invasive Asian tiger shrimp, Penaeus monodon. An investigation may be warranted.

7) Determine the effects of hunting/fishing on South Carolina's priority species. [Moderate priority]

Many of South Carolina's species hold a significant place in our hunting heritage. However, sound science should prevail over culture. Therefore, the SCDNR closely monitors the impact of hunting on both common and priority species. While other states have placed a moratorium on Bobwhite quail hunting, documented harvest rates on quail in SC, based on fall covey count data and harvest data, has ranged from <1% to nearly 30%. It is unclear if hunting has a marked influence on quail numbers. Habitat restoration is thus preferred. Ruffed grouse, another priority species, is rarely hunted in SC and is thus assumed to not be under immediate threat. Waterfowl trend graphs, similarly, show no hunting impact on populations in SC. Black bear, despite increases in hunting pressure, are in fact increasing in number and have become a nuisance in some parts of the State. Public alligator hunts have been allowed since 2008 (private land hunts since 1995) now that the population appears recovered and stable, but a management plan for the species is in progress (Clemson University graduate work) which will help to analyze and guide the long-term effects and direction of the hunting program.

CONSERVATION ACTION AREA 8: Urban and Developing Lands

Since the 1950s, the United States had experienced a mass migration to the suburbs. Fueled by the proliferation of the automobile, residential and commercial growth has expanded into the far reaches of what once were healthy wetlands, uplands and forestlands. Many have determined that nationally, land consumption has outpaced population growth two to one.

Anthony Downs of the Brookings Institute defines sprawl as "a specific form of suburbanization that involves extremely low-density settlement at the far edges of the settled area, spread out far into previously undeveloped land." Sprawl development began to take place in the last half of the 20th Century. However, when it arrived to South Carolina, it proceeded quickly. Land conversion in the State ranked ninth in the nation between 1992 and 1997, with over 539,700 acres converted for development. During this time period, South Carolina's population increase was 5.3% while the percentage of developed land was 30.2 for almost a six-fold increase. The trend has continued as new projections estimate a statewide population figure of 5 million people by the year 2030 (SCFC 2010). This number may be reached before this date. Chapter 1 of this SWAP further explains South Carolina's population growth statistics.

South Carolina's dramatic growth has occurred primarily on the outskirts of the State's larger metropolitan areas, as well as Charlotte, North Carolina and in the coastal/tourism centers of Hilton Head Island, Charleston, and Myrtle Beach. Much of this growth has come in the form of sprawl development. The impact of sprawl on wildlife has not been measured directly.

As previously natural lands are converted to urban lands, wildlife and habitat are undoubtedly affected as habitat is lost or fragmented in this process. However, the impacts of development on South Carolina's priority species and their habitats can be mitigated, if efforts are made to do so. Effective planning is imperative in protecting natural resources during development. **Chapter 3** discusses the urban landscape and its potential for wildlife habitat in more detail.

In April 2005, the 7 members of the Urban and Developed Lands Conservation Action Committee met to discuss priority species, their habitats, and the overarching actions that could affect urban and developing lands in South Carolina. Members included municipal leaders, home builders associations, academia, land trusts, and other non-profit conservation organizations. The group identified 5 areas for conservation action opportunities which are presented in Box 5-7. These ideas have been incorporated into the specific conservation strategy list.

BOX 5-7: FIVE AREAS FOR CONSERVATION ACTION OPPORTUNITIES

- Protection of habitat through acquisition and easements.
- Habitat (corridor and buffer) research and public education.
- Strengthen comprehensive planning through research, enforcement, and public education. Coordinate the development process between the developer and local level stakeholders in a one-stop-shop manner.
- Promote better storm water management regulations and techniques on impervious surfaces. Develop constructive wetlands education and incentives.
- Develop a higher-level coordination and training program for all levels of government and professionals, including appointed and elected officials.

Future measures of success may include: the number of cooperators; number of technical guidance interactions; number of recommendations implemented; number of BMPs developed; measurements of the degree of compliance and the quality thereof; number of site visits

conducted; number of partnerships developed; number of decision-making protocols adopting aquatic conservation priorities; number of acres/miles of wetland/stream positively affected; number of plans/permits commented on; number of collaborative efforts; number of species for which threats are conclusively identified and abated; number of information requests received and responded to; number of mitigation scenarios developed; number of species/habitats affected; number of outreach programs conducted; number of audiences reached and number of participants; number of comprehensive plans prepared; and the number of urban wildlife calls received from the public and handled effectively.

Specific Conservation Strategies for Urban and Developing Lands

1) Encourage responsible land use planning throughout South Carolina that ensures the protection of natural resources. To do this, an urban biologist is needed to collaborate with municipalities and communities to reduce the impacts of development. This can be accomplished by assisting local governments in drafting meaningful comprehensive plans, as they relate to the Natural Resources section of local comprehensive plans. Other ideas include:
    a. Implementation of Best Management Practices
    b. Planned development communities such as conservation community design principles by Arendt (2003)
    c. Low impact development; infill
    d. Passive recreation park design and trail systems, especially with minimal stream crossings
    e. Greenways and "green space" that also function as wildlife corridors
    f. Creation of a "green growth" manual for municipalities including natural resource-friendly ordinances and incentives for green growth

    [Highest priority]

    Currently, SCDNR averages 50 requests per year for general information near specific locations (i.e. what species are within a mile of a project site), and about 21 requests per year for GIS data (which varies from state- or county-wide to information by species). Usually, an average of 200 community officials and professionals are trained each year by SCDNR personnel while an additional 3,500 receive some sort of technical assistance.

2) Encourage SCDNR staff to provide wildlife/habitat educational information to communities. Inform elected and appointed officials about environmental issues relating to local development and wildlife/habitat issues and disseminate information on the following:
    a. Support the creation of local habitat protection capabilities.
    b. Work with local land trusts on the location of priority habitats.
    c. Promote and educate about transfer of development rights.
    d. Collaborate with local governments to develop Best Management Practices for storm water run-off: education, incentives, and awards.

    [Highest priority]

3) Develop wildlife/development win-win situations and disseminate information to local governments and the development community. [Highest priority]

   The partnership between local high-rise owners and SCDNR in which gravel rooftops are maintained by these businesses for nesting Least Terns has been a positive one. Signs have brought attention to the businesses as conservation-minded. The next step will be installing cameras to show the public live footage of the terns nesting. The Charleston Aquarium, a conservation partner of the SCDNR, already has used real-time video footage of nesting Brown Pelicans on Crab Bank Seabird Sanctuary to show the public the importance of minimizing human interference during critical stages in a species life cycle.

4) Act as a repository for Best Management Practices relating to natural resources. [Highest priority]
   SCDNR has already helped create or comment on various Best Management Practices documents for specific locations or projects. One that has been previously mentioned in the above Education and Outreach CAA section concerns BMPs for maritime forest communities.

5) Research existing Dept. of Defense, Dept. of Transportation, Dept. of Energy plans, etc. to find ways to coordinate objectives and efforts. [High priority]

6) Participate in the environmental review process for development projects throughout South Carolina. [High priority]

   As mentioned previously, SCDNR routinely provides an average of 1,400 comprehensive environmental reviews per year to a variety of entities. These include environmental impact statement reviews, FERC relicensing projects, nuclear projects, mine construction, jetty construction, and beach renourishment and dredging projects. Trend graphs show a steady increase in requests per year. SCDNR also assisted with the completion of the SC State Water Assessment, 2nd ed.

   Also, SCDNR staff provide comment as needed to city/town council on erosion control measures (e.g. dikes and dredge sites), stream buffers, sensitive habitats, and cultural resources.

7) Collaborate with partners to establish appropriate recommendations for riparian buffer widths to assist in the protection of coastal and inland water quality. [High priority]

   In 2008, SCDNR published a booklet on the subject, which is also available online, entitled "Protecting Your Streams: Choices for Conservation".

8) Collaborate with the South Carolina Department of Transportation (SCDOT) to protect priority species and their habitats during and after road construction, bridge replacement, etc. [High priority]

The SCDOT receives a copy of the SCDNR's Heritage Trust Threatened and Endangered Species database on an annual basis for use in planning purposes. They are also encouraged to report bat colonies on bridges so that mitigation efforts can be made if the bridge needs to be modified or replaced. At the Stevens Creek bridge by the SCDNR Heritage Preserve, a replacement will be constructed that will be I-beam or T-beam in nature (instead of slab) to benefit bats. However, SCDNR needs to create an MOU with SCDOT. Alternate roosts need to become a standard part of bridge replacement requests from the SCDNR.

9) Partner with other state and federal agencies, conservation organizations, industries, and permitting agencies to deter development in important breeding, feeding, and roosting/nesting sites that are important to South Carolina's priority species. [Moderate priority]

   SCDNR partnered with a local conservation group on Sullivan's Island and The Nature Conservancy to develop a video on the value of marine ecosystems to native wildlife and why these areas should be protected from development.

10) Discourage development in habitats for South Carolina's priority species; maintain an updated map for municipal partners showing sensitive habitat and focus areas. [Moderate priority]

11) Provide wildlife/habitat research and demonstration projects. These could include:
    a. A buffer demonstration project that provides a win-win for both developers and the environment.
    b. Research projects on the impact of buffers and corridors on wildlife and habitat.
    c. A storm water demonstration project.

    [Moderate priority]

    SCDNR personnel and partners assist schools with the creation of nature trails (e.g. Sullivan's Island Elementary School), butterfly gardens, rain gardens, and how to landscape with native plants (e.g. James Island Elementary School and Stiles Point Elementary School).

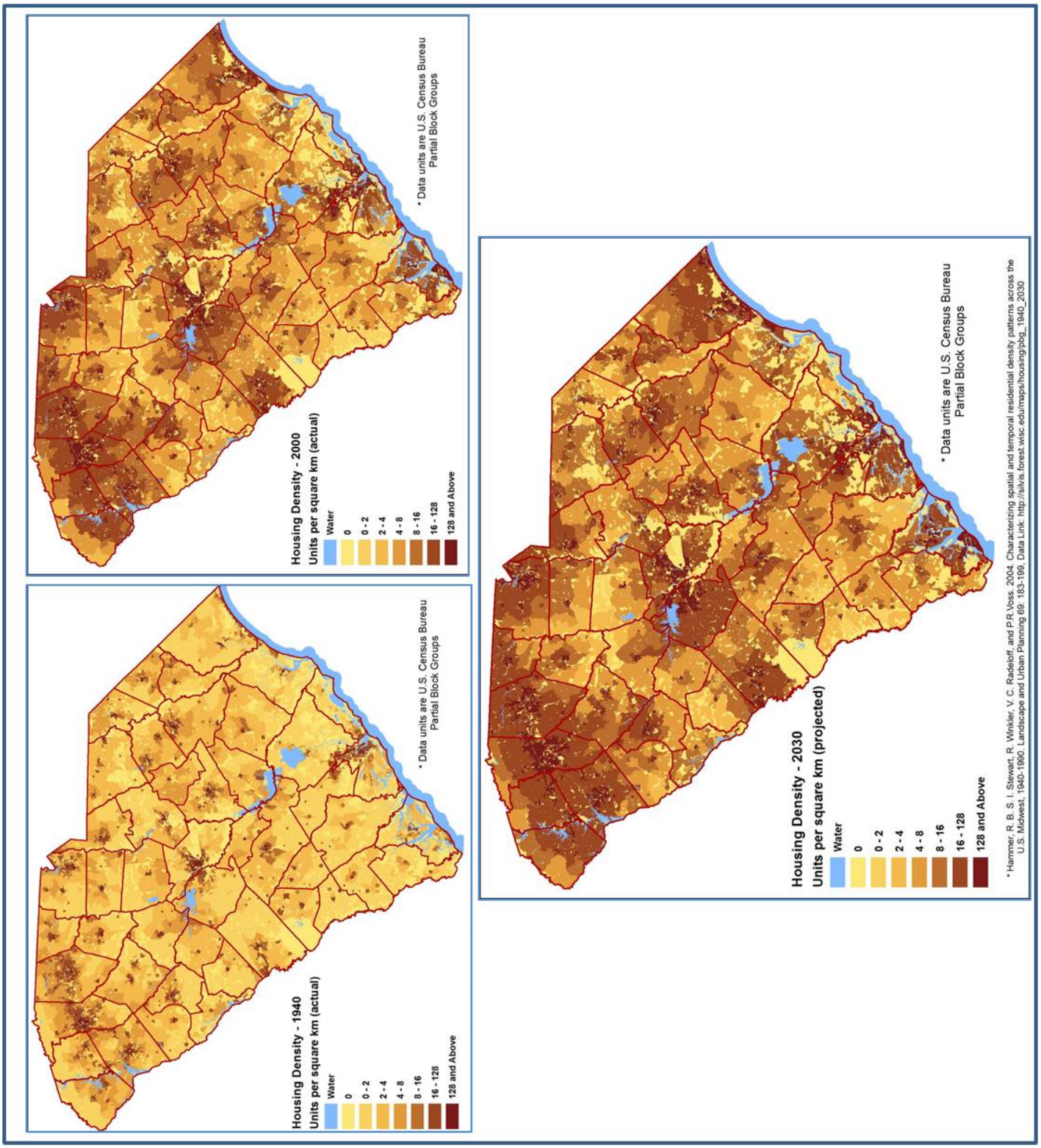


FIGURE 5-1: Housing density changes from 1940-2000 and projection to the year 2030 (Hammer et al. 2003).

CONSERVATION ACTION AREA 9: Climate Change

Anthropogenic and naturally occurring variability in combination are producing a change in the world's climate which will likely impact South Carolina and our natural environments in some fashion. As climate change issues have surfaced, SCDNR approached the subject proactively by creating the SC Climate Change Technical Committee, which in turn has produced a working document to address climate change issues relating to our natural resources and effective measures to realistically manage them in the face of imminent threats. The SCDNR draft document entitled "Climate Change Impacts to Natural Resources in South Carolina" is a collaboration of experts representing the diversity of the Agency (Perry et al. 2012). Each team member has put thoughtful consideration into their recommendations on how we, as lead agency for our natural resources, should address climate change and react accordingly. Within the current climate change document, the SCDNR has set clearly defined goals and future actions as climate change issues arise. This document was placed on the website for public review in early 2013 and can be viewed at http://www.dnr.sc.gov/lwc/climatereport.html.

Impacts of climate change can include the gradual warming of air and water temperatures, alteration of atmospheric water vapor, increases or decreases in annual rainfall, and rises in sea level (Perry et al. 2012). Many of these factors will directly or indirectly affect the priority species listed in this strategy. Some species will be directly impacted by a change in their habitat preferences in response to rising temperatures and changes in rainfall. Seasonal habitats available to SGCN will change in response to climate change. It is likely that climate change will have the greatest impact on high elevation species as their mobility or ability to re-colonize and adapt is limited. It may also increase the devastating effects of invasive species on species of greatest conservation need (priority species). For example, more temperate-loving invasive species have not migrated northward because they cannot tolerate the lower winter extremes. As climate change occurs, warmer average winter temperatures may open a door for further migration, which will have a greater impact on native species through direct and indirect competition for resources.

Management efforts need to be on a regional scale. Connectivity of important landscape features should be a priority, as the ability to re-colonize or re-locate becomes a factor in a species' ability to adapt to changes. It would be wise to develop land-use GIS maps to help prioritize areas of conservation in the face of climate change. Likewise, partnerships with other state and federal agencies, industry, NGO's, land trusts, and other conservation-based organizations will need to be strengthened as climate change issues are tackled. This Plan could utilize our existing partnerships to foster future talks and the development of statewide contingency plans. Climate change will also be an important consideration for collaboration between neighboring states as species populations' boundaries react to the change.

We will also need to constantly re-evaluate South Carolina's priority species list as species may be added or removed as they adapt/react to climate changes. Taxa chairs and their committees were charged with reviewing and updating the current priority species lists. During this review process, they considered climate change as a possible challenge to their species and listed these threats as applicable. Known climate change threats and issues, as considered by the committees, are addressed in Chapter 3 and in the species accounts found in the Supplemental Volume.

Although climate change discussion is not a required element within this document, we felt it was imperative that we include it for future considerations in management and protection of our priority species and habitats. The SCDNR is by law charged with the protection of our natural resources, as well as their sound management and enrichment. We need to be prepared to respond proactively by gathering and monitoring population status and habitat conditions so that we can then react more quickly to assist species in need. Whether climate change is considered a new or exacerbating threat to SGCN, monitoring species should be continued and a priority for our agency. As part of that monitoring effort, modeling should be conducted so that "tipping points" (thresholds) can be determined for species under various scenarios (Glazer 2013). Then strategies or actions developed for each possible outcome can be initiated if or when that scenario begins to occur. It will be crucial that we consult our internal climate change document, mentioned above, as a guideline for handling climate change issues as they arise.

The South Carolina State Climatology Office produced "The Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources" in 2012. Details are discussed in Chapter 7. Needs and challenges that came out of this public input process—plus additional comments from agency staff, and the climate report previously referenced—resulted in the following list of specific conservation strategies to respond to climate change issues.

Future measures of success may include: the amount of new data collected; number of models run or created; number of priority areas for conservation identified; number of multi-state partnerships created and projects implemented; and the number of relevant workshops attended.

Specific Conservation Strategies for Addressing Climate Change

1) Finalize the document, "Climate Change Impacts to Natural Resources in South Carolina" and begin implementing suggestions therein. [Highest priority]

2) Identify ways to collect data that tracts local effects and impacts (downscaling of global climate models). [Highest priority].

   The new (2013) Decision Support Tools program, developed for the Freshwater Fisheries Section of the SCDNR, is being used to model potential consequences of urban development, deforestation, and—potentially—climate change for streams in the State.

3) Identify monetary and staff resources for addressing management needs as they relate to climate variability. [High priority]

4) Create a centralized information area with data and tools to support decision making. [High priority]

   See Chapter 6 on SC's Monitoring Program for more discussions on database creation.

5) Prioritize areas for conservation actions using updated mapping capabilities. For example, conduct SLAMM modeling (Sea Levels Affecting Marsh Migration) of the State's coastline as needed to identify potential conservation focus areas for marsh migration inland (predictive impact modeling). [Moderate priority]

6) Conduct scenario planning for landscape changes in South Carolina. [Moderate priority]

7) Develop a map of new priority areas to target for conservation as old habitats dwindle or shift. [Moderate priority]

8) Conduct climate-related monitoring of species and habitats as needed. Run species- or habitat-based vulnerability index assessments as needed for priority species as it is a standardized data collection program with proven methods. [Moderate priority]

9) Collaborate with neighboring states to address species/habitat range shifts due to climate change. [Moderate priority]

10) Continue to participate in national workshops and meetings that discuss adaptive management techniques as it relates to our changing world. [Moderate priority]

11) Foster partnerships within the State and nationwide to address climate change in South Carolina. [Moderate priority]

CHAPTER 6: SOUTH CAROLINA'S COMPREHENSIVE MONITORING PROGRAM

Purpose and Justification for Monitoring

Throughout most of the history of natural resource conservation, single species management has been the focus. Threatened and endangered species, especially, have been the subject of intensive management. However, the literature provides testament to the effects of missed indices and unanticipated events on successful conservation. Although sometimes individual species need targeted management approaches, the majority of species would benefit from a broader strategy aimed at their shared ecosystems. The animals included on South Carolina's Priority Species List each have individual ecological roles connected in myriad ways to others. From this perspective, multi-species and systems approaches to conservation become the clearer path to accomplishing the many goals and strategies that the SCDNR has identified in the SWAP.

It seems apparent that this view of management will require constant and consistent adaptation to change. Single alterations in community function—such as the loss of a keystone species—can produce ripple effects that confound the most complete systems model. Despite imperfect knowledge, however, management must still move forward if conservation is to succeed. Likewise, as the system evolves, so does the method of management. Adaptive management cannot proceed without vigilant attention to these changes. Monitoring and evaluation then become the essential tools for detecting, measuring, and interpreting these changes over time.

Assessing changes in populations and habitats over time, especially in response to applied conservation actions, requires monitoring at multiple levels (species, guilds, natural communities, and implementation activities) and across multiple scales (local, statewide, regional, and national). Through varying styles of monitoring, SCDNR can detect species-specific trends from estimates of population size, relative abundance, or distributional shifts. Similarly, by measuring species associations such as longleaf pine-associated reptiles, we can assess habitat-level responses. Monitoring of habitats leads to identification of challenges or impacts of management activities or landscape alterations. Finally, monitoring simply helps us understand the effects, intended or otherwise, of any management approach.

During the initial planning stages before 2005, SWAP project leaders received guidance from partners—including USFWS, USGS, NPS and USFS—aimed at identifying essential elements in the design of effective monitoring programs to support the SWAP and its subsequent implementation. South Carolina's team attended meetings to discuss collaborative efforts and structural design of SWAP monitoring programs. Paul Dressler from the USGS presented a list of the basic elements of a monitoring program. Representatives of USFS and NPS provided descriptions of current monitoring programs instituted at varied scales by their agencies. This information has proved invaluable in considering the framework and strategies the SCDNR will employ through implementation of the SWAP to create a more effective and efficient statewide monitoring program.

Cooperative efforts remain essential to accomplishing the goals of these programs. SCDNR works first to ensure that existing programs remain effective where they meet the needs of conservation strategies within the SWAP. Monitoring continues to be a necessary component of most SCDNR efforts outside of the SWAP as well. The structure of the South Carolina Monitoring Program builds on existing SCDNR monitoring efforts and, where appropriate, partners' monitoring programs. Additional partnerships and support will continue to be researched during the development of the monitoring program.

Current Monitoring Programs in South Carolina

Monitoring programs are not a novel approach in successful conservation. International and domestic efforts to monitor migratory bird species provide excellent resources for developing species-level monitoring programs. The North American Breeding Bird Survey (BBS) is a well-known, long-term, continental sentinel monitoring program. The Christmas Bird Count similarly provides documentation of winter distribution and abundance for bird species. Such efforts set precedents in data collection and distribution which other taxa monitoring programs might find beneficial to emulate. Other bird surveys established in South Carolina include the International Migratory Bird Day and Backyard Feeder Watch. Of important note is the consistent, effective use of volunteers, or "citizen scientists," to conduct these assessments.

In South Carolina, current monitoring projects for both SWAP priority species and others include the following:

- The US Army Corps of Engineers and South Carolina Ocean and Coastal Resource Management (OCRM) provide essential monitoring efforts for marine invertebrates.
- SCDHEC monitors water quality while surveying for some freshwater invertebrate species.
- SCDNR assesses commercial fishery stocks and State Shellfish Grounds on an annual basis to evaluate shellfish population status.
- SCDNR estuarine trammel net sampling efforts have sampled SC estuaries since 1990, with over 20,000 net sets that intercept 151 species of fish.
- SCDNR's electrofish sampling program evaluates species abundance in the critical oligohaline stretches of SC rivers.
- SCDNR longline surveys monitor inshore waters for a number of species of concern, especially sharks.
- SCDNR monitors juvenile American Shad abundance and timing of outmigration in the Pee Dee, Edisto, and Savannah Rivers, as well as the Santee Cooper Lakes and tributaries.
- SCDNR monitors the movements and critical habitat use of adult Shortnose and Atlantic Sturgeon along the East Coast as part of a multi-state collaboration between SC, GA, and NC.
- SCDNR monitors Shortnose Sturgeon habitat use in the Santee Cooper Basin as part of the Santee Accord.
- SCDNR monitors young-of-the-year American Eel in the Rediversion Canal and Goose Creek Reservoir.

- SCDNR monitors the adult American Shad and Blueback Herring spawning migration in coastal rivers. Additionally, the SCDNR monitors fish passage of American Shad and Blueback Herring at the St. Stephen Fish Lift.
- The South Carolina Estuarine and Coastal Assessment Program (SCECAP) monitors habitat quality of estuarine waters statewide and identifies specific sites with degraded water or sediment quality.
- The SCDNR-SEAMAP program currently monitors the abundance of fish and decapod crustaceans using a trawl survey of coastal waters (4 to 10 m; 13 to 33 ft.) from North Carolina to Florida.
- South Carolina participates in the Harvest Information Program (HIP) that has been fully implemented nationwide, allowing for comparisons of migratory game bird numbers and harvest levels in South Carolina.
- Comprehensive hunter harvest surveys have been conducted for all species in South Carolina periodically since 1963. Fifteen surveys have been completed spanning 44 years. (1963–64; 1966–67; 1975–76; 1978–79; 1981–82; 1984–85; 1991–92; 1993–94; 1999–2000; 2002–03; 2004–05; 2006-07; 2008-09; 2010-11; 2012-13).
- The South Atlantic Fishery Management Council (SAFMC) assesses stock status of many species.
- Reproductive effort and fledging success of South Carolina nesting Bald Eagles has been documented (mid-winter surveys) on an annual basis since 1986.
- SCDNR monitors the reproductive effort and success of Wood Storks nesting in South Carolina.
- A spring Whistling Call Count Survey for Northern Bobwhite has been conducted annually since 1979.
- South Carolina has participated in Mourning Dove Call Count Surveys since 1966. Annual banding also occurs across the State.
- Annual summer Wild Turkey Brood Surveys have been conducted since 1982 to monitor reproductive success.
- Over 1,250 Furbearer Scent (Tracking) Station Survey routes have been run annually since 1984, while Black Bear Bait Stations have been monitored every other year since 1993 for the mountain population.
- Fox Squirrel Sighting Surveys were initiated in 1989 and began being conducted on even number years starting in 1994.

This list only briefly describes some of the monitoring efforts SCDNR undertakes in current management programs. An extensive list of monitoring efforts currently employed across the State and region is included in Appendix 7.

Additionally, the Freshwater Fisheries section of the Wildlife and Freshwater Fisheries Division of the SCDNR has run continued surveys of user preferences and user impact on the fisheries of the State. The following are those programs completed within the last 25 years.

- 1990 - Freshwater fishing study
- 1998 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources, results of Largemouth Bass and Smallmouth Bass anglers

- 1998 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources
- 1999 - Youth and fishing in South Carolina
- 1991, 1996 and 2001 - The 2001 Economic Benefits of Freshwater Fishing in SC
- 2000 - Striped Bass anglers' attitudes toward fisheries management on Lake Murray
- 2000 to present - Annual Cooper River Tailrace Canal American Shad Fishermen Survey
- 2001 - South Carolina youth aquatic survey
- 2003 - South Carolina residents' attitudes and behaviors toward aquatic resources
- 2003 - South Carolina and Georgia anglers' attitudes on fishing regulations on Lake Russell
- 2004 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources

Authors of the SWAP species accounts identified monitoring, survey, and research needs for priority species. Recommendations for individual species can be located in the separate volume, Supplemental Volume: Priority Species Accounts. Several needs are currently being addressed to varying degrees while others still need to be done. Some of the general needs for monitoring efforts are described here.

Many freshwater species—especially invertebrates such as crayfish, snails, and mussels—lack distribution and survey information for baseline data upon which a monitoring program could be built. Similarly, many of the marine fish and marine invertebrates on South Carolina's Priority Species List have only recently received initial survey attention and will require further study to create effective tracking programs. Where baseline data is available for freshwater aquatic species, there is a strong need to improve long-term monitoring across species groups. SCDNR fisheries biologists have recently developed a system for stream habitat monitoring and assessment (Decision Support Tools for Stream Conservation), made possible through State Wildlife Grants. Otherwise, monitoring is needed to assess specific management actions such as buffer establishment and species restoration projects. Impacts of introduced or exotic species on priority species remain a concern for many freshwater systems.

A pressing issue for monitoring terrestrial species is the establishment of taxa-relevant monitoring protocols such as those already established for birds. Efforts to expand monitoring on public lands and initiate monitoring on key private lands, where possible, should be addressed. A monitoring protocol for small mammals and bats should be developed. Survey and data needs are most pressing for all species of bats on South Carolina's Priority Species List. Therefore, it may be most important to survey and institute long-term monitoring programs at roosting locations. A pilot project on conducting bat acoustic surveys statewide is currently being developed.

Ongoing monitoring coordination and support of recommendations of national and regional planning bodies (such as PIF, SAMBI, NABCI, NAWMP and others) should be continued. Primary landbird species identified for specific monitoring programs include Swainson's Warbler, Henslow's Sparrow, Bachman's Sparrow, Wayne's Black-throated Green Warbler, Loggerhead Shrikes and Painted Buntings. Baseline studies are currently being conducted on Black Rail and MacGillivray's Seaside Sparrow which will help with their future monitoring. Key habitats of concern include pine savannah and pine woodland, early-successional types,

grasslands, and forested wetlands. Efforts to continue the monitoring of migratory and resident waterbirds and waterfowl are also recommended.

Development of monitoring protocols for amphibians and reptiles is of primary importance. SE PARC has published an Inventory and Monitoring Guide for the US and has developed protocols for some species. SCDNR's continued involvement in this process is important for both the continued development and refinement of reptile and amphibian monitoring guidelines.

Strategies for South Carolina's Comprehensive Monitoring Program

The following are specific strategies outlined for the advancement of South Carolina's Comprehensive Natural Resources Monitoring Program (South Carolina Monitoring Program). These strategies were developed during the initial iteration of the SWAP in 2005. Continuing to address these strategies should be considered a priority for future implementation goals. Where progress has been made, successes are discussed in italics under each strategy.

Strategy 1: Initiate a comprehensive monitoring program to coordinate monitoring efforts, including establishment of a collaborative working group staffed with agents both from the SCDNR and partner agencies. Data sharing in regards to common monitoring efforts should be a priority.

- Coordinate monitoring efforts across scales and jurisdictions through partnerships, defining scope as a function of the monitoring subject.
- Provide a means to share information, provide advice, and coordinate state monitoring efforts to be nationally and internationally compatible.
- Develop an ecologically-based framework considering the incorporation of an ecosystem-based approach to allow for regional compatibility.
- Use monitoring results to prepare future iterations of the SWAP.
- Build on existing state monitoring systems; utilize existing protocols where applicable.
- Support local planning initiatives, regional planning teams, and existing cooperative agreements where appropriate (See Appendix 3 for a list of existing partnerships).
- Develop a monitoring process that is easily understood, sustainable, cost-effective and relevant to all parties involved, and paced appropriately.
- Include assessments of cumulative impacts and, where possible, an interdisciplinary approach (geologic, genetic, ecologic, climatic).
- Maintain participation in monitoring networks as established between states during the national SWAP planning efforts.

Strategy 2: Create a South Carolina Comprehensive Natural Resources Data Initiative. Currently, there are various means of storing data in use by the agency. Unfortunately, many of these data layers are housed within separate divisions and are not compatible across operating systems at this time. A goal would be to standardize data gathering and prepare a repository for housing it. This data could then be retrieved in-house or shared, as appropriate, with partners or the public. Specifics of this initiative may include the following:

- Develop a standard system to facilitate species, habitat, and monitoring data collection for storage and dissemination across the agency and partnerships.
- Create a SWAP project monitoring system to link tracking of conservation actions with recommendations and appropriate species of concern.
- Establish standard operating procedures for project reporting and provide access to templates for web-based data input that will support research and monitoring efforts.
- Provide public and partner access to information collected and maintained to increase ownership and collaborative efforts. This collaborative data interface should allow for input directly from the field.
- Examine the ability to link previous databases with new information through consistent species and habitat codes.
- Collaborate with neighboring and regional states to create standardized platforms, enabling information exchange at broader scales.
- Spatially relate all database information, where appropriate, to provide summarizations through geographic information systems (GIS) software capabilities.
- Regularly update the conservation status (S-ranks; state listings) of species in South Carolina.
- Track distribution and status of all priority species with the intent to expand the database for tracking non-priority species as well.
- Use element of occurrence points to create more accurate range maps for species.
- Design the database with the intent to facilitate future reporting and revisions of the SWAP.

Strategy 3: Translate species-level goals and objectives to habitat and landscape scales for implementation and monitoring.

The Freshwater Fisheries division has created a Decision Support Tools application for online modeling of watershed impacts relative to deforestation, urbanization, road building, and other disturbance scenarios. Element of Occurrence Records (EORs) for freshwater fish species are overlaid to represent species that may be affected by habitat alterations. These new EORs were made possible by the Stream Assessment Survey (2006-2011) funded by State Wildlife Grants. Further needs include:

- Accomplish long-term objectives of monitoring key habitats using existing and new GIS programs.
- Continue to update and analyze the existing GAP databases and crosswalk this information with a statewide habitat characterization as provided in the SWAP.
- Design and implement an aquatic GAP initiative to support aquatic monitoring.
- Complete periodic updates of land use and land cover in the State to help translate threats from species to a habitat scale.
- Elevation models of the State, especially the coastal counties, should be updated and at a finer scale so that potential sea level rise due to climate change can be more accurately predicted and charted over time.
- Evaluate the existing SWAP species' goals for feasibility and applicability at broadening scales.

- Utilize landscape-level remote sensing and other mapping techniques, which are of particular value given the proportion of key habitats and priority species that are located on private lands.
- Monitor partnerships and public involvement such as conservation easements, stewardship agreements, and volunteer efforts at the habitat scale.

Strategy 4: Augment monitoring group efforts by developing or expanding citizen science partnerships, where appropriate. The SCDNR already relies on volunteers and citizen scientists to assist with surveys and DNA collection for research, especially in freshwater and marine fisheries. Further suggestions include:

- Consider the efficacy of developing and training citizen science groups to expand data gathering capability across the State.
- Build public understanding of ecological issues and meet the varied educational and public outreach recommendations for priority species by involving increasing numbers of citizens and institutions in basic status and trends monitoring efforts.
- Encourage partnerships with secondary and higher education institutions to provide students with opportunities to integrate classroom learning with practical experiences.
- Increase the use of graduate training programs in creating and implementing response monitoring, an excellent opportunity for standard graduate level research.

While presented last, it is important to consider the potential benefits of citizen-based programs (AFWA 2012). The Breeding Bird Survey and Christmas Bird Counts are citizen initiatives. These programs provide some of the most complete data on bird distributions. Already, South Carolina citizens utilize online reporting systems for monarch butterfly counts, green darner migration counts, firefly sightings, Purple Martin scout sightings, and Swallow-tailed Kite sighting reports. Support for continued conservation efforts can only benefit from a sense of ownership and collaboration among partners and the public. For more information regarding public input and partnership development, see Chapter 7.

Monitoring Program Defined

As the SCDNR proceeds with the refinement of the South Carolina Monitoring Program in support of the SWAP, several elements of design must be considered; these are outlined in Box 6-1 and are adapted from guidance provided to the States by federal partners.

BOX 6-1: BASIC ELEMENTS OF A MONITORING PROJECT AND PROGRAM

- Identification of monitoring goals and objectives
  - What is the question and why; identify existing information; conceptual model
- Identification of targets to monitor
  - Selection based on above results and availability of resources (fiscal/human)
- Establishing monitoring protocol (peer reviewed)
  - All elements documented (question; sampling design; methodology; anticipated analysis/analytic tools; data management and reporting strategy; schedule)
- Quality assurance and quality control
  - Assuring and controlling quality; training and potential certification of users
- Data management and archiving
  - Scheme to ensure data are documented, maintained, archived, and accessible
- Data analysis and assessment
  - Anticipated analysis including estimates of confidence
- Reporting
  - Reporting formats and schedule (useable, understandable, responsive) to user
- Periodic review and evaluation
  - Ensure project is responsive to the need and reflects the best available science

Monitoring targets will be dictated during the program implementation and adaptive management process; this process is more thoroughly described in Chapter 8: Implementation and Adaptive Management. In most cases, one or more of the following types of programs will be developed:

1) **Targeted species or habitat status and trends.** This type of monitoring tracks the status and trends of selected species, habitats, and communities and how they respond to management.
2) **Multi-species context or habitat condition.** Context or condition monitoring for either species or habitats allows us to track change at the ecosystem level to understand patterns of change.
3) **Cause and effect or response.** Cause and effect or response monitoring, in reality, mimics traditional research on the underlying explanation of observed events.
4) **Management action effectiveness.** Effectiveness monitoring relates directly to adaptive management as it assesses how well management actions undertaken achieve desired results.

Effective monitoring must integrate trend data with cause and effects for successful adaptive measures to be taken. Likewise, it must integrate habitat description with species measures. Viewing either as a surrogate for the other is inappropriate. Habitat-species relationships are not

always well understood; often, quality habitat will lack presence of expected species. Species trends, conversely, cannot provide direct insight into changes in habitat composition.

Targeted Monitoring

Targeted species status and trends monitoring might assess species presence/absence, population density, productivity (number of offspring), breeding success, offspring and adult survival, and/or the use of treated areas. In general, this form of monitoring is very similar to existing efforts to monitor harvested species. Targeted monitoring focuses on species or primary habitats selected due to risk, concern, or interest. Strengths of this facet of monitoring are first, the ability to narrow perspective to those elements likely to change, and second, to tie monitoring efforts to management actions. However, a drawback of such a focused effort is the very assumption that a relationship truly exists between the target and the attributed management action or threat. It is necessary, then, to conduct targeted monitoring within a contextual frame produced in the second division of monitoring efforts: condition and context monitoring.

For comparatively well-studied species, targeted monitoring protocols have been described—often in great detail—in recovery plans, conservation plans, published literature, and gray literature; SCDNR will use these if available. If no established protocol exists, SCDNR will adapt protocols from similar species or develop its own protocols based on what is known about the species. In developing protocols, we will follow Oakley et al. (2003). For species deemed important to target but with disparate information, inventories must first be conducted. When presence data are assembled, distributions of the species, along with population conditions can be mapped and used to direct future efforts.

Context and Condition Monitoring

Context monitoring is not restricted to particular species or system elements. Rather it provides status and trend information on a wide range of related facets of an ecosystem. With context monitoring, managers may detect unanticipated effects on a system that would have been lost in a targeted approach. It is a necessary link between targeted and response monitoring. In contextual monitoring, data may be collected for species not identified in specific targeted studies as described above. Additionally, monitoring of communities can provide context documentation against which targeted trends can be evaluated. Context-based monitoring extends to the habitat or landscape level when possible to further explain trend relationships between populations and habitats. When appropriate, context and condition monitoring will rely heavily on the identification of indicators. For example, with their large home range, Swallow-tailed Kites can serve as umbrella species for other area-sensitive wetland wildlife including Neotropical migrants, Barred Owls, Red-shouldered Hawks, Pileated Woodpeckers, river otters and black bears. The selection of appropriate indicators is challenging. The SCDNR will rely on the guidance provided by Schoonmaker and Luscombe (2005) (see Box 6-2 for additional definitions and discussions of indicators). It is important to stress that context and condition monitoring is not intended to follow every component of a system but rather provide a picture of the system from a broader perspective.

BOX 6-2: DEFINITION AND SELECTION OF INDICATORS

Categories for Indicator Evaluation:

- Relevance – the degree to which the indicator measures the issue of concern
- Practicality – the feasibility of measuring the indicator
- Scientific merit – the extent to which the indicator is supported by science
- Ecological breadth – the number of ecological components the indicator includes
- Usability – the ability of decision makers to make decisions using the indicator

Qualities of Valid Indicators

- Intended use is clear
- Simplifies status of a complex system
- Sensitive to known stressors
- Able to distinguish between anthropogenic stressors and natural variation
- Provide early warning of change
- Not greatly sensitive to sample size
- Low variability in response
- Easy and inexpensive to measure
- Easy to understand and translate into decision making
- Represents cause and effect relationships

Pressure-State-Impact-Response Indicator Framework

- **Pressure indicators** represent the level of a pressure or stressor that affect a natural resource
- **State (or condition) indicators** describe the current state or condition of a natural resource
- **Impact indicators** indicate the change in a natural resource as a result of a pressure
- **Response indicators** indicate the level of human action taken to reduce the pressure on a value of interest

Response Monitoring

Response monitoring or cause and effect monitoring (Holthausen et al. 2005) dovetails tightly with the objectives of targeted and condition/context monitoring and is the monitoring of species responses to management changes at the project (or several projects) level. It can be further described as the collection and assessment of observations to evaluate changes in condition in relationship to actions (Elzinga et al. 2001). Response monitoring of relationships between targets and conditions integrates monitoring with research. For this reason, efficiency may be increased where researchers and managers work closely to identify objectives for management. With proper choice of management goals and well-identified expectations that are defensibly quantifiable, response monitoring lends itself easily to the collaborative development of research efforts.

Effectiveness Monitoring

A final necessary division of monitoring includes efforts to quantify the effects of management actions in relation to management goals, rather than the effectiveness of an action taken. Effectiveness monitoring will be essential to adaptive management and future revisions of the SWAP. It involves not only looking at outcomes but at processes. This type of monitoring can determine whether the treatments were applied as they were conceptualized and prescribed. In order to adapt management efforts effectively, managers must be able to evaluate why an action is successful or unsuccessful and be able to gain a clear understanding of actions implemented so that future assessments are based on actual occurrences.

Proposed quantifiable criteria of management actions include net increases in partner and public involvements, removal of threats to priority species, or successful completion of conservation actions. Additional qualitative measures will be important as well (see Chapter 8: Implementation and Adaptive Management, for further descriptions of implementation and review). Of course, the long-term measure of effectiveness would be a reduction in the number of species of conservation need.

The balance between these four forms of monitoring is an important consideration in the design of conservation actions and projects at all scales. Additional attention will be given to the appropriate use of each facet of monitoring to most effectively meet the goals of the SWAP.

Experimental Design for Monitoring Programs

As successful research is typically built on detailed experimental design, so shall design efforts benefit the SWAP monitoring process. Attention to statistical design will improve the applicability of most monitoring outputs. While not all facets of the program need to be rigorously treated, an understanding of traditional scientific reasoning may increase the effectiveness of the program as a whole. Additionally, response monitoring endeavors would likely rely on sound analytical design due to their relationship to research.

Analyzing monitoring data most effectively will require the use of several techniques including traditional hypothesis testing, as well as less traditional techniques such as information theoretics methods (Burnham and Anderson 2001) and meta-analysis (Franklin and Shenk 1995). The object will be to determine whether actions do or do not produce their intended effect. Model comparisons and comparisons of treatments across differing areas and scales may require extended analysis of non-traditional statistical testing and inference.

Setting Monitoring Objectives

The proposed South Carolina Monitoring Program working group will establish measurable monitoring objectives through the planning of the monitoring program and selection of individual projects. These objectives will be closely tied to priorities for conservation actions as provided in Chapter 5: Statewide Conservation Strategies. Statistically defensible design will be employed, if applicable, to the measurements made. Attention in these decisions should also be given to the provision of opportunities for local and community involvement as well as cooperation among agencies and stakeholders. Similarly, a primary directive for selection of

objectives within the outlined framework should be the ability to acquire and use information for adaptive management.

CHAPTER 7: SEEKING PUBLIC INPUT AND MAINTAINING PARTNERSHIPS

The Initial Stages: Focus Groups and Public Meetings (2005)

From the beginning of the SWAP effort, the South Carolina Department of Natural Resources (SCDNR) and the planning team sought to realize successful partnerships and public involvement in the development of the Action Plan. It is understood that successful conservation is furthered by the existence of a strong collaborative involvement between all resource stakeholders, private or public, governmental or non-governmental. In July 2003, a Neighboring States meeting was held in association with our regional Federal Assistance coordinators to discuss issues common to all as well as to develop an outline and format for our Action Plans. Participating states included Virginia, North Carolina, South Carolina, Georgia and Alabama. The model created was one of two used by the US Fish and Wildlife Service as an example for the rest of the nation to immolate.

The SCDNR retained the Clemson Institute for Economic and Community Development (CIECD) to manage and conduct the Public Participation Process with planning beginning in January 2004. The team used a parallel participation process (focus groups and public meetings) to ensure that both the professional and general public concerns and comments were separately heard and acknowledged.

For the very first iteration of the SWAP (the 2005 CWCS), the team identified the issues of most prominent concern for wildlife conservation from both the perspective of agency staff and that of individuals and groups outside of the SCDNR. First, focus groups were developed in order to determine the wildlife conservation priorities of the SDCNR's partners. Representatives from partner groups were invited to share their ideas with the planning team. These partner organizations included federal and state agencies such as the US Fish and Wildlife Service, the US Forest Service, Clemson University, and the SC Forestry Commission. Likewise, non-governmental organizations like The Nature Conservancy, Katawba Valley Land Trust, SC Sporting Protection League, SC Native Plant Society, and Safari Club International were also involved. To ensure that SCDNR received input from partners with more diverse interests in wildlife conservation, other non-governmental organizations also participated in the focus groups including developers, local and county planners, professional foresters, and representatives from the agricultural community.

Five focus group meetings were held across the State in 2004 and were facilitated by our partners at Clemson Extension. Participants were invited via email and phone calls. The goal of these meetings was to identify general actions that would protect priority species in South Carolina. After discussing current wildlife conservation methods in the State and the factors contributing to wildlife and habitat decline, the participants determined that three broad general actions should be considered high priority by the SCDNR in conserving priority species; these three actions are:

- Public education
- Land use planning

- Habitat acquisition and protection

In addition, the following four actions were given slightly less priority but were mentioned at all focus group meetings:

- Greater research and monitoring - (population and species monitoring; exotic/invasive species management; investigating and verifying the decline of species)
- Water quality - (better water quality management programs; wetland protection)
- Agency collaboration - (inter- and intra-agency collaboration; public-private cooperation; collaborating with neighboring states; enforcing existing regulations)
- Landowner incentives - (landowner incentives improved; ecological restoration on private lands; cost-sharing programs)

After the focus group meetings, the SCDNR conducted four public meetings throughout South Carolina in order to allow all segments of the population to provide their opinions on priorities for wildlife conservation in the State. Announcements for the meetings were advertised in newspapers, mentioned on local television news reports, and an interview with the SWAP (CWCS) Coordinator was conducted by ETV radio. The information obtained through the focus groups allowed the SCDNR to be better prepared to answer questions that might arise during these public meetings. Public meetings were attended by representatives of groups similar to those present at the focus group meetings as well as members of the general public. The public meetings brought together a wider array of people and concerns. However, the dominant actions were similar to those stated in the focus groups: public education, land use planning, and habitat acquisition and protection.

A complete list of partners established throughout the 2005 planning process, and continued into the present (with additions), is included in Appendix 3.

Adding to Our Knowledge Base: Climate Change Workshops (2012)

Since 2005, discussions about climate change have increased, leading the Agency to once again gain public input into a topic that greatly affects priority species in SC. As suggested by the Association of Fish and Wildlife Agencies' Best Practices for State Wildlife Action Plans (2012), the number and types of public participants solicited was at a scale that would make efficient use of agency resources and glean the type of information we desired.

The South Carolina State Climatology Office produced "The Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources" which was held three times in three different locations across the State and attracted 151 total participants representing federal, state, and local governments; scientists; land and water resource managers; utility representatives; NGOs; the media; private companies; and other interested stakeholders. The purpose of these workshops was to increase awareness and utilization of climate knowledge to improve natural resource management. There exists a genuine need for new approaches and partnerships to cope more effectively with climate variability. The series was advertised to the general public on the State Climatology Office's website, but also invitations were sent to ~350 select individuals / organizations that had attended like conferences and workshops in the past.

As with the 2005 focus groups and public meetings, workshops were strategically located across the State. The first climate workshop was held in Charleston, SC in September 2012 and was attended by 68 people. The second workshop was held in Columbia, SC in October 2012 with an attendance of 48. The final workshop was held in Greenville, SC in December 2012 and was attended by 35 people.

The workshops began with a series of presentations on climate science and impacts to natural resources. Over 26 speakers participated. A PowerPoint presentation on the State Wildlife Grants program and SC's State Wildlife Action Plan (SWAP) was presented at each workshop. An interactive session came next in which Turning Technology (a polling process) was utilized to elicit responses from all members of the audience for guaranteed feedback on topics presented. Twelve questions regarding climate issues, impacts, actions, and perceived needs and challenges were asked and responses were gathered and displayed anonymously. In addition to the SWAP, other discussions included: SC climate trends for the past 109 years; an analysis of 60 years of water temperature data; aquifer water level trends; how climate affects estuarine fauna, shrimp abundance, and other wildlife and plant species; climate variability and forest health; fire regimes; urban growth's impacts during changing times; salinity intrusion into freshwater areas; the National Integrated Drought Information System; and partnership needs in data gathering and analysis. Responses were graphed and analyzed for the final report which can be viewed at http://www.dnr.sc.gov/ccworkshops/reports.html.

All participants selected drought as the primary climate-related issue affecting the State, probably since South Carolina has had frequent drought episodes within the last 15 years. Other concerns included sea level rise (especially among coastal participants), temperature extremes, and severe weather. Water quantity was likewise a concern for its impact on natural resources. Ecosystem integrity, water quality, and shoreline change were also important. The responses revealed that research, survey, education, and outreach are the main actions perceived being undertaken to address climate-related issues. Needs and challenges identified regarding climate-related work included tracking local data on effects and impacts, creating a centralized information area to store it, and obtaining monetary and staff resources to improve management related to climate variability. Other tools suggested included the need for predictive impact modeling, legislation, standardized climate modeling, and standardized data and methods. These needs then translated into action items that are listed in Chapter 5: Statewide Conservation Strategies. The workshop website can be accessed at http://www.dnr.sc.gov/ccworkshops/.

Building Consensus on the Issues

Partnerships and collaborations were essential to the development of the first Action Plan and this iteration. Not only were partners identified and sought for technical advice in creating the extensive compilation of species and habitat background accounts, but also further connections were built in the process of defining threats to SCDNR's priority species and developing conservation recommendations and strategies for abating these threats. The implementation of the SWAP has brought in new partners and volunteers to help with research, survey, and habitat enhancement work.

BOX 7-1: EIGHT CONSERVATION ACTION AREAS

- Education and Outreach
- Habitat Protection
- Invasive and Non-native Species
- Private Land Cooperation
- Public Land Management
- Regulatory Actions
- Survey and Research Needs
- Urban and Developing Lands
- Climate Change [NEW]

The development of the South Carolina Priority Species List, as well as the accounts for listed species, was a broad, collaborative effort that involved partners from all over the Southeastern United States and from every facet of natural history background. The taxa teams responsible for creating the species lists were selected by agency staff as well as individuals from State universities and other agencies. Taxa leaders often sought input from taxa experts from all over the country. Lists were also reviewed extensively both inside the agency and out. For example, in 2005, over 100 individuals were contacted in the creation and review of the bird priority list alone. The varying approaches to taxa priority list creations reflected the varying degree of expertise available and the efforts necessary to employ their help.

The habitat characterization of the State helped to identify potential partners well beyond the doors of research institutions. Concerned individuals from myriad groups were also given opportunities to provide input for defining the key habitats, threats to their continued health, and potential conservation actions. Additionally, technical assistance was pursued to create a proper vegetative classification and develop mapping capabilities.

Conservation recommendations provided by species account contributors and taxa groups were refined by a process of identifying concrete strategies, plausible actions to carry out those strategies, and potential partners for proposed measures. As conservation strategies were developed for each species, it became evident that they could be separated into eight categories, which we have designated as Conservation Action Areas (CAAs). A ninth—climate change—was added in 2013. These CAAs and their associated specific implementation strategies are presented in Chapter 5 and repeated here in Box 7-1.

Additionally, the SCDNR recognized that there are overarching conservation strategies that are likely to assist in protecting wildlife and habitats statewide. Therefore, the SCDNR determined that formation of Conservation Action Committees around each of the CAAs identified would assist in determining these overarching strategies. Conservation Action Committees would provide an excellent opportunity to work with partners to develop comprehensive statewide strategies for South Carolina that were not tied specifically to a single species or habitat. The strong partnerships between the SCDNR and other state and federal agencies, organizations, academic institutions, and industries within the State demonstrate dedication to overcoming challenges inherent in implementing conservation strategies. Two Conservation Action Committees, those for Education and Outreach and Urban and Developing Lands, were convened prior to completion of the 2005 SWAP (then CWCS); additional committee meetings will be held as needed for the remaining CAAs as the SWAP continues to be implemented. Resulting conservation strategies will be included in future revisions of the South Carolina SWAP.

The two Conservation Action Committees that were convened in 2005 were facilitated by planning team members, but attendees were otherwise allowed to discuss the technical process and elaborate as a group. Typical information derived from these working groups included not only specific identification of interested parties and stakeholders, but also histories of related actions and leads for further partnering efforts. Perhaps most exciting were the instances where working groups reached consensus on issues and began brainstorming innovative solutions. Additional discussion of the fruits of the working groups efforts is included within each CAA discussion in Chapter 5.

Late in the 2005 planning process, a representative of the Catawba Indian Nation was briefed on the SWAP (then CWCS) to explore partnership opportunities. The Catawbas, located in York County near Rock Hill, SC, are the only federally recognized tribe in South Carolina. According to the SC Commission for Minority Affairs, state recognized tribes in South Carolina include the Beaver Creek Indians, Edisto Natchez-Kusso Tribe, Pee Dee Indian Nation of Upper SC, Pee Dee Indian Tribe of SC, Santee Indian Organization, Waccamaw Indian People, and the Wassamasaw Tribe of Varnertown Indians. There are five other state-recognized groups and 15 non-recognized entities.

Potential actions identified for future discussion with the Catawba Nation are based on four broad goals. (1) Support for aquatic resource conservation, education, and recreation activities where the Catawba reservation borders the Catawba River could be broadened through financial and technical assistance from the SCDNR. (2) Similarly, the SCDNR could help Reservation land managers develop biological resource inventories and site-specific management plans for priority species. (3) The Catawba Nation could also support expanding outreach to other Native American bands and groups. (4) In return, the SCDNR could assist in developing new and existing cooperative conservation projects with neighboring landowners where objectives cross the Reservation boundaries. These ideas are still being considered.

In 2013, a list of priority species that would be in the revised SWAP was mailed to Catawba Nation representatives. This list only contained those species relevant to the Nation’s land holdings—those that were known or suspected to occur on site.

Brining the Message to Partners and the Public

With the collaborative foundations built during the initial stakeholder input and the planning stages of the project, the focus now turns to the future and the potential to continue these efforts. As the newest revision of the SWAP drives the implementation stage, partnering will become even more important in reaching successful outcomes. Financially, the ability to collaborate can only improve the efficiency of all partner efforts.

As implementation continues and planning for future revisions is on the horizon, the State Wildlife Grants (SWG) Coordinator will be tasked with maintaining the network of partnerships. Web-based contacts and media, presentations, and popular publications will continue to be utilized in this endeavor. *South Carolina Wildlife*, the SCDNR magazine publication, will continue to release updates on the SWAP and related SWG-funded research. The magazine has

over 52,000 subscribers with research indicating that each issue is read by three to four individuals. In 2005, SCDNR planned to create a Wildlife Initiative Newsletter so that partners and the public could follow the successes of the SWAP. Instead, the magazine plans to include a section highlighting one or two species of need in each issue. Challenges and successes will be discussed, and a section on how the public can help support conservation efforts will be a key component. The vast readership of the magazine makes this route a better alternative to the previously proposed newsletter and cuts down on printing and distribution costs.

In addition, a SWAP display was created for use at various workshops, educational facilities, and outdoor programs to inform the citizens of South Carolina about our species of greatest conservation need, where they live, and the challenges they face. An accompanying handout provides information on simple actions people can take to be environmentally conscience and help implement the SWAP.

Finally, as the development of data tools to support the SWAP continues, the SWG Coordinator will continue soliciting involvement and interest from partners throughout the State and region, to create a dynamic user interface for collaborative input on projects, species and habitat information, as well as demographics and, ultimately, future SWAP iterations. A novel approach to information collection, the collaborative data interface described in Chapter 6 will allow field biologists access to the SCDNR's information storehouse in an effort to make data updates fluid and almost instant. This open information gathering, while closely moderated for technical accuracy, will allow planners and managers to actively adapt their land use decisions with the most current knowledge of species needs and threat characterizations.

The SWAP will be placed on the World Wide Web through a SCDNR link on our homepage. Web-enabling the SWAP will make searching it easier, and interactive maps are being considered to accompany the document.

The mission of the SCDNR defines our role as one of stewards of the State's natural resources. Essentially, that role depends on the support and involvement of those groups and individuals with vested interests in the continued health and wealth of South Carolina's natural heritage. Public and partner involvement must—and will—continue to be a focus of the SWAP as the program strives to meet the needs of present and future interests.

CHAPTER 8: IMPLEMENTATION AND ADAPTIVE MANAGEMENT

Implementation of the SWAP

The primary focus of South Carolina's SWAP is continued, efficient, and effective conservation and management of wildlife diversity. Through implementation of the Plan, coordination of diverse conservation efforts, and forging of effective partnerships, the SWAP will meet its mandate. Coordination efforts will bring together expertise and funding sources from various partners and apply them to needs identified in the SWAP. The initial congressional intent for the State Wildlife Grant Action Plans was to identify and focus on the species in greatest conservation need and yet "address the full array of wildlife and wildlife related issues." At this nexus, the SWAP provides focus and guidance for SCDNR priorities when allocating personnel and financial resources for research and management.

Already, partnerships bolstered during the creation of the SWAP are offering potential resources for meeting the objectives and strategies described in this Plan. Many potential SWAP partners have also identified the Action Plan as an excellent resource to forge additional support for conservation. By compiling state fish and wildlife conservation issues in a single document for the first time, it was possible to develop a coordinated approach ranging from individual species' concerns up to regional habitat-level concerns. This Plan is more than an outline for specific conservation actions; it continues to serve as a framework for expanding partnerships and interdisciplinary collaboration in support of these actions. An important first step will be to identify these additional individuals, land managers, and organizations that can contribute to and use SWAP information in a timely way.

Two main concerns were identified in the past in association with implementation planning. The first, identified in the 2005 public input process undertaken in the early stages of initial Plan development, involved the need to communicate with constituents more effectively about the goals and vision of the SCDNR and the SWAP. Such communication, it was deemed, would increase public support, ownership and partnership development. In response, news articles, poster sessions, videos, and other outreach materials have been created highlighting SDNR's role in the SWAP. The second concern dealt with the potential expense of time and funding for the collection, analysis, and reporting of extensive data needs as identified by SCDNR biologists. These needs included those associated with the development of the South Carolina Comprehensive Monitoring Program outlined in Chapter 6. The Monitoring Program is still being refined and the SCDNR will continue to expound upon this concept. These challenges must, and will be, met as the evaluation of this Plan in future revisions depends on public support and effective monitoring for dynamic management.

In 2006, SCDNR drafted an Implementation Plan for the SWAP (then CWCS) which made suggestions for priority research. Many of these suggested topics went on to become State Wildlife Grant proposals that were chosen for funding and have been successfully completed. Those projects that have been completed as of 2013 are summarized in Chapter 9. An additional 17 more are in some phase of completion and will be summarized in subsequent iterations of the Plan.

Request for Proposals and Project Selection within the SWAP

Every year, the State Wildlife Grants Coordinator solicits proposals via an email network. All submitted proposals are reviewed and compiled by the Coordinator in preparation for formal review. Rigorous review and selection procedures ensure that sponsored projects are effective and efficient in meeting the goals and objectives of the SWAP. The SWAP Steering Committee reviews all proposals to determine if projects clearly focus on South Carolina priority species and their associated actions recommended within the SWAP.

Members of the SWAP Steering Committee include the following or their designee:

- State Wildlife Grants Coordinator
- Deputy Director of Wildlife and Freshwater Fisheries
- Assistant Deputy Director of Wildlife and Freshwater Fisheries
- Chief of Wildlife Management
- Assistant Chief of Wildlife Management
- Chief of Freshwater Fisheries
- Assistant Chief of Freshwater Fisheries
- Deputy Director of Land and Water Resources
- Deputy Director of Marine Resources
- Assistant Deputy Director of Marine Resources

The SCDNR seeks to fund innovative, interdisciplinary projects that attempt to address the needs of priority species listed in the SWAP and undertake practical application of SWAP goals. The urgent need to achieve environmental sustainability and protect South Carolina's ecosystems challenges applicants to develop new ways to engage organizations in problem solving. Proposals selected will:

- contribute to applied problem-solving for an immediate and specific issue that is directly related to wildlife conservation;
- build capacity for collaborative statewide wildlife conservation; and
- incorporate strategies to apply and communicate outcomes for the improvement of policies and/or management practices.

Funding is allocated according to budget cycles and request-for-proposal processes associated with State Wildlife Grants and other funding sources. Competitive SWG and Multi-state SWG proposals are reviewed in the same fashion.

Adaptive Management, Maintenance, and Communication Plan

Implementation will continue to be a dynamic process through time, involving monitoring process management, performance assessment, adaptation as new information dictates, and refocusing to new tasks and projects as appropriate. As described in Chapter 6: SC's Comprehensive Monitoring Program, a major component of the SWAP's coordination and review will be dependant on successful monitoring of conservation projects and actions—

effectiveness monitoring. In the long-term, effective review and revision of the Plan will depend on the proposed effectiveness monitoring protocols and procedures. Conservation actions will have to be evaluated based on their ability to further the goals and objectives of the SWAP. As an agency, SCDNR sets project objectives and identifies measures of success for management actions. As SWAP projects are evaluated, similar indicators of success will be defined at the strategy level.

As a requirement of the SWG program, project leaders will be required to produce annual progress reports for review by the Steering Committee. These reports will be evaluated for insight into adaptive management needs and reassessments of the SWAP. Final project reports will be available in an online repository linked to the SWAP website and will be summarized in future revisions of the SWAP. Continued monitoring and evaluation of management actions will create an active implementation of the "living" SWAP document. Project leaders will also be involved in periodic communication efforts focused on increasing public awareness of SWAP implementation. The Catawba Indian Nation will also receive updated lists of priority species that do or may occur on their tribal lands. Maintaining these communication links with the public and broader conservation community will be critical to the success of the SWAP.

Review and Revision: Considering Lessons Learned

As discussed in Chapter 5, the purpose of a monitoring plan is to assess both species and habitats as well as related conservation actions. Also, as it pertains to the SWAP, it is important to evaluate the effectiveness of projects funded through the State Wildlife Grants program. Performance measures should be selected that are realistic goals and easily reportable in the USFWS's Wildlife TRACS online system.

As per Element 6 of the original legislation establishing the SWG program, all states made a commitment to review and revise the SWAP within ten years. The SWAP/SWG program in South Carolina will continue to be reviewed on a 5-year cycle to ensure the program and the SWAP remain relevant and current with evolving landscapes and developing conservation efforts. This cycle will include the previously described plans for monitoring, maintenance, adaptive management, review and revision. Within the 5-year time period, it is expected that certain issues will trigger an early revision of the SWAP or submission of addendums for the Plan. The identification of new information on species priorities gained through surveys, research, and monitoring or reprioritization of projects and actions following goal achievement will be recognized as adaptive management efforts requiring Plan reassessment. However, planning improvements such as (1) identification and elimination of flaws in the program or SWAP implementation process, (2) identification of more efficient or valid approaches to internal supporting processes such as species prioritization and threat assessment, and/or (3) expansion of those taxa groups treated only cursorily in this current SWAP document would be viewed as lessons learned contributing to the next iteration of the SWAP during a regular revision cycle.

CHAPTER 9: SC'S STATE WILDLIFE GRANTS PROJECT SUMMARIES

South Carolina began implementing its Action Plan as soon as it was initially approved back in 2005. Since that time, 35 State Wildlife Grants have been completed and are summarized in this chapter. Table 8-1 lists them in numerical order. Due to personnel turnover, the author of the report may differ from the actual principal investigator (PI) of the project. This is noted in the title of each report. There are an additional 18 regular grants in progress as well as 3 competitive SWG grants, and those will be reviewed in the next revision of the SWAP. All final federal reports can be found online at the State Wildlife Grants website and go into more depth for each grant. The subjects of these projects range from research and survey to habitat enhancement.

TABLE 9-1: CLOSED SWG GRANTS FROM 2005-PRESENT

Federal Grant No.	Duration	Project / Grant Title
T-6	2004-2005	Census and Monitoring of Waterbird Nesting in the South Carolina Coastal Plain *(continued from R-3)*
T-7-R-2	2006-2008	Conservation of Water and Seabirds in South Carolina
T-8	2005-2007	South Carolina Stream Planning Project *(became T-25-R-1)*
T-9	2005-2013	Robust Redhorse Restoration and Conservation
T-10-P	2005-2009	Landscape Planning for Priority Species on Agricultural Lands *(also T-46)*
T-11	2005-2008	Restoration of Longleaf Pine Forest on State-owned Land
T-13-R	2006-2009	Conservation of Migratory Landbirds in South Carolina *(previously T-4)*
T-14-T	2005-2009	Development of BMPs for Sustaining Wildlife in the Maritime Zone of South Carolina
T-15-P	2005-2007	South Carolina Reptile and Amphibian Conservation Planning
T-16-R	2005-2009	Upland Habitat Improvements on Lewis Ocean Bay Heritage Preserve
T-17-R	2006-2010	Protection and Management of Seabird Colonies (Monitoring/Breeding Parameters)
T-19-R	2006-2010	Habitat Enhancement on North and South Williman Islands, Beaufort County, South Carolina
T-20	2006-2007	Status and Management Plan Development for Three Rare Burrowing Crayfish
T-23-R-1	2006-2011	Controlling Access to Known and Potential Bat Roosts
T-24	2006-2008	Fish Passage on the Broad River: An Assessment of Benefits of Freshwater Mussels
T-25-R-1	2006-2013	South Carolina Stream Assessment *(previously T-8)*
T-27-R-1	2009-2012	Habitat Improvement for Grassland Birds
T-30-R	2007-2008	Taxonomy, Life History, and Distribution of the Crayfish, *Procambarus echinatus* (Edisto Crayfish)
T-31-R-1	2007-2012	Assessing Introgressive Hybridization Within and Habitat Requirements of Native South Carolina Redeye Bass
T-32-T-1	2007-2008	Restoring Seabird Nesting on Bird Key Stono Seabird Sanctuary
T-33-R-1	2007-2012	Robust Redhorse Electrofishing and Radio Telemetry Tracking of the Great Pee Dee River, South Carolina
T-35	2009-2010	Identification of Diamondback Terrapin Habitats in South Carolina *(thesis)*
T-36-HM	2008-2010	A GIS Model to Guide Landscape Scale Restoration at the Woodbury Tract and Hamilton Ridge Properties
T-37-T	2008-2010	Carolina Herp Atlas
T-38-R-1	2010-2012	Mink Restoration and Monitoring Development Project *(see 2 theses)*
T-39-M-1	2008-2013	Prescribed Burning Crew for South Carolina DNR Lands
T-40-L	2008-2009	Conservation of Belfast Plantation, Phase I
T-42-R-1	2008-2009	Use of GIS to Assess the Demographic Isolation of RCW Groups in South Carolina
T-44-R	2008-2010	Least Tern Reproductive Success on Rooftops
T-47-R-1	2008-2011	Conservation of Breeding Painted Buntings and Other Songbird Indicators in Early-successional Shrub-scrub Habitat Modified by CP-33 Buffers in South Carolina
T-48-R	2008-2010	Effects of Predation on Seabird Nests in Cape Romain
T-50-L	2009-2010	Conservation of Belfast Phase II
T-51-R-1	2009-2011	Ecology and Impacts of Coyotes on Loggerhead Sea Turtles, Least Terns, and Other Wildlife: Implications for Management
T-54-R-1	2010-2013	Monitoring Impacts of Yellow Pine Restoration of Avifauna in the SC Mountains
T-55-R-1	2010-2012	Using Citizen Science in the Study and Conservation of Breeding Painted Buntings
T-61-R-1	2012-2013	Decision Support Tools for Stream Conservation
U2-1-HM-1	Incomplete	Multistate Sandhills Ecological Restoration Project: Alabama, Florida, Georgia, and South Carolina

Note: T-5, T-21, T-29, and T-52 were CWCS/SWAP revision grants. T-1, T-3, t-12, T-22, and T-28 are unassigned numbers. T-26 is being continued as T-57. T-34, T-41, T-43, T-45, T-49, and T-53 are still active.

Project Summaries

Census and Monitoring of Waterbird Nesting in the South Carolina Coastal Plain (Federal Grant #: T-6 (continued from grant R-3), Duration: 2004–2005) PI: Laurel Barnhill, SCDNR (formerly)
This grant is a continuation of South Carolina Grant R-3, which utilized WCRP funds This grant picks up where Grant R-3 left off, with the exception that the Bald Eagle work initiated under R-3 continues under that grant and is excluded from this grant. To read a review of T-6, please see the online final report.

Conservation of Waterbirds and Seabirds in South Carolina (Federal Grant #: T-7-R-2, Duration: 2006–2008) PI: Thomas Murphy, SCDNR (retired); Author: Christine Hand, SCDNR

Grant T-7 funded the monitoring and management of waterbirds nesting on the South Carolina Coastal Plain from October 2006–September 2008. Bald Eagle surveys and ground visits were used to document chick production, estimate mortality rates, and assess population levels. Colonially nesting wading birds were surveyed. More extensive surveys were conducted at Wood Stork colonies to document nest numbers and to estimate productivity. A decline in numbers of colonially nesting wading birds that may be due to loss of habitat and drought conditions was documented. Movements from natural wetlands to constructed wetlands and an increase in human-bird interactions was observed. Censuses were conducted for 6 species of seabirds, and signs were posted to protect sensitive nesting areas. Least Terns nesting on rooftops were surveyed. American Oystercatchers were surveyed and banded to yield data that will improve regional estimates of survival. Research projects conducted by 3 graduate students at Clemson University were supported and coordinated. Research topics include seabird/human disturbance, techniques to enhance Oystercatcher productivity, and identifying preferred winter foraging habitat for Oystercatchers.

DNR staff participated in professional meetings including the annual Wood Stork Working Group, American Oystercatcher Working Group, and gave presentations to educate the public about coastal birds. Technical assistance was provided for a variety of projects including negotiating management zones around eagle nests and enhancing the use of managed impoundments by wading birds and shorebirds.

Robust Redhorse Restoration and Conservation (Federal Grant #: T-9, Duration: 2005-2013) PI: Ross Self, SCDNR; Author: Scott Lamprecht, SCDNR

The objective of this project was to establish self-sustaining populations of Robust Redhorse, (*Moxostoma robustum*), suckers in the Santee River Basin using Savannah River brood stock. The first step was to stock the Santee River Basin with cultured Savannah River strain Robust Redhorse (RRH). The Santee Basin was identified as a potential population establishment site because its size, location between two identified population, and evidence of historical RRH occurrence in the drainage. A primary consideration of this effort was to use progeny from 100 pairings to ensure that the new population would be genetically diverse. Brood stock collection was made from a numerically healthy and geographically nearby population of Savannah River RRH. Fish were collected during their natural spawning activities over a mid-channel gravel bar

using stationary electro-fishing grids and a mobile electro-fishing boat. Eggs and milt were immediately collected from the actively spawning adults, and fertilization occurred individually between eggs from one female and milt from one male. Depending on the quantity, a female's eggs were divided between 1 and 3 males. Fertilized eggs were transported to the Bayless Hatchery for incubation and hatching. Grow-out was made in production ponds at the Dennis Wildlife Center. Spawning efforts occurred in every spring from 2004-2013.

Of the 45 females spawned over 10 years, 3 females have been used more than once. However, 2 of these incidences occurred in 2010 where production failed. The number of eggs collected from each female varied, and their contribution to subsequent stocks was not monitored. Through the 2009 spring spawning season, we have produced offspring from 98 individual matings. However, production over the last 3 years has been minimal. As a result, we continued spawning efforts through the spring of 2013 in order to reach an introduction goal of 100 genetically distinct matings. Spawning efforts produced 15,000 eggs which resulted in the stocking of 11,000 fry into grow-out ponds. All fish stocked to date have been tagged with either coded wire (CW) tags or pit tags (P).

We also surveyed and monitored the growth, survival, maturation, and spawning success as well as habitat use of stocked RRH in the Santee River Basin and monitored existing populations in the Savannah and Pee Dee River systems. Monitoring efforts continued into 2013. Building on previous work, observations were collected incidental to anadromous fish monitoring below Wateree Dam, Columbia fish way monitoring on the Congaree River, directed collection effort in the Congaree and Wateree Rivers, and by telemetry studies described below. DNR collected 4 specimens in the lower Wateree River during December 2012 and subsequently equipped 2 with sonic transmitters. This collection was made by using transmittered fish to locate aggregations outside of the spawning season. Duke Power picked up 16 specimens during their 2013 spring anadromous fish survey of the Wateree Dam tailrace. The Columbia fishway monitoring was hampered by high flows and turbid water during the spring of 2013. However, when observations were made, RRH were observed moving upstream.

Because of the difficulty in collecting information on juvenile and RRH, a telemetry survey was initiated in 2009 in the Wateree River/Congaree portion of the system. At total of 14 fish have been actively monitored, and the following pattern has been observed during multiple years: all the study fish occupied the Wateree Tailrace during spawning season; all fish used the lower Congaree River after spawning season; 11 of the 14 fish traveled up the Congaree to at least the midway point; 9 of the 14 passed upstream of Rosewood landing; 2 were documented using the Broad River (below the Columbia Dam); 2 fish used the lower Saluda (one in successive years); and 3 fish were detected in the upper Santee River above Lake Marion. The repeated summertime use of the Congaree River is interesting because it is significantly cooler than the Wateree River and may indicate a temperature preference. It is interesting to note that while we observed fish exhibiting spawning behavior in the Wateree Dam tailrace, we observed significant numbers of fish ascending the Columbia Fishway. Long distance movement of these fish can occur relatively quickly; one fished moved downstream 124 km (77 mi.) in 2.6 days and there are numerous instances of fish moving more than 30 km/day (19 mi./day).

The project also gave us the opportunity to inform and educate the public about the relevance of our efforts to reestablish and conserve RRH in South Carolina. During the past year, staff members have included our RRH studies in all appropriate public outreach efforts. Staff often addressed the need for display specimens at the Charleston Aquarium. Staff attended the 2013 annual meeting of the Robust Redhorse Conservation Committee (RRCC) in Georgia, and a plan for brood stock collection, spawning, stocking and research efforts were reviewed. Conservation and recovery were coordinated among the agencies and organizations involved. Staff members were also actively involved in a larval fish toxicology study lead by an NC State researcher.

The development of baseline genetic data for the Savannah population was realized and a foundation for future evaluation of ongoing re-establishment within the Santee River System is being built. Subsequent to development of genetic markers, fin clips from all collected specimens were catalogued in order to determine stock contributions based on individual crossings and to detect evidence of natural recruitment.

Landscape Planning for Priority Wildlife Species on Agricultural Lands (Federal Grant #: T-10-P, Duration: 2005-2009) PI: Judy Barnes, SCDNR (retired); Author: Billy Dukes, SCDNR See also T-46.

The approach utilized in this grant was to employ 3 technical guidance biologists to work with USDA staff to engage in landscape-level planning for priority wildlife species on private agricultural lands. The technical guidance biologists worked to incorporate habitat restoration measures for priority wildlife species into plans written through the Conservation Reserve Program, Environmental Quality Incentives Program, Conservation Security Program, Wetland Reserve Program, Wildlife Habitat Incentives Program, Grassland Reserve Program, and Forest Land Enhancement Program.

Over the course of the grant period, 248 conservation plans potentially affecting 170,359 acres in 23 South Carolina counties were written. Technical guidance biologists also delivered 47 programs for a combined audience of 2,511 people. Nine news releases promoting habitat conservation for priority wildlife species were written and submitted, 6 technical brochures on various aspects of wildlife conservation were developed, and 22 fact sheets on threatened and endangered species were completed. In addition, one biologist provided technical guidance and assistance in the development of a statewide Gopher Tortoise Conservation Plan for South Carolina.

Restoration of Longleaf Pine Forests on State-Owned Lands (Federal Grant #: T-11-1-R, Duration: 2006-2008) PI and Author: Tim Ivey, SCDNR

The objective of T-11-1-R was to restore longleaf pine forests and associated herbaceous species on a minimum of 1,000 acres of state-owned lands. Accomplishments included herbicide treatment of 45 acres of established longleaf stands to reduce competing hardwood vegetation on three SCDNR-owned heritage preserves. Twenty-five acres of new longleaf plantings (8,000 seedlings) were established on Little Pee Dee River Heritage Preserve and 8500 containerized longleaf pine seedlings were interplanted within 42 acres of sparse existing stands of longleaf pine on Longleaf Pine Heritage Preserve. Re-establishment and/or improvement of 14 miles of

firebreaks and prescribe burning of 1,213 acres of longleaf stands occurred on Woods Bay and Longleaf Pine Heritage Preserves. Aerial herbicide site preparation and planting of 14,000 longleaf pine seedlings was conducted to convert 25 acres to longleaf pine on Congaree Bluff Heritage Preserve. Site preparation and planting of 25 acres of longleaf pine was accomplished at Janet Harrison High Pond Heritage Preserve. Herbicide release of competing vegetation with 40 acres of longleaf was conducted at Longleaf Pine and Lynchburg Savannah Heritage Preserves. Understory brush control was utilized in 140 acres of longleaf stands at Webb Wildlife WMA. The construction of 18 miles of new firelanes at Lewis Ocean Bay Heritage Preserve was also accomplished as well as 162 acres of site prep and longleaf pine establishment at Woodbury WMA. McBee WMA underwent 8 acres of longleaf planting while 25 acres of longleaf plantings were done at Hamilton Ridge WMA. Site prep and planting of 831 acres of longleaf pine at Manchester State Forest was also accomplished. Mechanical understory control of competing vegetation in 32 acres of longleaf pine stands at Lewis Ocean Bay Heritage Preserve and herbicide timber stand improvement of 40 acres at McBee WMA was completed. The total longleaf habitat improvements made equaled 1,510 acres with new longleaf pine stands established on 1,135 acres.

Conservation of Migratory Landbirds in South Carolina (Federal Grant #: T-13-R-2, Duration: 2006-2009) PI: Laurel Barnhill (formerly with SCDNR now USFWS); Author: Janet Thibault, SCDNR

Grant T-13-2-R funded prescribed burns at Bonneau Ferry Wildlife Management Area during the growing season of 2008. It also funded research on the habitat requirements and demographics of Swainson's Warblers (*Limnothlypis swainsonii*) and Painted Buntings (*Passerina ciris*) and the development of monitoring protocols for bird species with the greatest conservation need to better manage for these species in coastal South Carolina.

Productivity, survival, habitat use, diet, and movements of Swainson's Warblers were studied at the Woodbury Tract Wildlife Management Area during 2006-2009 and built upon previous research conducted since 1997. Swainson's Warblers were color banded and several were radio tagged and followed with telemetry equipment throughout the nesting season. The site fidelity to Woodbury Tract was high with most birds returning to the same territories year after year. Females appeared to breed after their initial hatch year, while first year males did not. Home ranges often overlapped with other Swainson's Warblers and territory sizes varied. Swainson's Warblers forage in the upper layer of decaying leaves, and hydrology and flooding of the site affects the timing of breeding and foraging opportunities for this species.

The ecology of painted buntings and other early-successional passerines was studied at the Webb Center Wildlife Management Area and The Nemours Wildlife Foundation during the breeding seasons of 2006-2008. The study assessed the suitability of wildlife food plots in these two differently managed landscapes and how the management regimes affected the occurrence of Painted Buntings and other bunting species. Results indicated that buntings were not likely to be present at either of the managed sites due to the frequency of management at these areas. Buntings likely prefer larger areas of old/fallow fields that are interspersed among mid- to late-successional forests.

Development of Best Management Practices for Sustaining Wildlife in the Maritime Zone of South Carolina (Federal Grant #: T-14-T, Duration: 2005-2009) PI and Author: David Whitaker, SCDNR

The goal of this project was to develop Best Management Practices (BMPs) for anyone building a home or development within an existing maritime forest. These BMPs would have the goal of minimizing ecological impacts to native fauna and flora. Staff conducted an intensive literature review, contacted numerous managers of "low impact" coastal developments to review their development guidelines and regulations, and interviewed various experts. Staff asked for advice from upland mammal biologists, botanists, ornithologists, herpetologists, foresters, and others. A 76-page booklet entitled, "Best Management Practices for Wildlife in Maritime Forest Developments" was published in November 2009. This document reviewed the animal species of the Maritime Forest with emphasis on habitat requirements for each, and special emphasis was given to SWAP priority species. This was followed by detailed descriptions of BMPs at the community, neighborhood, and individual home levels. Immediately after printing, 225 copies were distributed to planners and other officials of coastal communities, Office of Coastal Resources, Coastal Conservation Association, SC Forestry Commission, various SCDNR staff, SC Sea Grant office, SC Wildlife Federation, Coastal Conservation Association, and a number of private citizens. Additionally, the complete document was made available on the SCDNR website with 1,429 requests for the document being made in the first month after publication.

SC Reptile and Amphibian Conservation Planning (Federal Grant #: T-15-P, Duration: 2005-2007) PI: Steve Bennett, SCDNR (retired); Author: Will Dillman, SCDNR

This multi-task project included 4 separate jobs for 4 separate priority species: gopher tortoise diamondback rattlesnake, timber rattlesnake, and seepage slope salamanders. Each job will be addressed in its own section.

Gopher Tortoise Management – The objective of this job was to develop a plan to recover and enhance the gopher tortoise population at Aiken Gopher Tortoise Heritage Preserve (AGTHP) in Aiken County to include the re-stocking of tortoises from the surrounding habitat and from other sites in South Carolina. Three 1 ha (2.5 ac.) pens were established on site at the Aiken Gopher Tortoise Heritage Preserve to provide an area to house relocated tortoises. These pens housed groups of tortoises for approximately one year, and then were removed to allow the tortoises to become "established" in their new environment. Waif gopher tortoises were received from a variety of different places within the Southeastern US, and several federal and state agencies and placed into the pens. Pen 1 housed waif tortoises from the Southeast and a group of hatchling tortoises from Hilda, SC that were contained within the pen under a separate hatchling enclosure. Pen 2 contained tortoises that were trapped on the AGTHP and considered to be the "resident" group. Efforts were made to trap and relocate all known Gopher Tortoises occurring on the site. In addition, aprons of AGTHP tortoises were excavated during the summer of 2007 by Tracey Tuberville and Kurt Buhlmann. One gopher tortoise nest containing two eggs was found. One of the eggs hatched, the other was infertile. That hatchling is small and is currently being maintained at SREL with the intention of adding it to the Pen 2 population in the spring of 2008. Pen 3 was used to house a group of gopher tortoises from a private property owner near the town of Grays, SC. In addition, two separate introductions of hatchling tortoises were made to Pen 3

during the Project period. Six hatchlings from laboratory-hatched eggs from the Tillman Sand Ridge Heritage Preserve were released into Pen 3 with starter burrows during summer 2007. An additional 6 hatchlings (also form Tillman Sand Ridge HP) were released into Pen 3 but covered under an 8 ft. x 8 ft. wire mesh cage in the autumn of 2007. The intention of the cage was to prevent predation by coyotes, crows, or raccoons. To date, the hatchlings seem to be surviving under the cages.

All tortoises have been measured, marked, and had blood samples taken (by Tracey Tuberville) for further genetic analyses. At the conclusion of this project, 56 tortoises were contained in the pens at the AGTHP.

Diamondback Rattlesnake Management – The first objective of this job was to determine the feasibility of managing rattlesnake populations by translocating Eastern diamondback rattlesnakes to sites with appropriate habitat within the historic range of the species, and to develop a model for eastern diamondback rattlesnake demography to include population size, survivorship, mortality, growth patterns, age classes, and sex ratio. The second objective was to conduct research and monitoring at the Webb Wildlife Center (continuation of ongoing monitoring) and at least 3 other public properties in the SC Coastal Plain that support longleaf pine habitat. Another task was to determine the potential distribution of longleaf pine habitat on public properties in the SC Coastal Plain using a qualitative vector GIS model.

The study was initiated in 2006, encompassing 4 study areas in the South Carolina Coastal Plain: Hoover Plantation (Jasper County), Nemours Wildlife Foundation (Beaufort County), Cheehaw Combahee Plantation (Colleton County), and Donnelly Wildlife Management Area (DWMA; Colleton County). In 2007, we added another study site, Okeetee Plantation (Jasper County), and discontinued efforts to monitor the EDB at DWMA. The study areas comprised varying degrees of upland pine savanna, and thus harbored Eastern diamondback rattlesnakes. In March 2007, we translocated all of the study animals that were telemetered in 2006 to the Webb Wildlife Center. We captured 4 new rattlesnakes (Nemours, N=1; Cheehaw Combahee Plantation, N = 3), and they were translocated in March 2008. All telemetered rattlesnakes were located weekly. We will continue to quantify movement patterns using data collected in 2007 following November ingress. We have begun our analysis comparing pre- and post-translocation movements using the individuals that were captured in 2006.

The long-term monitoring and research on the diamondback rattlesnake population at Webb Wildlife Center continued, and additional surveys were performed at Donnelly Wildlife Management Area, Cheehaw Combahee Plantation, Hoover Plantation, and Nemours Wildlife Foundation. No Diamondbacks were found at Donnelly Wildlife Management Area; however, diamondbacks were found at the other properties surveyed.

Timber Rattlesnake Surveys – The objectives of this job were to (1) determine the distribution of the montane phase and the Coastal Plain phase of this species in the region and to (2) develop a management strategy for the timber rattlesnake on public lands in South Carolina. (3) The population size and demography at selected sites had to be determined and included gathering information on population structure, sex ratios, mortality, reproductive success, survivorship, and

mortality. (4) The home range size had to be determined as well as habitat use and seasonal activity patterns for both "forms" of this species in this region using radio telemetry.

Between September 2006 and fall 2007, 15 timber rattlesnakes were implanted with radio transmitters and tracked. During the course of the study, hibernation, courtship, mating, and birthing were observed. Movements of male snakes appeared to be greater than those of the females, and both sexes showed an affinity for wooded areas. Both the montane and Coastal Plain phase of the timber rattlesnake were captured, implanted, and tracked. Currently, there appears to be no elevation, habitat, or sex differences in either phase of the Upstate timber rattlesnake. Data collected during this study has contributed to the understanding of the biology and habitat requirements of this species in South Carolina.

Seepage Slope Salamander Investigations – The objective of this project was to develop a predictive model for Coastal Plain seepage slope habitat as a means of identifying potential habitat for the Southern dusky salamander and Chamberlain's dwarf salamander, and to survey potential habitat for presence/absence of the target species. During the study, we collected specimens of the southern dusky salamander, when present, for genetic analysis to determine if there are "cryptic" species of this complex found in South Carolina.

Eight seep sites were monitored with water sampling wells and cover-board transects. Water quality and hydrology sampling was conducted at all seeps quarterly during the reporting period, and cover-boards were sampled three times. We initiated a molecular phylogeny study involving the two focal species of this project *Desmognathus auriculatus* and *Eurycea chamberlainii*. The goal of this study was to resolve the phylogenetic—and eventually the taxonomic status—of these 2 species and their "closest" relatives in South Carolina. Additionally, staff surveyed 26 sites for Plethodontid salamanders. Some of these sites were historic locations for *Desmognathus* and others were new sites selected due to their hydrologic and topographic characteristics. Salamander species in the family Plethodontidae were collected at 18 of these sites—*Eurycea chamberlainii* at 2 sites and *Desmognathus auriculatus* at 9 sites. One additional site in the Piedmont was sampled and a *Desmognathus* was collected there.

Preliminary results from the molecular phylogeny study indicate that the "focal" species *Desmognathus auriculatus,* Southern dusky salamander does not occur in South Carolina. To date, this analysis has identified 4 separate lineages of *Desmognathus* in the Coastal Plain and Piedmont of South Carolina, none of which are closely aligned with *D. auriculatus*.

Upland Habitat Improvements on Lewis Ocean Bay Heritage Preserve (Federal Grant #: T-16-1-R, Duration: 2007-2008) PI and Author: Tim Ivey, SCDNR

The objective of the habitat improvement project at Lewis Ocean Bay Heritage Preserve was to restore grassland, pine savannah, and pine woodland habitat sites within the 3-year funding period. Habitat restoration and management included clearing competing vegetation along 13 miles of roads, ditches, and rights-of-ways; 210 acres of competing understory removed from longleaf stands using herbicides and mechanical removal; 20 acres of longleaf pine stands underplanted with longleaf seedlings; 533 acres converted from slash pine to longleaf pine; and 18 miles of new firebreaks established. In addition, 76 miles of firebreaks were maintained and 2,338 acres prescribe burned.

Protection and Management of Seabird Colonies (Monitoring/Breeding Parameters) (Federal Grant #: T-17-R, Duration: 2006-2010) PI: Laurel Barnhill (formerly with SCDNR and now USFWS); Author: Janet Thibault, SCDNR

Seabirds such as Brown Pelicans, Sandwich Terns, Royal Terns, and Black Skimmers nest in large colonies on isolated islands and are susceptible to human disturbance. Over time, effects of disturbance may manifest as reduced reproductive success and increased energy expenditure on the part of adults and young. In 2006, the South Carolina Department of Natural Resources (DNR) established 3 barrier island seabird sanctuaries in Charleston County: Crab Bank, Bird Key, and Deveaux Bank. New regulations were designed to limit human disturbance and prohibited public access at Crab Bank and Bird Key during the nesting season and limited access to below the high tide line at Deveaux Bank. All 3 of these islands provide nesting habitat and stopover locations for seabirds and shorebirds which require islands that have suitable habitat for nesting and rearing young. The goal of this project was to monitor seabird colonies on these DNR protected islands and collect baseline measures of breeding parameters, determine habitat use of seabirds and shorebirds on the islands, and to better evaluate the health and condition of seabird populations in South Carolina in relation to the new regulations and for future comparisons. Research was conducted from 2006 to 2008.

Overall, the effects of the new seabird conservation regulations resulted in an increase in size of the Black Skimmer colony on Crab Bank, increased productivity of Black Skimmers at Deveaux Bank, and a re-establishment of nesting of Black Skimmers on Bird Key. Colony size and reproductive success of Brown Pelican and tern species at other islands was variable among locations and years. The results of the intertidal surveys indicated that the intertidal area is an essential component of seabird breeding habitat and is used for loafing, feeding, courtship, and chick-rearing by seabirds and shorebirds. The majority of birds were located along the water and on the lower portion of the beach during surveys. Brown Pelicans, Laughing Gulls, Black Skimmers, and Royal, Sandwich, and Gull-billed Terns were most frequently engaged in loafing and maintenance behavior in the intertidal zone of the islands, while shorebirds were most often observed foraging there. The health parameter analyses revealed that age was a significant factor affecting many health parameters of Brown Pelican nestlings. Packed cell volume increased with age when compared to wild adults. Levels of proteins and cholesterol were higher in the older age category, which may be necessary to support physiological development. Collection of baseline data such as that collected in this study provides a means to monitor the health of nesting populations and provides baseline data for comparative and long-term studies. These data are particularly valuable after catastrophic disease outbreaks or environmental contamination events.

Habitat Enhancement on North and South Williman Islands, Beaufort County, SC (Federal Grant #: T-19-R, Duration: 2006-2010) PI and Author: John McCord, SCDNR (retired)

This was a large, non-native invasive species eradication project that occurred on North Williman Island and South Williman Island which are located in north Beaufort County, South Carolina. Both islands exceed 1,000 acres in total size, and both are composed of a mosaic of

tidal estuarine marshland and interspersed hammocks (small upland islands also called hummocks). These islands are State-owned and are under the management authority of SCDNR.

North Williman Island includes 9 hammocks, ranging from 1.5 to 436.4 acres, while South Williman Island contains 12 hammocks, 0.4 to 688.4 acres in size. Biological inventories of plants and animals were performed by SCDNR on all of the hammocks of North Williman Island and South Williman Island during fall 2003 through winter 2005-2006. These initial SCDNR surveys revealed significant habitat degradation that was presumed to be caused primarily by the impacts of the invasive Chinese tallowtree (*Triadica sebifera*) and, specifically on several hammocks of North Williman Island, by feral goats (*Capra hircus*).

Habitat enhancement activities for this project were performed primarily on the largest hammocks within both North Williman Island and South Williman Island, hereafter referred to as "Goat Island" (436.4 acres) and "Big South Williman Island" (668.4 acres), respectively. Chinese tallowtree was particularly abundant and problematic in association with isolated freshwater depression wetlands. Such freshwater wetlands are most abundant on the largest hammocks within both North Williman Island and South Williman Island, and particularly on "Goat Island" and "Big South Williman Island". Chinese tallowtree out-competes many native plants and, as observed in isolated wetlands on both North Williman Island and South Williman Island, may ultimately produce nearly mono-species stands. Fallen leaves of Chinese tallowtree can alter water chemistry and water quality and may negatively impact populations of some amphibians. Additionally, dense populations of Chinese tallowtree may limit surface water availability and alter hydrology in isolated wetlands due to high water demand and heightened evapotranspiration during late spring through early fall.

Feral goats were only present on several nearly interconnected hammocks within North Williman Island, and these grazing mammals were typically only observed on "Goat Island". Evidence of over-browsing by feral goats was obvious and widespread, particularly on "Goat Island". Native plant diversity and populations of individual plant species were obviously suppressed relative to the observed status of such made during SCDNR surveys of nearby hammocks of comparable size and habitat diversity and where feral goats were not present.

Habitat restoration and enhancement efforts on North Williman Island were primarily based upon attempts to remedy and/or reduce perceived negative ecological impacts from both feral goats and Chinese tallowtree. The successful removal of the population of approximately 100 feral goats from "Goat Island" and all of North Williman Island was completed in early 2008. After goats were successfully removed, 423 seedlings of sweetgrass (*Muhlenbergia sericea*) were planted within 12 colonies on "Goat Island" at scattered sites in the upland transition zone just inland of tidewater influence. Though considered uncommon, this native grass was found to be rather widespread on hammocks within North Williman Island and South Williman Island that were not impacted by feral goats. Sweetgrass and other native grasses provide valuable cover and seeds for wildlife. Only a few damaged specimens of this species were observed on "Goat Island" prior to the successful removal of feral goats. The overall survival rate for planted sweetgrass was nearly 75%, and thriving colonies remained at most planting sites at the completion of this project.

Fourteen trips were made to North Williman Island for herbicide injection of Chinese tallowtrees from 5 November 2007 through 20 December 2007. Approximately 4,750 such plants were injected with herbicides (50% Habitat® or 50% Clearcast™) over 5 North Williman Island hammocks. The remaining 4 North Williman Island hammocks do not have suitable habitat for Chinese tallowtree. The total acreage canvassed for Chinese tallowtree herbicide treatment was ~526.5 acres, requiring 272.5 man/woman-hours. A general evaluation of herbicide injection results was made from spring 2008 through summer 2010 and indicated the successful kill of ~95% of the total Chinese tallowtree (tree-stage plants) population for the entire North Williman Island hammock group. Isolated, low-salinity wetlands were of highest priority in the attempted eradication of Chinese tallowtree. The kill rate for tree-stage Chinese tallowtrees associated with 17 such wetlands likely approached 98%, with nearly 2,500 mature trees killed. Observations through the summer of 2010 revealed a gradual positive response of native plant communities throughout North Williman Island hammocks on which Chinese tallowtree was eradicated and particularly on hammocks on which feral goats were removed in addition to Chinese tallowtree eradication.

Primarily due to funding limitations, habitat enhancement on South Williman Island was limited to the placement of Wood Duck (*Aix sponsa*) nesting boxes (one box each) in 7 isolated wetlands within "Big South Williman Island". Two Wood Duck nesting boxes were placed in an isolated freshwater wetland on "Goat Island". Wood Duck had been recorded in winter on both islands during initial SCDNR surveys, but no evidence of nesting was observed prior to these habitat enhancement efforts. All nesting boxes were erected in late winter 2008, and all boxes were inspected for signs of Wood Duck nesting activity during each spring, 2008-2010. One, 2 and 6 boxes were used by nesting wood duck in 2008, 2009, and 2010, respectively. The observed increase in nest box utilization over the 3 years of observations suggests a likely increase in the local Wood Duck population in the vicinity of the Williman Islands, potentially in response to the provision of nesting cavities.

In addition to the aforementioned habitat enhancement activities, complimentary habitat enhancement and restoration activities were achieved on "Goat Island" through a Cooperative Agreement between the United States Department of the Interior, Fish and Wildlife Service and SCDNR from 1 August 2008 through 30 June 2010. The Cooperative Agreement included: (1) the follow-up eradication of Chinese tallowtree (mostly seedlings); (2) the removal of dead tree-stage Chinese tallowtree snags (trees killed by herbicide injection in late 2007 and early 2008) from 3 isolated wetlands which previously had particularly dense stands of this invasive plant; and (3) the damming of old historic drainage ditches associated with 5 isolated wetlands. Positive responses of native plants, plant communities and wildlife observed on "Goat Island" through the completion of this project should be attributed to habitat enhancement activities achieved through both this project and the Cooperative Agreement.

"Goat Island" was more severely negatively impacted by the combined impacts of feral goats and Chinese tallowtree than was any other hammock within either North Williman Island or South Williman Island. Both habitat restoration, as observed through positive responses of native plants and plant communities, and positive responses of wildlife were most obvious on this North Williman Island hammock. Habitat enhancement and restoration activities yielded a nearly immediate positive response in recovery of native plant communities, particularly in and near

isolated wetlands and on the periphery or outer upland fringe of hammocks that had been drastically impacted by browsing goats. Wetland plant diversity increased dramatically, as demonstrated by a threefold increase in recorded plant species diversity in one isolated wetland as compared to the recorded diversity prior to habitat enhancement activities. Buttonbush (*Cephalanthus occidentalis*), which is a valuable wetland wildlife plant, responded dramatically to the removal of over-shading Chinese tallowtrees and to the removal of feral goats. Prior to habitat enhancement activities, buttonbush was fairly widespread and abundant in wetlands on "Goat Island", but practically all specimens were in poor condition and few, if any, specimens produced blooms or seeds. Following habitat enhancement activities, buttonbush specimens throughout wetlands on "Goat Island" displayed dramatic growth of new stems and foliage and produced abundant flowers and seeds by 2009 and 2010. Plants typical of the upland-tidal marsh ecotone recovered from severe browsing with sprouting of new growth and by recolonization from seedlings. Sweetgrass plantings in peripheral upland areas of "Goat Island" were very successful and supplemented natural colonies of native grasses, including several naturally occurring sweetgrass colonies which slowly recovered and became established after goat removal. The recovery of this forest edge habitat should provide additional breeding and foraging habitat for Painted Bunting (*Passerina ciris*), a species of highest conservation priority in South Carolina and throughout the region. The recovery of forested plant communities and habitats was more subtle since much of "Goat Island" and other North Williman Island hammocks are covered in closed canopy forest. Subcanopy shrubs, saplings, and herbs slowly responded with resprouting from previously heavily browsed trunks and stems and from rootstock. Also, substantial and diverse germination from the seed-bank was observed. Prior to removal of feral goats, seedlings—including those of Chinese tallowtree—were quickly consumed and were rarely observed. Several decades will likely be required for subcanopy plant communities to recover to a stage similar to such communities on nearby hammocks that have not been impacted by feral goats. With further recovery of shrub thickets and habitat complexity anticipated for "Goat Island" over the next several decades, additional recruitment of breeding birds will likely occur as gradually recovering habitats become suitable as nesting and brood-rearing habitat.

Amphibians and dragonflies were quickly recruited to depression wetlands that displayed enhanced surface water duration following removal of Chinese tallowtree and damming of drainage ditches. Increased surface water retention in such isolated wetlands on "Goat Island" will likely sponsor an increased distribution of "Lunz's crayfish"—or hammock crayfish—(*Procambarus lunzi*), a species of conservation priority in South Carolina, as well as other aquatic animals as well. Increased surface water retention may also attract American alligator (*Alligator mississippiensis*) to additional wetlands on "Goat Island", which could result in the creation of dens and pools that may further enhance wetlands for potential colonization by additional aquatic species.

A rookery used by 4 species of wadingbirds was found in the largest wetland on "Goat Island" during SCDNR surveys in spring 2006. The removal of hundreds of large Chinese tallowtrees from the perimeter of this wetland may have improved the quality of this wetland for wadingbird nesting and foraging habitat. Both White Ibis (*Eudocimus albus*) and the endangered Wood Stork *(Myctera americana*) were observed in higher numbers in association with this wetland after the removal of Chinese tallowtrees, indicating that access to shallow water foraging sites was

improved. Wading bird nests were not observed in Chinese tallowtrees in spring 2006 or in spring 2007, and all wading bird nests were in either buttonbush or Coastal Plain willow (*Salix caroliniana*). Both of these native wetland plants responded very positively with enhanced growth following the eradication of competing Chinese tallowtrees. By the spring of 2010, 5 species of wadingbirds, all of which are considered priority conservation species in South Carolina, were recorded within the rookery in this wetland. Also, 2 Great Blue Heron (*Ardea herodias*) nests were constructed in large pines bordering a small, open, isolated wetland on "Goat Island" in spring 2010. No wading bird nesting activity had been observed in association with this wetland prior to the eradication of many large Chinese tallowtrees that had dominated the perimeter of this and other wetlands.

Habitat restoration and enhancement efforts on North Williman Island—particularly on "Goat Island"—and on "Big South Williman Island" yielded varied positive ecological impacts. The gradual recovery of habitats and plant communities should continue well into the future throughout North Williman Island hammocks on which habitat restoration and enhancement activities were conducted under this and the complementary Cooperative Agreement. Particularly for "Goat Island", where the most intensive habitat enhancement efforts were made and where feral goats had drastically impacted nearly all habitats by over-browsing, native plant communities and associated wildlife should continue to show positive responses well into the future. However, since seeds of Chinese tallowtree are very resilient within the seed-bank and can also be transported by birds and by water, future herbicide control of this aggressively invasive plant on hammocks of North Williman Island may be necessary to prevent recolonization by Chinese tallowtree. Because of the positive results of efforts on hammocks of North Williman Island, serious consideration should be given to the expansion of Chinese tallowtree eradication throughout the hammocks of South Williman Island, where many isolated freshwater wetlands remained heavily colonized by Chinese tallowtree at the end of this project in 2010.

Status and Management Plan Development for Three Rare Burrowing Crayfish, *Distocambarus youngineri*, *D. hunteri*, and *Cambarus reflexus* (Federal Grant #: T-20, Duration: 2006-2007) PI: Jennifer Price (formerly SCDNR); Author: Jim Bulak, SCDNR

The purpose of this study was to create habitat models for 3 species of crayfish of conservation concern in South Carolina - *Distocambarus youngineri, D. hunteri, and Cambarus reflexus*. For the two species of *Distocambarus,* soils data were used to predict occurrence sites. The developed habitat model was a significant predictor of *D. youngineri* occurrence. This species was found in Piedmont prairie habitat. Future management efforts should focus on acquiring property with prairie or savanna-like vegetation structure in the Piedmont. Perhaps due to a severe drought during the collection period, *D. hunteri* was not collected during the study. Future efforts should use genetic techniques to verify collections of *D. hunteri;* its status of "critically imperiled" is appropriate.

Cambarus reflexus habitat was modeled at the Webb Wildlife Center, Palachucola Wildlife Management Area (WMA), and Hamilton Ridge WMA. Model selection indicated that the presence of wiregrass (*Aristida* sp.) was the most important habitat component, indicating *C. reflexus* was associated with high quality, fire-maintained, pine savanna habitats in the Coastal

Plain. The species appears to be limited to the Coastal Plain and sensitive to soil surface disturbances. Management should focus on maintaining remnant pine savanna stands with prescribed burns to help maintain this species.

Controlling Access to Known and Potential Bat Roosts (Federal Grant #: T-23-R-1 F06AF00025, Duration: 2006-2011) PI and Author: Mary Bunch, SCDNR

Human disturbance is a very significant threat to bat colonies. Disturbance can be in the form of recreational caving, mining, or exclusions or disruptions to natural or man-made roosts. This project sought to protect some important bat roosts from human disturbance and to find new bat colonies. When awarded funding in 2006, White-nose Syndrome (WNS), a disease of hibernating bats, had not yet been discovered.

We assessed known roosts for suitability to bat-friendly gating or other measures to reduce disturbance. Sites with priority species from South Carolina's Comprehensive Wildlife Conservation Strategy (CWCS), the Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), Southeastern myotis (*Myotis austroriparius*), and small-footed myotis (*Myotis leibii*) were given highest priority, but other bat species would also benefit from the work. We partnered with the US Forest Service and The Nature Conservancy to erect 6 bat-friendly gates at 5 locations, and modified an existing barricade to allow bat passage at another site. We also sought to place a bat-friendly cupola on an open shaft to a tunnel, but lacked sufficient funds for such a large project. We planned to erect a fence (site was not suited to gating) around the state's largest southeastern bat colony, but state parks declined the fence because they didn't want to maintain a fence. We mapped 338 potential mine sites and 17 old wells. All of the wells and 54 of the mine sites were evaluated. None of the wells were good bat habitat. Many of the old mine sites had no underground structure but we did locate 8 mine adits with tri-colored bats (*Perimyotis subflavus*). Of those, 5 would be suitable for gating.

Concrete bat roosts were built at 4 locations to serve as alternate roosts for Rafinesque's big-eared bats where known roosts were imperiled or limited. Other bats will also use the structures. Currently, all of those new roosts are in use by bats. After dramatic WNS related mortality was noted in other colonial hibernating bats typical to our mountains, we provided bat boxes to 3 state parks with known vulnerable colonies (threatened by exclusion), with great success at one of the parks.

Fish Passage on the Broad River: An Assessment of the Benefits to Freshwater Mussels (Federal Grant #: T-24, Duration: 2006-2008) PI: Jennifer Price (formerly SCDNR); Author: Jim Bulak, SCDNR

The objective of this work was to determine the effects of a newly constructed fish passage facility on the Broad River in Columbia, SC to freshwater mussel populations. Surveys were conducted on the Broad River, upstream of the dam, and on the Broad and Congaree Rivers, downstream of the dam. Nine species of mussels were downstream of the dam and 4 species were observed in upstream areas to Parr Reservoir. The Broad River upstream of Parr Reservoir contained sparse populations of mussels, possibly due to habitat degradation associated with sedimentation. Efforts were made to collect gravid females and determine the seasonality of

reproduction of the various mussel species. Peak reproduction and release of glochidia generally occurred in April through June, though this general trend exhibited variability among the various species. Fish host evaluation was conducted for 6 species of mussels - *Ligumia nasuta, Elliptio roanokensis, Lampsilis cariosa, Lampsilis radiata,* and *Elliptio congarea.* Results suggest that the fish lift will benefit mussel populations upstream of the dam (to Parr Reservoir) as increased passage of glochidia-carrying fishes from the more species rich areas downstream of the dam should increase colonization potential. Continued monitoring is recommended.

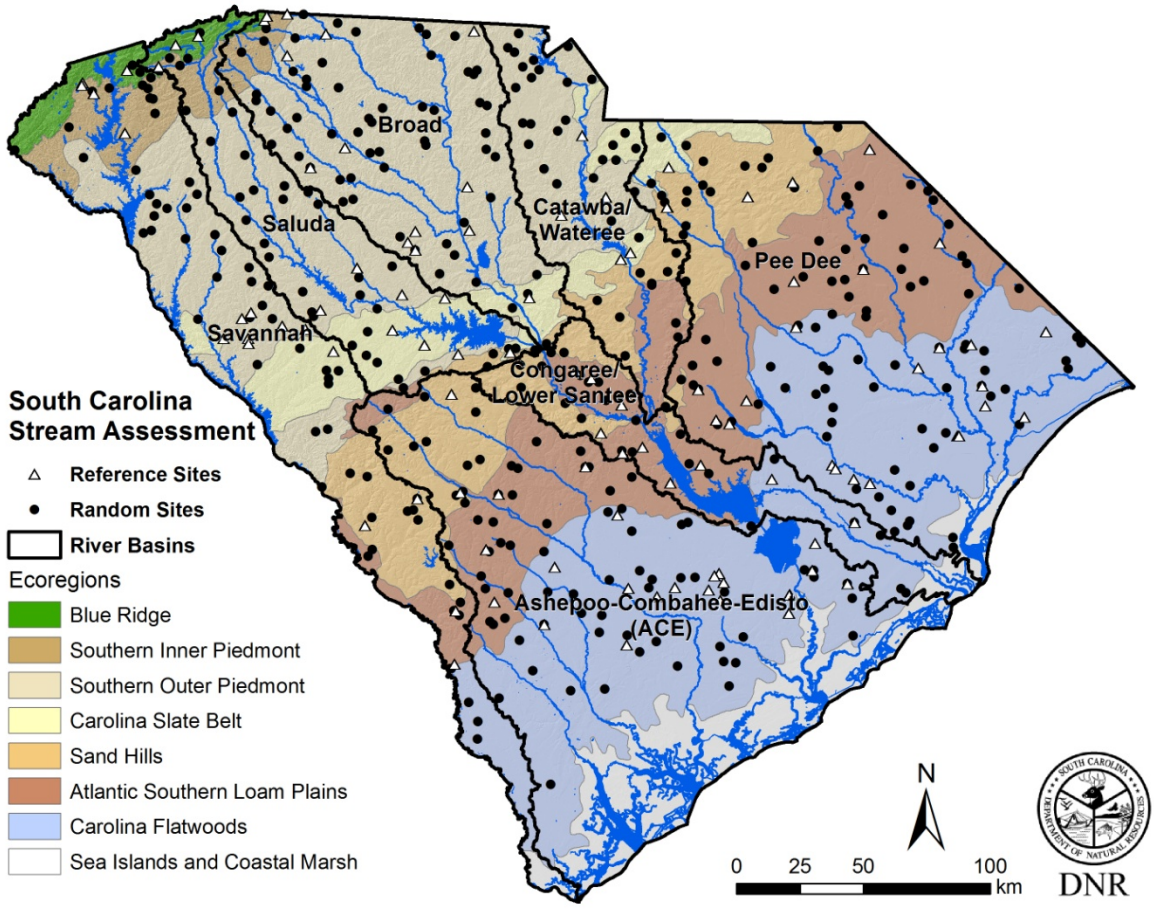
South Carolina Stream Conservation Planning Project [SC Stream Assessment] (Federal Grant #: T-25-R-1 F06AF00027 [formerly T-8], Duration: 2006-2013) PI and Author: Mark Scott, SCDNR; Map created by Kevin Kubach, SCDNR

The objective of this project was to conduct an assessment of wadeable streams to gather appropriate data that will allow SCDNR to design effective and efficient management strategies to protect, conserve, and restore the aquatic resources of the State. Freshwater species worldwide face accelerated extinction rates relative to most other wildlife taxa. The Southeastern US, in particular, has been suffering long-term declines in native species of fish and aquatic invertebrates. SC SWAP species of concern number well over 100 fish, reptiles, amphibians, mussels, crayfish, and snails that are directly dependent on aquatic systems for most or all of their life-stages. Common threats appear in their species accounts, generally associated with pollution from point- and non-point sources. Reversing the decline of native aquatic species requires an understanding of factors that are critical for maintenance of suitable habitat capable of supporting sensitive taxa. It follows that we must also understand the threats that degrade the quality of aquatic habitats to the point where they no longer support vulnerable species. The South Carolina Stream Assessment was designed to provide information to fill these gaps.

Watersheds of appropriate size (4 km^2 to 150 km^2) were sampling units stratified by unique combinations of ecoregion and major river basin in the state, called "ecobasins". Two methods of watershed selection were employed. The first method established long-term annual monitoring of least-impacted, or reference, watersheds, identified by biologists familiar with the region. This method is intended to provide expected resource condition as well as range due to temporal variability. The second method employed random selection of watersheds within ecobasin strata to allow statistically defensible estimates of statewide resource parameters from the sample data. Data collection was identical in both sampling designs, occurring at two spatial scales:

- *Watershed* – Point-sources as measured by NPDES permits; non-point sources as measured by appropriate land use/land cover classes in entire basin and within riparian buffer, hydrological disruption as measured by impounded area or occurrence of dams.
- *Stream Reach* – Selected measures of channel geomorphology and flow characteristics, water quality, and vertebrate and invertebrate community structure.

The Stream Assessment project ran from 2006 to 2013, with the data collection phase completed in 5 years and resulting in nearly 700 samples, each of which has over 200 associated variables that reside in an Oracle database titled StreamWeb. Estimates of stream resource condition have been calculated and mapped, and a number of publications and presentations have been produced to communicate various aspects of these data and results.



Habitat Improvement for Grassland Birds (Federal Grant #: T-27-R-1, Duration: 2006-2012)
PI: Tim Ivey; Author: Brett M. Moule, SCDNR

The goal of this project was to improve grassland bird habitat on Oak Lea Wildlife Management Areas (WMA), Bland Tract WMA, and Tuomey Tract WMA by developing and implementing various management strategies (e.g. burning, mowing, disking; creating fallow buffers and fallow fields; establishing longleaf pine and native grasses) and monitoring bird population responses. Over the course of the grant period, 496 acres were winter disked to improve brood rearing and songbird habitat. In order to improve native grass habitat, 1,247 acres were burned while 2,095 acres were disked, fertilized, and planted to enhance forage for dove, quail, and migratory songbirds. Fallow buffer areas totaling 410 acres were maintained. Soft mast seedlings (6,200) and hardwood mast trees (400) were planted.

Fall quail covey counts were conducted on Oak Lea WMA, Bland Tract WMA, and Toumey Tract WMA in either October or November each year. Survey points were established on all 3 tracts, and summer quail and songbird surveys were conducted in July. These call counts were continued annually to monitor the impacts of management activities on quail and grassland birds. Dove banding was conducted each year as part of the Eastern Management Unit project. Quail

banding occurred the first year with walk-in trap sites to monitor impacts of hunting on the population.

Taxonomy, Life History, and Distribution of the Crayfish, *Procambarus echinatus* (Federal Grant #: T-30-R, Duration: 2007-2008) PI: William Poly (formerly SCDNR); Author: Jim Bulak, SCDNR

The goals of this project were to examine the distribution, abundance, life history, and taxonomic status of the Edisto crayfish (*Procambarus echinatus*), a crayfish species of conservation concern. Surveys were made in the Salkehatchie, Edisto, Ashepoo, and Coosawhatchie River drainages. Detailed, quantitative sampling was conducted at 3 specific sites within these drainages. Collections indicated that *P.echinatus* was common in the study area, suggesting the perceived rarity of the species was associated with limited sampling for crayfish in these systems. The habitat for this species was undercut banks with root masses and accumulations of leafy debris in areas of good flow. Collections indicated that a new, distinct species, similar to *P. echinatus*, may be found in the South Edisto River and its tributaries as there was a substantial difference in the size of the structure of reproducing adults. This species was found in similar habitat to *P.echinatus.* Some concern exists that continued population expansion in Aiken County could impact the South Fork Edisto River crayfish. Additional monitoring of this perceived new species is recommended.

Assessing Introgressive Hybridization Within and Habitat Requirements of Native South Carolina Redeye Bass (Federal Grant #: T-31-R, Duration: 2007-2012) PI and Author: Jean Leitner, SCDNR

A survey was conducted to assess genetic impacts of Alabama Bass (*Micropterus henshalli*) introductions to Redeye Bass (*M. coosae*) in the Savannah Basin. Analysis was completed for N=669 Black Bass collected in 2004, and N=632 black bass collected in 2010 from reservoir sites on Lakes Russell, Hartwell, Keowee and Jocassee. Species composition was compared, and showed a precipitous decline in Redeye Bass collected from 2004 to 2010. Our 2004 survey indicated redeye bass had been virtually eliminated from Lakes Keowee and Russell, where they comprised 0% and 2% of black bass collected, respectively. Collections in 2010 show little change in Redeye Bass proportions from these two lakes, but a decline is evident in Lakes Hartwell (from 26% to 8%) and Jocassee (from 39% to 14%). Hybrids between the two species were prevalent in collections and ranged across years/reservoirs from 26% to 54% of black bass collected. Proportions of hybrids increased from 2004–2010 on all but Lake Russell.

Genetic analysis of black bass collected from Savannah basin tributaries in 2009 and 2010 confirmed non-natives and/or hybrids from 5 of 9 collection sites, and from at least one tributary associated with each of 3 reservoirs. Three of these collections represent new documentation of Alabama Spotted Bass hybrids, as we collected only native black bass from those sites in 2004. The potential for the spread of Alabama Spotted Bass and their hybrids from the reservoirs to additional tributary populations is indicated. A new incidence of the non-native Smallmouth Bass (*M. dolomieu*) and their hybrids was documented in the Savannah River, as was the presence of an extant Redeye Bass population throughout the Enoree River in the Santee drainage.

A GIS database was developed that includes all Savannah and Santee basin black bass collections associated with this study (2004–present), all Savannah and Santee Basin South Carolina DNR stream team collections made within the range of Redeye Bass (2008–present), and all historic South Carolina stream database collections that include record of Redeye Bass (1962–2002). The spatial distribution of tributary collections that included hybrids between Alabama Bass and Redeye Bass provides important information with respect to the spread of non-native black bass alleles in the Savannah Basin. Tributary populations where hybrids have been collected were those in closest geographic proximity to the reservoirs, within which non-native alleles are already widespread. Our results indicate that the spread of Alabama Bass alleles into the sampled tributary populations is the result of upstream movement from the reservoirs.

New genetic assays for the mtDNA locus ND2 were successfully developed. ND2 is one of 4 loci used to differentiate the species of black bass found, or having genetic influence in South Carolina populations. Previously, sequencing of all loci was necessary to classify individual fish as a particular species or hybrid. Primers were designed for haplotypes specific for Largemouth Bass (*M. salmoides*), Florida Bass (*M. floridanus*), Alabama Bass, Redeye Bass, and Smallmouth Bass. These new assays provide a new tool, less expensive and time consuming than sequencing, for the evaluation of hybridization among black bass in South Carolina.

In an effort to assess the status of Redeye Bass in the Santee drainage as native or introduced, species of minnow were collected from sites within the Santee, Tennessee (French Broad), and Savannah River drainages. Genetic divergence among drainages, and diversity within drainages, was compared to that for Redeye bass in the Savannah and Santee drainages. The Santee population of Redeye Bass is not genetically differentiated from populations collected throughout the upper Savannah River drainage. In contrast, Saffron and Warpaint Shiner populations collected in the Savannah and Santee drainages are significantly differentiated from each other. Pair-wise comparisons between individuals sampled from these 2 drainages, for 2 loci, were significantly differentiated. Results indicate that the Santee Basin Redeye Bass populations evaluated here are the result of a more recent, and likely human-mediated, introduction of fish originating from the Savannah Basin.

Restoring Seabird Nesting on Bird Key Stono Seabird Sanctuary (Federal Grant #: T-32-T-1, Duration: 2007-2008) PI and Author: Felicia Sanders, SCDNR

Bird Key Stono Seabird Sanctuary is an estuarine sandbar that provides nesting, roosting, and foraging habitat for a variety of seabirds and shorebirds. From the late 1980s–1994, it was the largest Brown Pelican rookery in North America. Isolated sand islands, such as Bird Key, make ideal nesting habitat due to the lack of mammalian predators such as raccoons. Bird Key was designated as a Seabird Sanctuary in March 2006 because of its importance as a seabird nesting island and because seabirds were declining probably due to human disturbance. The "sanctuary" status limited human disturbance on the island. This project used social attraction to decoy seabirds to Bird Key in efforts to increase the number of birds nesting on the island. Social attraction is a combination of decoys and a sound system. The sound system is a solar-powered audio system which continuously plays the calls of nesting seabirds.

Unpainted 122 Royal Tern, 52 Black Skimmer, and 32 Least Tern decoys were purchased and shipped to Huntington State Park. Horry County school children painted the decoys as part of an educational program about seabirds. At the beginning of the nesting season, Least Tern decoys were spaced approximately 1 m apart on Bird Key. Black Skimmer decoys were placed approximately 2 m apart in 2 separate flocks of 26 decoys each. Royal Terns were placed approximately ½ m apart in one colony. The sound system was placed near the Royal Tern decoys. The sound system constantly played Black Skimmer, Least Tern, and Royal Tern calls. Five days after placing decoys on the island, approximately 40 Black Skimmers were roosting with and courting the decoys. Royal Terns and Least Terns were observed roosting with their decoys. The seabirds were mostly unsuccessful due to depredation by a Great Horned Owl although they nested on Bird Key in low numbers. These decoys were used in other projects to attract nesting seabirds and continued to be part of an educational program for school groups.

Robust Redhorse Electrofishing and Radio Telemetry Tracking of the Great Pee Dee River, SC (Federal Grant #: T-33-R-1 F07AF00062, Duration: 2007-2012) PIs: Ross Self, SCDNR and Elizabeth Osier (formerly with SCDNR); Author: Robert Stroud, SCDNR

In late April and early May of 2008, SCDNR Freshwater Fisheries Region 2 personnel met with NCWRC, Progress Energy, Duke Energy, South Carolina Aquarium, and North Carolina Natural History Museum personnel to sample the Great Pee Dee River in NC by electrofishing for spawning Robust Redhorse. Twenty-three Robust Redhorse were collected between 22 April and 8 May 2008, of which 7 were recaptures from previous years, 2 were within year recaptures, and 14 were newly collected fish. All fish were PIT tagged and 10 had new radio tags surgically implanted. The fish ranged from 576 to 766 mm with a weight range of 2,630 to 8,450 grams. All fish were adult and many were ready to spawn.

In October 2008, boat electrofishing was conducted for two days on the Pee Dee River focusing below the South Carolina state line. One Robust Redhorse was collected. In late April and early May of 2009, the survey was conducted above the South Carolina state line using boat electrofishing. The areas targeted were known Robust Redhorse spawning grounds and locations where radio telemetered fish were detected. Twenty Robust Redhorse were collected between 20 April and 7 May 2009, of which 8 individuals were newly collected fish. All fish were PIT tagged and 10 had new radio tags surgically implanted. The fish ranged from 594 to 740 mm with a weight range of 2,986 to 6,660 grams. All fish were adult and many were ready to spawn.

Spring electrofishing for Robust Redhorse was not conducted in the Pee Dee River during or after October1, 2009. At the September 2009 annual meeting of the Yadkin-Pee Dee Technical Working Group of the Robust Redhorse Conservation Committee, it was decided that spring electrofishing would be suspended for 4 to 5 years until minimum flows are established at the Blewitt Falls Hydroelctric Facility.

SCDNR Freshwater Fisheries personnel participated in radio telemetry tracking of previously tagged Robust Redhorse in the Great Pee Dee River in October, November, and December 2007; February 2008; March, April, July and August 2010; and March 2011. In 18 days of tracking during the grant period, 6 different fish were located a total of 22 times in the SC portion of the Great Pee Dee River. Habitat ranged from open channel to along the riverbank, and always in

association with submerged woody debris. Region 2's participation in tracking was not required from March 2008 through July 2009 due to a NC State graduate student having been funded by Progress Energy for the work. Radio telemetry tracking was not performed during 2012 due to the expected expiration of transmitter battery life.

Identification of Diamondback Terrapin Habitats in South Carolina (Federal Grant #: T-35, Duration: 2009-2010) PIs: Erin Levesque (SCDNR), David Whitaker (SCDNR), and Elizabeth Broyles (CofC graduate student); Author: Elizabeth Broyles, College of Charleston

Very little is known about the current population number, sex ratio, and distribution of diamondback terrapin populations in Charleston, South Carolina estuaries. Terrapins were caught in the Ashley River, and population estimates were calculated using mark and recapture techniques and analyzed using the MARK program. Population size was estimated to be 3060 with a 95 % confidence interval of 1,964-4,156. This gives around 179-378 terrapins per km^2 of marsh habitat. The sex ratio was 1.7:1 male biased ($p < 0.001$). Investigations into changes in land usage were used to reveal reasons for change in terrapin abundance in the watersheds of the Ashley River, the Wando River, and the Charleston Harbor from 1995-2009. The number of terrapins caught at all Wando River sites combined significantly decreased during the study period ($r = 0.83$, $p < 0.001$). There has been approximately 12.9 km^2 (10% of 127.72 km^2) of land use change in the Wando River watershed from 1996-2006. Diamondback terrapin abundance, estimated via catch per unit effort, has remained constant for most of the Ashley River and Charleston Harbor areas. Land use change has been minimal ($\leq$ 2%) in both of these watersheds during the same time frame. The Wando River, on the other hand, had a significant decline in terrapin catch per unit of effort (CPUE) and also had a much greater amount (10%) of land use change. Land use can encroach on terrapin habitats and nesting sites as well as impact food and foraging areas. If the declining trend of the terrapin population in the Wando River continues, regulatory intervention may need to be considered. This information on population size, sex ratios, and distribution can be used as a baseline to track long-term changes in terrapin populations. This project produced a Master's thesis entitled, "Diamondback Terrapins (*Malaclemys terrapin*) of Charleston, South Carolina: Population Estimate, Sex Ratios, and Distribution."

A GIS Model to Guide Landscape-scale Restoration at the Woodbury Tract and Hamilton Ridge Properties (Federal Grant #: T-36-HM, Duration: 2008-2010) PI: Steve Bennett, SCDNR (retired); Author: Will Dillman, SCDNR

The purpose of this investigation was to create a GIS-based model of pre-fire excluded landscape patch dynamics and hydrologic change for the Woodberry Tract and Hamilton Ridge properties. At the time of this project, these two properties were recent acquisitions by the SCDNR. Land use histories varied for both properties but included a variety of industrial forestry practices. In developing a Conservation Plan for these properties, the hopes were to (1) restore important ecological processes to the landscape (e.g. fire), and (2) provide habitat structures needed to maximize conservation benefits while using the species composition of the current industrial forest.

The use of GIS and a selection of historical aerial photography of the sites allowed identification of reference forest conditions, and the ability to identify likely locations where remnant fire-maintained landscapes most recently occurred. We were also able to create a GIS coverage identifying former isolated wetlands and a GIS coverage identifying changes in hydrology related to road construction and ditching at the Woodberry Tract and Hamilton Ridge properties. Indices were created to quantify mechanical degradation to the wetland area, provide measures of ecological integrity, and to measure the restoration potential of each wetland, based on time since degradation and current habitat structure, relative to other isolated wetlands in the study area.

Carolina Herp Atlas (Federal Grant #: T-37-T, Duration: 2008-2010) PI: Steve Bennett, SCDNR (retired); Author: Will Dillman, SCDNR

The objective of this project was to develop the Carolina Herp Atlas (CHA) (www.carolinaherpatlas.org) and to provide detailed locality data on the reptiles and amphibians of the Carolinas, in particular those species whose distribution and status are poorly known. The CHA was officially launched in March 2007. Prior to the launch, the Davidson College Herpetology Lab imported approximately 3,900 records, primarily from Mecklenburg, Iredell, and Cabarrus counties in the western Piedmont of North Carolina. From March 2007 through 16 November 2010, the CHA totaled 839 registered users, 91 of which identified South Carolina as their home residence. The CHA received 4,930 reptile and amphibian records from South Carolina. Of the 5,008 records, 912 were accompanied by a voucher photograph and/or given a status of 10. A total of 122 South Carolina reptile and amphibian species have at least 1 record in the CHA. Thus far, the CHA has collected species-level distribution data on 151 species of amphibians and reptiles, including the occurrence of 32 anurans, 29 salamanders, 37 snakes, 11 lizards, 14 turtles, and the American alligator.

The CHA has thus far been a highly successful, citizen science-based project to document the distribution of reptiles and amphibians in South Carolina. The collection of 4,930 reptile and amphibian records in South Carolina (and 16,958 total records submitted from both South and North Carolina) during the first 3.5 years suggests that the CHA has the potential to surpass many other citizen science-based herpetological atlas projects. For example, the Georgia Herp Atlas collected a total of 7,452 records during the 5 years of operation. Thus far, the CHA represents a significant step towards the development of a better understanding of the distributions of reptiles and amphibians in the Carolinas. An overriding goal of the CHA is to promote conservation and understanding of reptiles and amphibians in South Carolina. The interactive nature of the CHA appears to appeal to a wide variety of people, including school teachers, professional herpetologists, and those generally interested in wildlife.

Mink Restoration and Monitoring Development Project (Federal Grant #: T-38-R, Duration 2007-2012) PI and Author Jay Butfiloski, SCDNR

The goal of this project was to develop a monitoring program that would minimize staff time and effort by establishing alternative methods of mink survey techniques to be used to monitor the success of mink restoration along the coast of South Carolina. Track boards appeared to have the most promise as the boards could be set out and checked at a later date using one person.

However, many of the same issues that previously plagued track board work such as tidal fluctuations, wave action, and other environmental factors hampered track board implementation. Once again, track boards were dismissed as a feasible tool in this instance. Previous mink survey work depended on spotlight surveys that required significant high tides occurring a few times per year. The exact heights of these tides were undetermined as to which would be sufficiently high enough for survey work, often leading to poor surveys and wasted manpower. Thus, emphasis was placed on perfecting spotlight surveys in an effort to evaluate which environmental factors were most significant in surveying mink. The project determined that tide heights 6.05 ft. above Mean Lower Low Water (MLLW) level as measured at the Charleston station and adjusted for local areas was the best predictor for when to use spotlight surveys.

During the course of this study, two family groups of mink (5 total) were relocated into the Hog Inlet portion in the northernmost coastal march in the State. This area was the last remaining significant portion of coastal marsh where mink had not been reintroduced. Moving captured mink to this marsh would be the last location along the coast where mink needed to be reintroduced to complete mink reintroduction that was begun in the late 1990s. However, during the course of this project, mink depredation in the original mink restoration site of Cape Romain National Wildlife Refuge (CRNWR) became a concern for refuge staff. As the reintroduced mink into CRNWR began to thrive, concerns from staff at the refuge centered on the impacts mink may be having on nesting shorebirds. Therefore, much of the emphasis of this project became the assessment of reintroduced mink impacts in the original reintroduction site.

A total of 9 mink were implanted with transmitters to assess impacts their activity may be having with other species. Radioed mink did not venture far from initial capture sites and most of their activity appeared to be tide dependent. In addition, diet analysis from mink taken from the CRNWR in an effort to increase shorebird nesting success found that out of 45 mink stomachs collected, 7.4 % contained avian material of unknown species. A bioenergetics model developed from this estimated that an individual mink would consume 8.5 avian prey items per month based on the sampled diet. It is still undetermined to what extent mink predation is affecting shorebird success at CRNWR, as other predators and mortality factors still plague nesting efforts on the refuge.

Prescribed Burning Crew for SC Department of Natural Resources Lands (Federal Grant #: T-39-M-1 F08AF0008, Duration: 2008-2013) PI and Author: Tim Ivey, SCDNR

The objective of this grant was to facilitate and increase prescribed burning on Wildlife Management Areas and Heritage Preserves for wildlife habitat enhancement. SCDNR contracted with the South Carolina Forestry Commission to perform the fire management activities of the grant. During 2009, growing season prescribe burning was conducted on 8 DNR properties. A total of 3,830 acres were prescribe burned and 49.25 miles of firelanes were disced. During 2010, dormant and growing season prescribe burning was conducted on 18 DNR properties. A total of 10,312 acres were prescribe burned and 81.15 miles of firelanes were disced. During 2011, dormant and growing season prescribe burning was conducted on 23 DNR properties. A total of 7,906 acres were prescribe burned and 120.9 miles of firelanes were disced. During

2012, dormant and growing season prescribe burning was conducted on 19 DNR properties. A total of 6,322 acres were prescribe burned and 44.65 miles of firelanes were disced.

Conservation of Belfast Plantation, Phase II (Federal Grant #: T-40-L, Duration: 2009-2010) Author: Emily Cope

SCDNR utilized $1,188,654 from the USFWS (of which $1,063,654 was Wildlife Restoration funding and $125,000 was State Wildlife Grant funds) to acquire the southern half of the Belfast Tract totaling 2,436 acres (also known as Belfast Phase II). The total land acquisition cost for Phase II was $7,710,440. This completes the Belfast acquisition project by protecting a total of 4,664 acres. The Belfast Tract has long been managed to support a diverse range of wildlife species. The hardwood drains, creeks, and beaver ponds support waterfowl management objectives. In addition, the age-class diversity of the pine stands provides valuable wildlife habitat. The property supports excellent populations of deer and turkey, and the uplands provide excellent habitat for Bobwhite Quail. Improved timber thinning and a more aggressive prescribed burning regime will increase the already existing quail population. This will expand the ongoing efforts on the nearby Sumter National Forest to increase the Piedmont quail population. Mudlick Creek, the beaver ponds, and the man-made pond provide many fishing opportunities for sunfish and bass.

The property provides habitat for many priority bird species such as Acadian Flycatcher, American Woodcock, Great Blue Heron, Kentucky Warbler, Little Blue Heron, Louisiana Waterthrush, Rusty Blackbird, Wood Duck, Wood Thrush, and Yellow-crowned Night Heron. The wetlands associated with the river corridor and its tributaries provide habitat for many reptiles and amphibians including but not limited to the black swamp snake, common snapping turtle, and yellow-belly turtle. Little River, which traverses the Belfast Tract and is the Southern boundary for Phase I, is comprised of Carolina Slatebelt geology. This specific geology is known to be associated with the federally-endangered mussel, the Carolina heelsplitter. While initial survey work has not detected the heelsplitter on the Belfast Tract, it has been located in the nearby area. Further survey work could find the heelsplitter on the tract or the tract may also serve as a restoration/reintroduction area for the species. In addition, several rare species of burrowing crayfish have been found in nearby areas.

Use of GIS to Assess the Demographic Isolation of Red-Cockaded Woodpecker Groups in SC (Federal Grant # T-42-R-1, Duration: 2008-2009) PI: Jason Craig and Drew Lanham (Clemson University); Author: Derrell Shipes, SCDNR

This project was sub-contracted to Clemson University. Jason B. Craig (graduate student) and Dr. J. Drew Lanham were the Principal Investigators and Ralph Costa and Dr. Robert Baldwin were collaborators. Eight km (5 mi.) and 25 km (15.5 mi.) radius circles were drawn around known active and inactive Red-Cockaded Woodpecker (RCW) cluster locations in SC in an effort to determine the occurrence of Demographically Isolated Groups (DIGs). These analyses concluded that there are 20 isolated clusters using 8 km (6 active, 14 inactive) and 3 isolated clusters using 25 km (1 active, 2 inactive). Habitat evaluation associated with isolated and non-isolated clusters was conducted. The concept of "isolation" and the location of isolated clusters are essential to the future management of this endangered species. It may be necessary to

relocate isolated birds to larger populations in order for the relocated birds to reproduce and contribute genetically. There is a tendency for isolated clusters with small numbers of birds to "blink out".

Least Tern Reproductive Success on Roof-tops (Federal Grant # T-44-R-1, Duration: 2008-2010) PI: Felicia Sanders, SCDNR; Author: Mary Catherine Martin, SCDNR

Nesting of Least Terns (*Sternula antillarum*) on flat, gravel-covered roofs was followed at colony sites in Georgetown and Horry Counties in coastal South Carolina. Colony success and failure were documented. Incubation duration was determined at 5 roof colony sites by encasing temperature data loggers in clay eggs. Successful colonies were characterized by incubation temperatures at a constant range except for periods of heavy rainfall, while unsuccessful colonies had incubation temperatures with cooling ranges of 14-20°C (57-68°F) that occurred at night with repeated nest abandonment attributed to possible predators. Movements of fledged Least Terns were tracked by attaching radio transmitters to the legs of the young. Injuries resulted from the transmitter attachments complicating methods of this part of the study. A very limited number of fledged Least Terns were tracked and results were inconclusive. An assessment of fish samples found at colony sites indicated that the more inland the site, the more freshwater fish species present. In addition, observations indicated that adults and fledged young foraged at sites within a 5-10 km (3-6 mi.) radius from the colony site. Inland storm water retention ponds have become a valuable foraging site for Least Terns. Finally, eggs from colony sites were tested for heavy metal contaminants usually found in storm water retention ponds. No contaminants were present in amounts detrimental to hatching or the development of young.

American Shad Culture and Stocking in the Edisto River (Federal Grant #: T-45-R-1, Duration: 2008-2011) PI and Authors: Bill Post and Chad Holbrook, SCDNR

Historically, the Edisto River in SC had one of the State's larger American Shad fisheries. Overfishing between the 1940s to1980s lead to a dramatic decline in shad landings and decreased abundance over time. These declines lead to added restrictions to the shad fishery beginning in 1998. More recently, in an effort to augment wild production, South Carolina Department of Natural Resources (SCDNR) and the United States Fish and Wildlife Service (USFWS) formed a partnership to create a hatchery program. Over a 4-year period (2008-2011), the feasibility of on-river broodfish collections, hatchery production, young-of-year relative abundance, annual hatchery contribution, movements of adult American Shad, genetic analysis of stock enhancement, and genetic uniqueness were evaluated for the Edisto River population. Collecting broodfish using electro-fishing gear proved to be successful with 347 adult American Shad caught over 3 years of sampling. Of the 347 collected fish, 235 have been used as broodfish; 92 had fin clip samples taken, were implanted with acoustic tags, and returned to the river; and the remaining 20 had fin clip samples taken and were returned to the river.

Collection efficiency of adult American Shad improved each year allowing us to increase the number of broodfish used each year as well as balancing the male/female ratio (2009 N=63; M 51, F 12; 2010 N=75; M 48, F 27; and 2011 N=97; M 57, F 36). Annual egg production has been variable and variability was independent of the number of females collected (2009 – 205,238; 2010 – 600,987; and 2011 – 184,677). From 2009-2011 a total of 39,688 fry were released,

ranging from a high in 2010 of 22,209 to a low in 2011 of 4,836. Out-migrating young-of-the-year American Shad were successfully sampled with electrofishing gear in 2010 (601) and 2011 (1,291).

All collected fish were kept to determine hatchery contribution via OTC detection and genetic detection using microsatellite markers. Detection rates for hatchery fish varied between the two methods with OTC indicating a hatchery contribution of 6.8% in 2010 and 0.3% in 2011, while genetic testing indicated a hatchery contribution of 3.6% in 2010 and 0.0% in 2011.

Additionally, this project provided the opportunity to generate baseline genetic data which had not previously been determined for this stock, finding that genetic diversity for the Edisto River American Shad population is high. An initial evaluation of our stocking program detected no difference in genetic composition between the broodstock and field collections in any of our production years ($p>0.692$), indicating the appropriateness of our broodstock collection process in minimizing potential negative impacts of stocking on the wild population. However, significant spatial genetic differentiation was detected between the Santee River and Edisto River ($X^2=\infty$, $p=0.000$). Therefore, broodstock for stock enhancement purposes in the Edisto River should originate only from the Edisto River itself.

Our study was a comprehensive look at the potential of using responsible stock enhancement as an effective management tool. Broodfish collections and hatchery production was a success; however we hope to improve fry/egg ratio with more experience. Telemetry results were somewhat inconclusive; however, it did appear mature shad were congregating in areas near Givhans Ferry State Park around river mile 60. Young-of-the-year collections improved throughout the study and were efficient in 2010 and 2011. Although contribution was relatively low, we were able to detect hatchery individuals in the Edisto River population prior to out-migration. The results of this project, along with future work, will provide valuable information which can be incorporated into management plans to aid in the recovery of this important species in the Edisto River in South Carolina.

Conservation of Breeding Painted Buntings and Other Songbird Indicators in Early-Successional Shrub-Scrub Habitat (Federal Grant #: T-47-R-1 F08AF00109, Duration: 2008-2011) PI: Derrell Shipes, SCDNR; Author: Mary Catherine Martin, SCDNR

Objectives of this study were to determine: (1) abundance of breeding Painted Buntings (*Passerina ciris*) and other indicator songbird species in paired CP-33 and non-CP-33 fields; (2) nest location and success of Painted Buntings in paired CP-33 and non-CP-33 fields; and (3) a landscape/GAP analysis model which tracks seasonal crop rotation and predicts a pattern of habitat occupancy and breeding distribution of Painted Buntings and other early-successional shrub-scrub songbird species. CP-33 is a conservation program established by the Department of Agriculture to provide habitat for upland birds through landowner incentives to plant native grass buffers along row crop field margins.

Eight fields of 4 CP-33 and 4 non-CP-33 were study sites. In each field, habitat types were classified as agriculture, forest, CP-33 border, and cut (recently cut forest area). To determine the abundance of Painted Buntings, 3 survey types were utilized: spot maps, transect counts, and

telemetry. The results of each type of survey indicated more Painted Buntings and other species were found in mature (≥ 10 years of growth) forest edges than in any other habitat, and there was no difference in species abundance between CP-33 and non-CP-33 fields. In addition, vegetation data gathered per protocols developed by the Breeding Biology Research and Monitoring Database (BBIRD) in the forested edges of agricultural fields, in the CP-33 strips, and in the crop fields indicated that wheat is preferred forage by Painted Buntings. Second, 3 types of fields (paired CP-33, non-CP-33, and a field managed for doves) were searched for Painted Bunting nests. Twenty-two nest sites were found in forest edge habitat, and none were found in the CP-33 and dove field habitats.

Finally, a landscape/GAP analysis map was created from the data obtained in the spot map, transect count, and radiotelemetry surveys. Results of the landscape/GAP analysis map indicated high priority habitats as: 25 m or less from the edge of mature forest; CP-33 strips, wheat fields, and early growth forests (≤ 10 years of growth) for foraging; and use of CP-33 strips, all agricultural fields, and early growth forests by Painted Buntings was limited to the edges of these habitats. Based on the completion of the study objectives, recommendations for Painted Bunting conservation in central rural South Carolina are: (1) mature forest edge habitat is essential; (2) painted buntings prefer to occupy and nest in the outermost edges of forests and/or thin forest strips (25 m or less from the edge); and (3) a source of food in the form of a wheat field or other grass seed as well as a source of insects when rearing young is necessary.

Effects of Predation on Seabird Nests in Cape Romain (Federal Grant # T-48-R, Duration: 2009-2010) PI and Author: Felicia Sanders, SCDNR

The goal of this project was to monitor seabird nesting in Cape Romain National Wildlife Refuge to guide management that can benefit seabird species nesting at natural sites. Nesting chronology, reproductive success, and causes of colony abandonment and nest loss were documented for Least Terns and Black Skimmers in 2009-2010. Although species of conservation concern, little is known about the reproductive success of Least Terns and Black Skimmers throughout the Southeastern US.

Nest monitoring occurred at Raccoon Key, Lighthouse Island, Middle White Banks, and Cape Island. Each island was checked every 2-7 days depending upon weather and logistical constraints. Least Tern and Black Skimmer nests were randomly selected across all 4 study sites. Nests were marked by wooden stakes 0.5 m from the nest scrape. Eggs were floated to estimate initiation date. At each visit, researchers recorded the number and condition of eggs or young and when possible, and determined the cause of failure by visual observation. Chick survival was determined at select sites by banding 1-2 day-old chicks with a unique, 2-color leg band combination. Researchers conducted re-sighting surveys every 2-4 days for Least Terns until no fledglings were observed. To determine the minimal survival of Black Skimmer chicks, an island-wide fledgling count was conducted at the end of the season.

Peak nesting for Least Terns occurred from mid-May to mid-June and for Black Skimmers in mid-June. Predation and over-wash were the primary cause of nest failure based on visual cues at or near the nest. Collectively, these ecological stressors attributed to 65% of nest loss for Least Terns and Black Skimmers. Video cameras installed at colonies documented disturbance to

colonies by Black Vulture, American mink, and Great Horned Owl. Of the 60 Least Tern chicks monitored, 13 (22%) were re-sighted at ≥ 17 days post hatch. Of the 52 Black Skimmer chicks monitored, 22 (42%) were re-sighted at ≥ 28 days post hatch. Nest success of Least Terns and Black Skimmers within CRNWR was variable among colonies and between years, suggesting that factors at the local level influenced reproductive success. Management techniques within the study area directed toward predator control to decrease nest loss of near-shore seabirds and shorebirds needs to focus on both the avian and mammalian predators identified in this study in order to be effective.

Ecology and Impacts of Coyotes on Loggerhead Sea Turtles, Least Terns, and Other Wildlife: Implications for Management (Federal Grant #: T-51-R-1 F09AF00159, Duration: 2009-2011) PI and Author: Jamie Dozier, SCDNR

Control of abundant mammalian predators is a common element of management programs aimed at increasing reproductive and recruitment success of many threatened ground-nesting turtle and bird species. Recent colonization of coyotes (*Canis latrans*) in South Carolina, however, is changing traditional community dynamics governing and impacting wildlife populations in coastal and barrier island systems. Coyotes have become a major nest predator on federally threatened loggerhead sea turtles (*Caretta caretta*) having devastating impacts on nest survival. For example, in 2009 on the Tom Yawkey Wildlife Center Heritage Preserve (TYWCHP) in Georgetown, South Carolina, extensive coyote depredation on turtle nests was documented with over 50% (21 of 40 nests; 1,208 eggs) of loggerhead sea turtle nests either completely or partially destroyed. The purpose of this project was to attempt to understand coyote ecology and impacts at the TYWCHP as it relates to loggerhead sea turtle and least tern nesting success. A major portion of the study attempted to examine coyote home range, habitat use, and diet composition on the island complex.

A total of 8 coyotes were trapped and fitted with radio-transmitters during the study period. Unfortunately, a combination of equipment failure and extreme difficulty in locating collared coyotes provided a low sample size of locations and data unreliable to support any reasonable estimations of coyote home range, movements, or habitat use on TYWCHP. Over 400 coyote scat samples were collected during the study periods on TYWCHP; 370 samples were usable for analysis. A total of 234 scats were collected on Cat Island and 136 on South Island. *Sigmodon* spp. were the most common food item found in Cat Island scats, followed by birds, vegetation, and *Peromyscus* spp. Birds were the most common item found in South Island samples, followed by *Sigmodon* spp., vegetation, and *Neotoma* spp. Cat Island samples comprised a larger percent of scats containing wild hog, lagomorphs, *Diospyros* spp., and soricomporphs, while South Island samples contained more birds, crabs, *Mephitis mephitis* (striped skunk), and mustelids. There was a significant difference between coyote diet on the two islands ($A = 0.0090$, $p < 0.0001$). Test results yielded significant indicator values for three animal groups and one plant genus (birds, lagomorphs, wild hogs and *Ilex* spp.). Although birds were a component of coyote diets, samples did not provide enough evidence to determine which species of birds or age class. Observation of Least Tern nesting colonies did not reveal coyote presence during the study period.

An additional component added to the project was the question of coyote impacts on mesopredators, in particularly raccoons, in suppressing depredation/predation on prey items. Three experiments were conducted to examine coyote-raccoon interactions: 1) space use of radio-collared raccoons (10-18) to test avoidance of coyote urine, 2) avoidance of captured raccoons (8) in enclosures to coyote scat, and 3) avoidance of free-ranging raccoons to monitored feeding sites containing coyote scat. Summary results of all 3 experiments revealed that raccoons did not avoid areas where coyote presence was artificially induced; therefore, this suggested that the threat of coyotes was not a deterrent in raccoon use of areas in space and time. From a management perspective, the most significant finding was from a companion study conducted on TYWCHP during the same time period as this study revealing that selective trapping of coyotes and beach night patrols significantly reduced coyote depredation of sea turtle nests from 52% in 2009 to 15% in 2010.

Monitoring Impacts of Yellow Pine Restoration on Avifauna in the SC Mountains (Federal Grant #: T-54-R-1 F10AF00443, Duration: 2010-2013) PIs: Curtis Walker, M.S. and J. Drew Lanham, PhD [Clemson University]; Author: Mark Hall, SCDNR

Note: The thesis name of this project is *Avian Community Response to Prescribed Fire in Yellow Pine Stands in the Jocassee Gorges Region of South Carolina*.

Comparisons of avian communities were made between the burned treatment sites and reference control sites to examine community and priority species response to prescribed fire in the Jocassee Gorges in the mountains of SC. To assess the impacts of fire disturbance management on the avian community, 10-minute, 50 m radius point counts were conducted in treatment and control plots during the spring breeding seasons of 2011 and 2012. Values of species diversity, richness, and total number of individuals were found to be significantly higher in the burned treatment plots than in the control plots as a result of differences in structural complexity and the distribution of resources. The occurrence of focal species, as well as other species, was found to vary between sites. Species associated with early-successional and more open habitats—such as Eastern Wood-Pewees and Indigo Buntings—were observed more often in burned sites, while species requiring shrubbery and broad-leaved foliage on which to forage—such as Black-throated Green and Hooded Warblers—were observed more often in control sites. Models created using structural vegetation data identified characteristics of vegetation and landform that were found to be useful in predicting the occurrence of 6 of the 7 priority species at Jocassee. Differences in the occurrence of nesting and foraging guilds were related to differences in complexity of habitat structure and composition. This research suggests that fire management can be a useful tool to create wider variation across the landscape, providing increased opportunities for nesting and foraging resources for an array of bird species.

Using Citizen Science in the Study and Conservation of Breeding Painted Buntings (Federal Grant #: T-55-R-1 F10AF00444, Duration: 2010-2012) PIs: John Gerwin, NCNMS; Author: Derrell Shipes, SCDNR

This project was sub-contracted to Dr. John A. Gerwin of the North Carolina Museum of Natural Sciences in Raleigh, North Carolina. Collaborators included Dr. Jamie Rotenberg of the

University of North Carolina – Wilmington and Laurel Barnhill formerly of SCDNR, now USFWS, Athens, Georgia.

Painted Buntings (PABU) were banded at 45 sites during 135 banding sessions across NC/SC including 15 in NC, 15 in Coastal SC, and 15 in "interior" SC. Birds were banded with a unique USFWS aluminum band on one leg and a unique combination of 3 plastic color bands on the other leg. Age, sex, and breeding condition was determined and recorded. An internet-based reporting system for reporting of sighted birds was developed, and reporters were recruited using workshops, short newspaper articles, word of mouth and through the website. Volunteers were encouraged to report sightings of birds—banded and un-banded—to the website. A total of 1,379 PABUs (454 females, 395 males, 231 unknown) were captured and banded in South Carolina. Following banding, 34,705 reports of PABUs—banded and un-banded—were received at the website. Researchers found that PABUs appear to survive an average of 5-6 years and appear to exhibit philopatry. They did not find an over-abundance of Brown-headed Cowbirds at the feeder sites or in agricultural areas nearby. Habitat preference, management guidelines, and productivity information is contained in the larger report of the project.

Decision Support Tools for Stream Conservation (Federal Grant #: T-61 F12AF01417, Duration: 2012-2013) PI and Author: Mark Scott, SCDNR

Identifying and communicating the relationships between natural gradients, human activities, and aquatic habitat integrity is crucial to aquatic conservation. The South Carolina Department of Natural Resources (SCDNR), in conjunction with Clemson University, has developed a novel, web-based South Carolina Stream Conservation Planning Tool that enables a spatially explicit understanding of how human activities affect the biological condition of wadeable streams. This is intended to support decisions about aquatic conservation actions. The web mapping application communicates findings from the South Carolina Stream Assessment (SCSA) to a broad audience, allowing users to visualize predicted biological conditions based on their status and severity across all South Carolina wadeable stream catchments. Additionally, an interactive catchment management tool allows users to explore and forecast the impacts of customized land management scenarios on aquatic resource indicators at any user-specified location across South Carolina, and so engages users in the process of modeling and forecasting stream conditions.

We selected stream condition metrics from over 200 measurements taken at approximately 700 streams locations sampled during the SCSA from 2006 to 2011. Metrics were related to spatial predictor data created under the National Fish Habitat Assessment. We generated prediction models using the Random Forest machine-learning technique from the sample data, and applied the predictions to the entire population of wadeable stream reaches in the State. The mapping application provides users with a browser-based interface to modify predictors at the catchment (local) scale. A web service dynamically generates predictions based on these user inputs, and results are mapped at watershed (network) scales to display cumulative effects of the changes. The dynamic execution of models broadens the utility of the application and opens the forecasting process to a non-technical audience. By providing an accessible means of forecasting the effects of management decisions, the tool encourages a watershed perspective towards aquatic conservation. The application is targeted to stakeholders at the policy making and

conservation planning levels. The approach described has been set up for South Carolina but is applicable to assessment programs at the regional and national levels.

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Appendix 1-A Terrestrial Priority Species and Their Ecosystems

						BLUE RIDGE ECOREGION										PIEDMONT ECOREGION									SANDHILLS ECOR					
						Appalachian Oak Forest	High Elevation Forest	Low Elevation Basic Mesic Forest	Low Elevation Acidic Mesic Forest	Rock Outcrops	Bottomlands and Riparian Zones	Depressions	Wet/Moist Unique Landforms	Streams/Rivers/Lakes	Grasslands/Early-Successional	Upland Pine Forest	Mesic Forest	Rock Outcrops	River Bottoms	Piedmont Small Stream Forest	Cove Forest	Depressions	Streams/Rivers/Lakes	Grasslands/Early-Successional	Sandhills Pine Woodlands	Mesic Forest	Rock Outcrops	Blackwater Stream Systems	River Bottoms	Depressions
SCIENTIFIC NAME	**COMMON NAME**	**G-RANK**	**S-RANK**	**LEGAL STATUS**	**PRIORITY**																									
MAMMALS																														
Condylura cristata	Star-nosed Mole	G5	S3?	Of concern, State	High	X						X	X						X										X	X
Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	G3/G4	S2?	State Endangered	Highest	X	X	X	X	X																		X	X	X
Eptesicus fuscus	Big Brown Bat	G5	SNR		Highest	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Eubalaena glacialis	North Atlantic Right Whale	G1	SNR	Federal and State Endangered	High																									
Kogia breviceps	Pygmy Sperm Whale	G4	SNR	Of concern, State	High																									
Kogia sima	Dwarf Sperm Whale	G4	SNR	Of concern, State	High																									
Lasionycteris noctivagans	Silver-haired Bat	G5	SNR		Highest	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X			X	X				
Lasiurus borealis	Red Bat	G5	SNR		Highest	X	X	X	X		X	X				X	X		X	X	X	X			X	X		X	X	X
Lasiurus cinereus	Hoary Bat	G5	S?		Highest	X	X	X	X		X	X	X			X	X		X	X	X	X			X	X		X	X	X
Lasiurus intermedius	Northern Yellow Bat	G4/G5	S?	Of concern, State	Highest																								X	
Lasiurus seminolus	Seminole Bat	G5	SNR		Highest											X	X			X		X			X	X		X	X	X
Megaptera novaeangliae	Humpback Whale	G4	S1	Federal and State Endangered	High																									
Microtus pennsylvanicus	Meadow Vole	G5	SNR	Of concern, State	High	X							X		X									X						

Mustela vison	Mink	G5	SNR		High						X								X	X								X	X	X
Myodes gapperi carolinensis	Carolina Red-backed Vole	G5	S2/S3	Of concern, State	High	X	X	X	X		X		X																	
Myotis austroriparius	Southeastern Bat	G3/G4	S1	State Threatened	Highest																						X		X	X	X
Myotis leibii	Eastern Small-footed Myotis	G3	S1	State Threatened	Highest	X	X	X	X	X	X	X																		
Myotis lucifugus	Little Brown Bat	G5	S3?		Highest	X	X	X	X	X	X	X																		
Myotis septentrionalis	Northern Long-eared Bat	G5	S4	Federally Threatened	Highest	X	X	X	X	X	X	X																		
Napaeozapus insignis	Woodland Jumping Mouse	G5	S4?	Of concern, State	Moderate	X	X	X	X		X		X																	
Neotoma floridana	Eastern Woodrat	G5	S3/S4	Of concern, State	Moderate	X	X	X	X	X					X			X							X	X	X		X	
Parascalops breweri	Hairy-tailed Mole	G5	SNR	Of concern, State	High	X	X						X																	
Perimyotis subflavus	Tri-colored Bat	G5	SNR		Highest	X	X	X	X	X	X	X				X	X	X	X	X	X				X	X	X	X	X	X
Sciurus niger niger	Southern Fox Squirrel	G5	S4	Of concern, State	Moderate											X			X						X				X	
Sorex cinereus	Masked Shrew	G5	SNR	Of concern, State	High	X	X	X		X																				
Sorex hoyi	Pygmy Shrew (Southern)	G5	S3		Moderate	X	X	X	X		X	X	X		X															
Spilogale putorius	Eastern Spotted Skunk	G5	S4	Of concern, State	Moderate	X	X	X	X	X	X																			
Sylvilagus aquaticus	Swamp Rabbit	G5	S2/S3	Of concern, State	High														X	X				X						
Sylvilagus obscurus	Appalachian Cottontail	G4	S3		High	X	X		X	X			X		X															
Trichechus manatus latirostris	Florida Manatee	G2	S1/S2	Federal and State Endangered	Highest																									
Tursiops truncates	Bottlenose Dolphin	G5	S4	Of concern, State	High																									
Ursus americanus	Black Bear	G5	S3?	Of concern, State	Moderate	X	X	X	X	X	X		X		X	X	X		X	X	X	X		X					X	
REPTILES & AMPHIBIANS																														
Alligator mississippiensis	American Alligator	G5	S5	Federal Threatened	Moderate																								X	

Acris crepitans	Northern Cricket Frog	G5	S5	Of Concern, State	Moderate						X	X	X						X	X		X									
Ambystoma cingulatum	Flatwoods Salamander (Frosted)	G2/G3	S1	Federal Threatened; State Endangered	Highest																										
Ambystoma tigrinum	Tiger Salamander	G5	S2/S3	Of Concern, State	Highest																				X	X				X	
Aneides aeneus	Green Salamander	G3/G4	S1	Of Concern, State	Highest	X	X	X	X	X			X																		
Apalone ferox	Florida Softshell Turtle	G5	SNR	State Threatened	High																										
Apalone spinifera	Spiny Softshell Turtle	G5	SNR	State Threatened	Moderate						X								X									X	X	
Caretta Caretta	Loggerhead Sea Turtle	G3	S3	Federal and State Endangered	Highest																										
Chelonia mydas	Green Sea Turtle	G3	SNR	Federal and State Endangered	Highest																										
Chelydra serpentina	Snapping Turtle (Common)	G5	SNR	State Threatened	Moderate						X	X							X	X		X						X	X	X
Chrysemys picta picta	Painted Turtle (Eastern)	G5	S?	State Threatened	Moderate						X	X							X											
Clemmys guttata	Spotted Turtle	G5	S5	State Threatened	High														X	X		X							X	X
Crotalus adamanteus	Eastern Diamondback Rattlesnake	G4	S3	Of Concern, State	High																										
Crotalus horridus	Timber Rattlesnake	G4	SNR	Of Concern, State	High	X	X	X	X	X						X	X							X	X	X			X		
Deirochelys recticularia	Chicken Turtle	G5	SNR	State Threatened	Moderate																										
Democheleys coriacea	Leatherback Sea Turtle	G2	S?	Federal and State Endangered	Highest																										
Desmognathus aeneus	Seepage Salamander	G3/G4	S?	Of Concern, State	High	X	X	X	X		X	X	X																		
Desmognathus folkerstii	Dwarf Black-bellied Salamander	G2	S?		High	X	X	X	X		X		X																		
Desmognathus marmoratus	Shovel-nosed Salamander	G4	S2	Of Concern, State	Highest	X	X	X	X		X		X																		
Eretmochelys imbricata	Hawksbill Sea Turtle	G3	SNR	Federal and State Endangered	Highest																										
Eumeces anthracinus	Coal Skink	G5	S?	State Threatened	Highest	X	X	X	X		X		X																		

Eurycea chamberlainii	Chamberlain's Dwarf Salamander	G4	SNR		Highest												X		X	X	X	X				X		X	X	X
Glyptemys muhlenbergii	Bog Turtle	G3	S1	Federal and State Threatened	Highest							X	X																	
Gopherus polyphemus	Gopher Tortoise	G3	S1	State Endangered	Highest																				X					
Hemidactylium scutatum	Four-toed Salamander	G5	SNR	Of Concern, State	High			X	X		X	X	X				X		X	X	X	X								
Heterodon simus	Southern Hognose Snake	G2	SNR	Of Concern, State	Highest																				X					
Hyla andersonii	Pine Barrens Treefrog	G4	S2/S3	State Threatened	Highest																									X
Hyla avivoca	Bird-voiced Treefrog	G5	S5	Of Concern, State	Moderate																									
Kinosternon baurii	Striped Mud Turtle	G5	S?	Of Concern, State	Moderate																							X	X	X
Lampropeltis triangulum	Milk Snake (Eastern)	G5	S2	Of Concern, State	Highest	X	X	X	X		X				X															
Lepidochelys kempii	Kemp's Ridley Sea Turtle	G1	S?	Federal and State Endangered	Highest																									
Malaclemys terrapin	Diamondback Terrapin	G4	S?		High																									
Micrurus fulvius	Coral Snake (Harlequin)	G5	S2	Of Concern, State	Highest																				X	X				
Nerodia floridana	Florida Green Watersnake	G5	S2	Of Concern, State	Highest																									
Ophisaurus attenuatus	Slender Glass Lizard	G5	S4		Moderate	X									X	X								X	X	X				
Ophisaurus compressus	Island Glass Lizard	G3/G4	S1/S2	Of Concern, State	Highest																									
Ophisaurus mimicus	Mimic Glass Lizard	G3	SNR	Of Concern, State	Highest																									
Pituophis melanoleucus	Pine Snake (Northern)	G4	S2/S3	Of Concern, State	Highest	X				X						X		X							X	X				
Pituophis melanoleucus mugitus	Pine Snake (Florida)	G4	S2	Of Concern, State	Highest	X				X								X							X					
Plethodon websteri	Webster's Salamander	G3/G4	S2	State Endangered	Highest												X				X									
Pseudacris feriarum	Upland Chorus Frog	G5	S3/S4	Of Concern, State	Moderate														X	X	X	X				X			X	X
Pseudemys concinna	River Cooter	G5	SNR	State Threatened	Moderate														X				X						X	

Pseudemys floridana	Florida Cooter	G5	SNR	State Threatened	Moderate																									
Pseudobranchus striatus striatus	Broad-striped Dwarf Siren	G5	S2	State Threatened	Highest																									
Pseudotriton montanus flavissimus	Mud Salamander (Gulf Coast)	G5	S3/S4	Of Concern, State	High													X	X	X		X					X	X	X
Rana capito capito	Gopher Frog (Carolina)	G3/G4	S1	Federal Threatened; State Endangered	Highest																									
Rana palustris	Pickerel Frog	G5	SNR	Of Concern, State	High							X	X	X					X	X			X					X	X	X
Rana sylvatica	Wood Frog	G5	S3	Of Concern, State	High	X	X	X	X			X	X																	
Rhadinea flavilata	Pine Woods Snake	G4	SNR	Of Concern, State	High																					X	X			
Seminatrix pygaea	Black Swamp Snake	G5	S?	Of Concern, State	High																								X	X	X
Terrapene carolina	Eastern Box Turtle	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X				X	X			X	X	
Trachemys scripta	Yellow-bellied Slider	G5	SNR	State Threatened	High														X	X		X	X					X	X	X
Urspelerpes brucei	Patch-nosed Salamander	G1	S?		Highest			X	X				X	X																
BIRDS																														
Actitis macularia	Spotted Sandpiper	G5	SNA		Moderate																		X							
Aenaria interpres	Ruddy Turnstone	G5	SNR		Highest																									
Aimophila aestivalis	Bachman's Sparrow	G3	S3	Of Concern, State	Highest										X	X								X		X				
Aix sponsa	Wood Duck	G5	SNRB,SNRN,SNRM		High													X				X						X	X	
Ammodramus henslowii	Henslow's Sparrow	G4	SZN	Of Concern, State	Highest											X							X		X					X
Ammodramus maritimus macgillivraii	Seaside Sparrow (McGillivray's)	G4	SNR		Moderate																									
Ammodramus savannarum	Grasshopper Sparrow	G5	SNRB,SNRN		Highest										X								X							X
Anas acuta	Northern Pintail	G5	SNRN		Highest																									
Anas discors	Blue-winged Teal	G5	SNRB,SNRN		Moderate													X				X						X		
Anas fulvigula	Mottled Duck	G4	S?		Moderate																									

Anas platyrhynchos	Mallard	G5	SNRB,SNRN		Highest														X				X					X	X	
Anas rubripes	American Black Duck	G5	SNRN		Highest														X				X						X	
Anhinga anhinga	Anhinga	G5	SNRB,SNRN		Moderate																							X	X	
Ardea alba	Great Egret	G5	SNRB,SNRN		High														X	X			X					X	X	X
Ardea herodias	Great Blue Heron	G5	SNRB,SNRN		Moderate						X	X		X					X	X			X					X	X	X
Aythya affinis	Lesser Scaup	G5	SNRN		Highest																									
Aythya Americana	Redhead	G5	SNRN		High																									
Aythya collaris	Ring-necked Duck	G5	SNRN		Moderate																									
Aythya marila	Greater Scaup	G5	SNRN		High																									
Aythya valisineria	Canvasback	G5	S4		High																									
Bartramia longicauda	Upland Sandpiper	G5	SNA		Highest																									
Bonasa umbellus	Ruffed Grouse	G5	S4		Highest	X	X	X	X																					
Botaurus lentiginosus	American Bittern	G4	SNRN	Of Concern, State	Highest																									
Buteo lineatus	Red-shouldered Hawk	G5	SNR		Moderate						X								X	X						X		X	X	
Buteo platypterus	Broad-winged Hawk	G5	S4		Moderate			X			X								X									X	X	
Butorides virescens	Green Heron	G5	SNRB,SNRN		Highest						X			X					X	X			X					X	X	X
Calidris alba	Sanderling	G5	SNRN		Highest																									
Calidris alpina	Dunlin	G5	SNRN		High																									
Calidris bairdii	Baird's Sandpiper	G5	SNA		Moderate																									
Calidris canutus	Red Knot	G4	SNRN	Federal Threatened	Highest																									
Calidris fuscicollis	White-rumped Sandpiper	G5	SNA		Moderate																									
Calidris himantopus	Stilt Sandpiper	G5	SNA		High																									
Calidris maritima	Purple Sandpiper	G5	SNA		High																									
Calidris mauri	Western Sandpiper	G5	SNRN		Highest																									
Calidris melanotos	Pectoral Sandpiper	G5	SNA		Moderate																		X							
Calidris minutilla	Least Sandpiper	G5	SNRN		High																		X							

Calidris pusilla	Semipalmated Sandpiper	G5	SNA		High																									
Caprimulgus carolinensis	Chuck-will's-widow	G5	S4		High	X	X	X	X		X				X	X	X		X	X	X			X	X	X		X	X	
Caprimulgus vociferus	Whip-poor-will	G5	S4		High	X	X	X	X						X	X	X							X		X				
Ceryle alcyon	Belted Kingfisher	G5	SNR		High						X								X									X	X	
Chaetura pelagica	Chimney Swift	G5	SNRB		High										X	X								X	X					
Charadrius melodus	Piping Plover	G3	SNRN	Federal Threatened	Highest																									
Charadrius semipalmatus	Semipalmated Plover	G5	SNRN		Moderate																									
Charadrius wilsonia	Wilson's Plover	G5	S3?	State Threatened	Highest																									
Cistothorus platensis	Sedge Wren	G5	SUB		Highest																									X
Coccyzus americanus	Yellow-billed Cuckoo	G5	S4		High	X	X	X	X		X						X		X	X	X					X		X	X	
Coccyzus erythropthalmus	Black-billed Cuckoo	G5	SNA		High	X	X	X	X		X																			
Colinus virginianus	Northern Bobwhite	G5	S4		Highest	X	X								X	X								X	X					
Columbina passerine	Common Ground-Dove	G5	SNR	State Threatened	Highest										X									X						
Contopus virens	Eastern Wood-Pewee	G5	S5		High	X	X	X	X		X					X	X				X				X	X		X		
Corvus corax	Common Raven	G5	S4		Moderate		X			X								X												
Coturnicops noveboracensis	Yellow Rail	G4	SNA		Highest																									
Cygnus columbianus	Tundra Swan	G5	SNRN		Moderate																									
Setophaga caerulescens	Black-throated Blue Warbler	G5	S4B		Moderate	X	X																							
Dendroica cerulea	Cerulean Warbler	G4	S1?B		Highest	X	X																							
Dendroica discolor	Prairie Warbler	G5	S4		High										X	X				X				X	X					
Dendroica pensylvanica	Chestnut-sided Warbler	G5	SNRB		Moderate	X	X								X															
Dendroica pinus	Pine Warbler	G5	SNR		Moderate										X	X									X					
Dryocopus pileatus	Pileated Woodpecker	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Egretta caerulea	Little Blue Heron	G5	SNRB,SNRN	Of Concern, State	Highest														X	X			X					X	X	X
Egretta rufescens	Reddish Egret	G4	SNR		Highest																									
Egretta thula	Snowy Egret	G5	SNRB,SNRN		Moderate																							X	X	X

Egretta tricolor	Tricolored Heron	G5	SNRB,SNRN		High																									
Elanoides forficatus	Swallow-tailed Kite	G5	S2	State Endangered	Highest																									
Empidonax virescens	Acadian Flycatcher	G5	S4B		High			X	X		X								X	X								X	X	
Eudocimus albus	White Ibis	G5	SNR		Highest																									
Euphagus carolinus	Rusty Blackbird	G4	SNRN		Highest					X	X								X	X								X	X	
Falco peregrinus	Peregrine Falcon	G4	SNR	State Endangered	Moderate					X								X												
Falco sparverius paulus	American Kestrel	G5	SNR		Highest																					X				
Fulica americana	American Coot	G5	SHB,SNRN		Moderate						X								X									X	X	
Gallinago gallinagodelicata	Wilson's Snipe	G5	SNRN		High						X				X				X					X				X	X	X
Gallinula galeata	Common Gallinule	G5	SNR		Moderate														X									X	X	
Gavia immer	Common Loon	G5	SNRN		Moderate																									
Haematopus palliates	American Oystercatcher	G5	SNR	Of Concern, State	Highest																									
Haliaeetus leucocephalus	Bald Eagle	G5	S2	State Endangered	High						X								X										X	
Helmitheros vermivorum	Worm-eating Warbler	G5	S4		Moderate	X	X	X	X		X						X		X	X	X									
Hylocichla mustelina	Wood Thrush	G5	S3?		High	X	X	X									X		X	X	X							X	X	
Icteria virens	Yellow-breasted Chat	G5	S4B		High										X										X	X				
Icterus galbula	Baltimore Oriole	G5	SNRB,SNRN		High	X	X	X							X		X			X					X					
Icterus spurius	Orchard Oriole	G5	S5?B		Moderate										X	X									X	X				
Ixobrychus exilis	Least Bittern	G5	SNRB,SNRN		Highest																									
Junco hyemalis	Dark-eyed Junco	G5	SNRB,SNRN		Moderate		X			X					X	X		X							X	X				
Lanius ludovicianus	Loggerhead Shrike	G4	S3	Of Concern, State	Highest										X										X					
Laterallus jamaicensis	Black Rail	G4	SNRB,SNRN	Of Concern, State	Highest																									
Limnodromus griseus	Short-billed Dowitcher	G5	SNRN		Highest																									
Limnodromus scolopaceus	Long-billed Dowitcher	G5	SNRN		Moderate																			X						
Limnothlypis swainsonii	Swainson's Warbler	G4T4	S4		High	X	X	X	X		X								X									X	X	
Limosa fedoa	Marbled Godwit	G5	SNRN		Highest																									
Loxia curvirostra	Red Crossbill	G5	S4		Highest		X	X	X																					

Melanerpes carolinus	Red-bellied Woodpecker	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Melanerpes erythrocephalus	Red-headed Woodpecker	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Melanitta fusca	White-winged Scoter	G5	SNRN		High																									
Melanitta nigra	Black Scoter	G5	SNRN		Highest																									
Mniotilta varia	Black-and-white Warbler	G5	SNRB,SNRN		High	X	X	X	X		X					X	X				X							X	X	
Mycteria americana	Wood Stork	G4	S1S2	Federally Threatened and State Endangerd	Highest																								X	X	X
Numenius americanus	Long-billed Curlew	G5	SNA		Highest																									
Numenius phaeopus	Whimbrel	G5	SNRN		Highest																									
Nyctanassa violacea	Yellow-crowned Night Heron	G5	SNRB,SNRN		Highest																								X	X	X
Nycticorax nycticorax	Black-crowned Night Heron	G5	SNRB,SNRN		Highest																								X	X	
Oporornis formosus	Kentucky Warbler	G5	S4		High	X	X	X	X		X						X		X	X	X							X	X	
Parula americana	Northern Parula	G5	SNRB		Moderate		X	X	X		X					X	X		X	X	X					X		X	X	
Passerina caerulea	Blue Grosbeak	G5	SNRB		Moderate										X										X	X				
Passerina ciris	Painted Bunting	G5	SNRB		Highest																									
Passerina cyanea	Indigo Bunting	G5	SNRB		Moderate										X										X	X				
Pelicanus occidentalis	Brown Pelican	G4	S1S2		High																									
Picoides borealis	Red-cockaded Woodpecker	G3	S2	Federal and State Endangerd	Highest																					X				
Picoides pubescens	Downy Woodpecker	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Pipilo erythrophthalmus	Eastern Towhee	G5	SNR		High	X	X	X	X		X				X	X	X		X	X	X			X	X	X		X	X	
Piranga olivacea	Scarlet Tanager	G5	SNRB		Moderate	X	X	X	X		X						X		X	X	X					X		X	X	
Piranga rubra	Summer Tanager	G5	S?		Moderate	X										X	X			X					X	X		X	X	
Platalea ajaja	Roseate Spoonbill	G5	SNR		Moderate																								X	X	X
Plegadis falcinellus	Glossy Ibis	G5	SHB,SNRN		Moderate																								X	X	X
Pluvialis dominica	American Golden Plover	G5	SNA		Highest																		X							

Pluvialis squatarola	Black-bellied Plover	G5	SNRN		High																									
Podiceps auritus	Horned Grebe	G5	SNRN,SNRM		Highest																									
Podilymbus podiceps	Pied-billed Grebe	G5	SNRB,SNRN		Highest																									
Poecile carolinensis	Carolina Chickadee	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Porphyrio martinica	Purple Gallinule	G5	S4	Of Concern, State	Highest																									
Porzana carolina	Sora	G5	SNRN		High																									
Progne subis	Purple Martin	G5	SNRB		High						X				X				X					X				X		
Protonotaria citrea	Prothonotary Warbler	G5	S3B		Moderate														X	X	X					X		X	X	
Rallus elegans	King Rail	G4	SNR		Highest														X									X	X	
Rallus limicola	Virginia Rail	G5	SNR		High																									
Rallus longirostris	Clapper Rail	G5	SNR		Highest																									
Recurvirostra americana	American Avocet	G5	SNRN		High																									
Regulus satrapa	Golden-crowned Kinglet	G5	S4		Moderate		X									X									X			X	X	
Rynchops niger	Black Skimmer	G5	S2	Of Concern, State	Highest																									
Scolopax minor	American Woodcock	G5	S4		Moderate										X				X					X				X	X	
Seiurus motacilla	Louisiana Waterthrush	G5	S4		High	X	X	X	X		X	X	X				X		X	X	X					X		X	X	
Setophaga dominica	Yellow-throated Warbler	G5	S3?		Moderate			X	X							X									X				X	
Setophaga virens	Black-throated Green Warbler	G5	S4		Highest		X	X	X		X					X	X		X	X	X									
Setophaga virens waynei	Black-throated Green Warbler (Wayne's)	G5TU	SNR		Highest																									
Sitta Canadensis	Red-breasted Nuthatch	G5	S4B		Moderate		X		X																					
Sitta pusilla	Brown-headed Nuthatch	G5	S4		Moderate											X									X					
Spiza americana	Dickcissel	G5	SNRB		Moderate										X									X						
Spizella pusilla	Field Sparrow	G5	S5?		High										X									X						
Sterna antillarum	Least Tern	G4	S3	State Threatened	Highest																									
Sterna forsteri	Forster’s Tern	G5	SNRN		High																									

Sterna hirundo	Common Tern	G5	S3?		Highest																									
Sterna maxima	Royal Tern	G5	SNRB,SNRN		High																									
Sterna nilotica	Gull-billed Tern	G5	SNR	Of Concern, State	Highest																									
Sterna sandvicensis	Sandwich Tern	G5	SNRB		Highest																									
Sturnella magna	Eastern Meadowlark	G5	SNR		High										X										X					
Thryomanes bewickii	Bewick's Wren	G5	S1?	State Endangered	Moderate										X															
Thryothorus ludovicianus	Carolina Wren	G5	SNR		Moderate	X	X	X	X		X					X	X		X	X	X				X	X		X	X	
Toxostoma rufum	Brown Thrasher	G5	SNR		High	X	X								X	X	X		X	X	X			X	X	X		X	X	
Tringa flavipes	Lesser Yellowlegs	G5	SNRN		High																									
Tringa melanoleuca	Greater Yellowlegs	G5	SNRN		High																									
Tringa semipalmata	Willet	G5	SNR		High																									
Tringa solitaria	Solitary Sandpiper	G5	SNA		Highest																									
Tryngites subruficollis	Buff-breasted Sandpiper	G4	SNA		Highest																		X							
Tyrannus dominicensis	Gray Kingbird	G5	SNRB,SNRN		Moderate																									
Tyrannus tyrannus	Eastern Kingbird	G5	SNRB		High										X										X					
Tyto alba	Barn Owl	G5	S4	Of Concern, State	Moderate										X										X					
Vermivora chrysoptera	Golden-winged Warbler	G4	SNA		Highest		X								X															
Vermivora pinus	Blue-winged Warbler	G5	SNA		Moderate										X															
Vireo flavifrons	Yellow-throated Vireo	G5	S3?B		Moderate	X	X	X	X		X						X		X	X	X					X		X	X	
Vireo griseus	White-eyed Vireo	G5	S4?B		Moderate	X	X	X	X		X						X		X	X	X					X		X	X	
Wilsonia citrina	Hooded Warbler	G5	S4?B		Moderate	X		X	X		X						X		X	X	X					X		X	X	
INSECTS																														
Acanthametropus pecatonica	"A Mayfly"																													
Agnorisma bolli	"A Moth"																													
Alloperla furcula	Blackwater Sallfly																										X		X	X	X
Arthroplea bipunctata	"A Mayfly"							X	X		X	X	X	X																	
Atrytone arogos	Arogos Skipper																									X					

Barbaetis benfieldi	"A Mayfly"							X	X		X	X	X	X			X		X	X	X	X	X			X		X	X	X
Cicindela dorsalis media	White Beach Tiger Beetle	G4,T3/T4	S4																												
Dolania americana	American Sand Burrowing Mayfly	G4	S3																							X		X	X	X
Dorymyrmex bureni	"A Pyramid Ant"																								X					
Dorymyrmex medeis	"A Pyramid Ant"																								X					
Ectemnia invenusta	Black Fly							X	X		X	X	X	X																
Euphyes bimacula	Two-Spotted Skipper																													
Heterocloeon berneri	"A Mayfly"							X	X		X	X	X	X																
Homoeoneuria dolani	"A Mayfly"																X		X	X	X	X	X							
Isoperla bellona	Smokies Stripetail	G2	SNR					X	X		X	X	X	X																
Leptoypha elliptica	"A Forestiera Lace Bug"																									X		X	X	X
Leptoypha ilicis	"A Forestiera Lace Bug"																									X		X	X	X
Maccaffertium lenati	"A Mayfly"																X		X	X	X	X	X							
Megaleuctra williamsae	Smokies Needlefly	G2	SNR					X	X		X	X	X	X																
Mycotrupes retusus	Sandhills Earth Boring Scarab Beetle																								X					
Oconoperla innubila	Hairy Springfly							X	X		X	X	X	X																
Photinus acuminatus	Pointy-Lobed Firefly							X	X		X	X	X		X		X		X	X	X	X		X						
Protoptila morettii	Moretti's Protoptila Caddisfly	G1	SNR																							X		X	X	X
Rhadinoceraea zigadenusae	Zigadenus Sawfly																													
Siphlonurus decorus	"A Mayfly"																													
Somatochlora calverti	Calvert's Emerald	G3	SNR																											
Speyeria diana	Diana Fritillary						X	X	X	X		X	X	X			X	X		X	X	X	X							

Sphodros coylei	Coyle's Purseweb Spinder															X														
Taeniopteryx robinae	Savannah Willowfly	G1	SNR																											
Toxorhynchites rutilus rutilus	"An Elephant (Tree Hole Mosquito)"					X	X	X	X		X	X	X	X			X	X	X	X	X	X	X							
Toxorhynchites rutilus septentionalis	"An Elephant (Tree Hole Mosquito)"																X	X	X	X	X	X	X							
Tsalia berneri	"A Mayfly"							X	X		X	X	X	X																
TERRESTRIAL LEECHES																														
Haemopis septagon	"A terrestrial leech"				High																									

REGION				COASTAL PLAIN ECOREGION												COASTAL ZONE ECOREGION																
Seepage Slopes	Upland Mixed Forest	Streams/Rivers/Lakes	Grasslands/Early-Successional	Pine Woodland	Sandhill Pine Woodland	Mesic Forest	Carolina Bays	Hardwood Slopes & Stream Bottoms	Blackwater Stream Systems	River Bottoms	Depressions	Upland Mixed Forest	Maritime Forest	Streams/Rivers/Lakes	Grasslands/Early-Successional	Pine Woodland	Mesic Forest	Hardwood Slopes & Stream Bottoms	Blackwater Stream Systems	River Bottoms	Depressions	Hammock Islands	Maritime Forest	Grasslands/Early-Successional	Estuarine Systems	Tidal, Fresh, & Brackish Systems	Beaches	Managed Impoundments	Upland Mixed Forest	Marine	Streams/Rivers/Lakes	Man-Made Structures	SPECIFIC HABITAT REQUIREMENTS
X				X				X		X	X	X						X		X									X				swamps, marshes, bogs, streamsides; dense leaf litter
X				X		X		X	X	X	X	X							X	X	X											X	T-beam and I-beam bridges, abandoned buildings, old bunkers and tunnels, cavity trees, rock outcrops, mines, caves
X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			X	X							X			X	buildings, cavity trees, under bridges and in bat boxes; forage in open fields or forest gaps
																														X			marine; bays, peninsulas, shallow coastal waters, open ocean
																														X			marine; deep waters of continental slope
																														X			marine; deep waters of continental slope
	X			X	X	X							X			X	X	X					X						X				roosts include tree cavities, under loose bark, rock crevices, under tree foliage, and occasionally in buildings, stacks of firewood, and bird boxes; forage over water
X	X			X	X	X	X	X	X	X		X	X			X	X	X					X						X				thinned stands; roost on smaller branches or twigs, often in the hardwood tree canopy; may roost in leaf litter
X	X			X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X						X				tree cavities, trunks, tree foliage, squirrel nests, and Spanish moss
				X	X	X		X		X	X	X	X			X	X	X		X	X		X						X				forage over open areas such as fields, pastures, golf courses, marshes, and along lake and forest edges; roost in clumps of Spanish moss or under old palm fronds
	X			X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X						X				roost in large pines located near forested corridors; may roost in leaf litter
																														X			marine; shallow banks and shelf waters
			X	X											X									X									tall grass prairie habitats

									X	X	X								X	X		X			X								near swamps, streams, rivers, ponds, and saltwater marshes
																																mesic sites with an abundance of litter, rotting logs, moss covered rocks, exposed roots, and rock crevices
	X					X	X	X	X	X	X	X	X				X	X	X	X	X		X						X			X	caves (including limestone sinks), mines, abandoned buildings, and large hollow trees; prefers to feed and roost over water
																																caves, mines, abandoned buildings, rock crevices and shelters, and crevices within bridges in wooded areas
																																buildings and picnic shelters, cavity trees, caves
																																crevices and cavities in dead or live-damaged trees, but they sometimes roost between loose bark and the bole of dead trees; forage in mature stands
																																cool moist habitats with abundant herbaceous cover; fungi species *Endogone* and *Glomus*used as food
			X	X	X	X		X		X		X	X		X	X	X	X		X			X	X					X			X	wide variety of habitats
																																loose and easily drained soils for excavation
	X			X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X		X						X	X			abandoned mines and caves, bridges, buildings
	X				X			X		X		X				X		X		X									X				cavity trees
																																high elevation sites in mesic mixed forest, mesic deciduous hardwood, dry deciduous forest, and eastern hemlock ravine forests; thick understory, high soil moisture, and high organic matter; logs, stumps, rocks, and dense leaf litter components
																																mesic mixed forest, mesic deciduous hardwood, dry deciduous forest, and eastern hemlock ravine forests
																																woods and brush near farmyards; dense hedgerows and old fields; dead and down trees
																																swamps, wet shrub/scrub, forested bottomlands, dense thickets; logs, stumps and treefalls
																																ericaceous cover (heath-like plants)
																							X	X				X				rivers, bays or estuaries with submerged aquatic vegetation
																							X					X				lagoons
				X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X				X				early successional habitat and forest interior; den sites
		X					X			X				X					X				X			X			X			large river swamps, lakes, ponds, coastal impoundments, abandoned rice fields, brackish water marshes, and estuarine tidal creeks; juveniles will use Carolina bays and other seasonal wetlands; shallow waters preferred

											X																									isolated, temporary wetlands with no fish; open grassy marshes or shallow water bodies
				X	X	X					X					X	X				X													isolated, temporary wetlands with no fish that have open canopy above and abundant grasses and sedges
	X			X	X	X	X	X			X					X	X	X			X													above and abundant grasses and sedges
																																			adjacent to rock outcrops
									X	X									X	X					X									wetlands like rivers, ponds, and lakes with sandy banks and bars; soft substrate for burrowing
									X	X										X					X									restricted to reservoirs and associated rivers with sandbars and sandy/soft substrates
																										X			X						marine; undisturbed sandy beaches
																										X			X						marine; sloping sandy beaches
							X		X	X	X								X	X	X				X		X							soft -bottomed wetlands like rivers, ponds, and lakes that have abundant aquatic vegetation
																																			water bodies with muddy substrates, abundant vegetation, and basking sites
							X			X	X								X	X	X													small ponds, streams, swamps, flooded bottomland hardwood forests, and other shallow water bodies with soft substrate for burrowing; aquatic vegetation
				X	X	X							X			X	X					X	X											underground refugia such as stump holes and rodent burrows
	X		X	X	X	X				X		X			X	X	X			X				X										dry, south-facing slopes at high elevations; rock outcrops or logs for den sites with south face exposed to sun
							X			X								X	X	X													freshwater and wetland systems with still water; surrounding upland habitat of live oak/pine
																										X			X						marine; sloping sandy beaches
																																			seepages associated with small streams and wetlands; leaf litter and other debris
																																			high-gradient, turbulent 1st and 2nd order streams in shallow areas; rocky substrate for cover
																																			in fast-flowing 2nd and 3rd order rocky streams; rocky substrate for hiding under
																										X			X						marine; undisturbed sandy beaches with vegetation for nest concealment
																																				moist wooded hillsides; mesic environments in forests with stones, logs, and other sheltering debris; Appalachin forests dominated by chestnut, chestnut oaks, and yellow poplar

X				X		X	X	X	X	X	X	X				X	X	X	X	X	X								X				wetland types like seepages near small streams; leaf litter and small debris
																																	streamside bogs, seeps, beaver ponds, and other wetlands that are grassy and have soft/muddy substrate
					X																												fossorial; deep droughty sands in xeric longleaf pine sandhills; open, early successional
																																	edges of wetlands and seepage slopes with abundant *Sphagnum*
			X	X	X								X		X	X							X	X									friable soils; underground refugia such as stump holes and rodent burrows; abundance of toads
X																																	open herb shrub bogs, pocosins, and related types; down-slope acidic seepage zones
										X									X														large river bottom swamps
							X		X	X	X								X	X	X												in and around the floodplain swamps of rivers; shallow water; soft substrates
																																	fossorial; rocky and woody debris
																											X			X			marine; sandy beaches
																						X			X	X							estuarine habitats; dry, soft sand areas
				X	X	X							X			X	X						X							X			underground refugia such as stump holes and rodent burrows; loose soil for burrowing
											X										X					X							quiet open water such as Carolina bays, lakes, old rice fields, and reservoirs with "pad plants"
	X		X	X	X	X						X	X		X	X	X						X	X				X					underground refugia such as stump holes and rodent burrows; open canopied forests or fields
													X										X				X						undisturbed coastal areas that are sandy
																X	X				X		X					X					open-canopied pine forests; leaf litter or pine needles; underground refugia such as stump holes and rodent burrows
	X			X	X	X						X				X	X																pine sites with dry soils; underground refugia such as stump holes and rodent burrows
	X			X	X	X						X				X	X																pine sites with well-drained soils; underground refugia such as stump holes and rodent burrows
																																	moist, mixed hardwood forests on steep, north-facing slopes; rocky substrate and course woody debris; dense canopy
	X					X	X			X	X						X			X	X												isolated, temporary wetlands with no fish
		X								X				X						X										X			Restricted to reservoirs and associated rivers with aquatic vegetation

										X	X			X						X										X		slow-moving rivers and non-flowing wetlands like ponds and small lakes with soft bottoms, basking sites, and aquatic vegetation
							X				X										X										isolated, shallow, acidic, temporary wetlands with no fish that have open canopy above and abundant grasses and sedges; small streams with no flow and muck bottoms sometimes
X		X						X	X	X				X				X		X										X		fossorial; wetland areas such as cypress-tupelo ponds, floodplain forests, and seepage slopes
				X	X	X					X					X	X				X											isolated, temporary to semi-permanent wetlands with no fish that have open canopy above and abundant grasses and sedges
		X						X	X	X	X			X					X	X	X									X		standing water in late winter; moist habitat usually within hardwood forests; sphagnum bogs, meadows, and grassy fields near shaded streams
																																wetlands such as small ponds and bogs; moist hardwood forests
	X			X	X	X						X	X			X	X					X						X				moist pine flatwoods with many rotten logs; underground refugia such as stump holes and rodent burrows
		X					X		X	X	X			X					X	X	X									X		wetlands with abundant aquatic vegetation; leaf litter; *Sphagnum* moss
	X		X	X		X			X	X		X			X	X	X															moist woodlands; sandy or loamy soils in open for egg laying; loose soils and leaf litter for burrowing
		X					X		X	X	X			X					X	X	X									X		non-flowing wetlands like ponds and small lakes with soft bottoms and abundant vegetation
																																leaf litter adjacent to headwater streams; mixed sand and cobble substrate with rocks and woody debris
		X												X									X	X	X	X			X		tidal to freshwater systems; primarily coastal but occurs inland
																							X	X	X						primarily coastal but occassional records inland
			X	X	X										X	X						X									areas
		X					X		X	X				X				X	X						X		X			X		nest cavities near fresh water; emergent vegetation; ponds, lakes, rivers, swamps, BEAVER PONDS
			X	X	X		X				X				X	X				X		X									moist, grassy areas in open pinewoods
																							X	X							brackish and salt marshes
			X	X			X				X				X	X				X											broomsedge fields and other openings
										X				X								X	X		X			X		shallow open water with accessible plants and invertebrates
		X								X				X								X	X		X			X		shallow open water with accessible plants and invertebrates
										X				X								X	X		X			X		shallow open water with accessible plants and invertebrates

		X					X		X	X				X					X	X							X			X		freshwater boides for foraging; shallow water with accessible plants and invertebrates
		X								X				X						X					X	X		X			X		shallow open water with accessible plants and invertebrates
		X							X	X				X					X	X		X	X						X			fresh or brackish water for foraging; trees over or surrounded by water for nesting
		X					X		X	X	X			X					X	X		X	X		X	X	X			X			shallow water bodies or shorelines for foraging; trees over or surrounded by water for nesting
		X					X		X	X	X			X					X	X		X	X		X	X				X			surrounded by water for nesting
																																	submerged aquatic vegetation and invertebrates such as mollusks
																																	submerged aquatic vegetation and invertebrates such as mollusks
							X		X	X										X					X	X				X			submerged aquatic vegetation and invertebrates such as mollusks
																																	submerged aquatic vegetation and invertebrates such as mollusks
																																	submerged aquatic vegetation and invertebrates such as mollusks
															X								X										occur throughout state
																																	upland hardwood or mixed forests; evergreens for winter cover
									X	X			X	X					X	X		X	X		X	X				X			extensive freshwater marshes with grasses>3ft. Tall
						X	X	X	X	X			X				X	X	X	X		X	X		X	X							wet or moist hardwood forests for nesting and foraging
	X							X	X	X		X																					upland hardwood or mixed forests; forage within woodlands; nests in tree crotches in canopy
		X					X	X	X	X	X		X	X				X	X	X	X	X	X		X	X		X			X			shallow water bodies and shorelines for foraging; dense shrubs and thickets near water for nesting
																				X	X	X											most frequent on front beaches
																				X	X	X	X										primarily coastal but occassional records inland
																				X	X		X										predominately freshwater wetlands; rare fall migrant in piedmont
																				X	X	X	X										most frequent on front beaches
														X						X	X		X										most frequent in managed impoundments
														X						X	X		X										most frequent in fresh to brackish ponds/impoundments
																																X	uses coastal rock jetties
																				X	X	X	X										common coastal migrant
		X												X						X	X		X										more common away from coast
		X												X						X	X	X	X										forages in clumps of marine vegetation; common on coast

																									X	X	X	X					common coastal migrant
X	X		X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X			X	X					X				understory
	X		X			X						X			X									X					X				understory
							X		X	X									X	X					X	X		X					foraging
			X	X	X										X							X										X	open areas for foraging; cavity for nesting (often chimneys)
																						X	X	X								primarily on front beaches
																						X	X	X	X							common coastal migrant
																						X	X	X	X							nests on front beaches in dunes; uncommon in winter
							X		X		X							X				X	X									favor brackish marshes
X						X		X	X	X			X				X	X	X	X			X										closed canopy deciduous forests with thick tangles
																																	closed canopy deciduous forests with thick tangles
			X	X	X										X	X								X									brushy areas and grasslands, thickets, woodland margins
			X	X											X								X		X							shrubs near openings for nesting; sandy bare ground or short grass for foraging
	X			X	X	X	X	X	X			X				X		X	X									X				open forests with sparse midstory
																																	rocky, remote cliffs for nesting; forage in openings
																			X	X					X	X		X					brackish or freshwater marshes and its vegetation
																									X			X			X		submerged aquatic vegetation; agricultural grain fields
																																	mountain forests with a thick, diverse understory; favor mountain laurel and rhododendron
																																	mature hardwood forest slopes; sparse understory
	X		X	X	X							X			X	X						X					X					open old fields with scattered saplings; open woodlands with shrub-scrub
																																	sapling to second-growth hardwood forests
				X	X											X																typically middle to mature pine forests
	X			X	X	X	X	X	X	X		X	X			X	X	X	X	X		X	X										extensive mature forests with dead snags for nest cavities; probably prefer riverbottom hardwoods
		X					X	X	X	X	X			X				X	X	X	X				X	X		X			X		shorelines, shallow water, or mudflats for foraging; shrubs or trees over or surrounded by water for colonial nesting
																									X	X	X	X					shallow (often salt) water for foraging; dense thickets on coastal islands for nesting
		X					X	X	X	X	X			X				X	X	X	X				X	X	X	X			X		shorelines, shallow water, or mudflats for foraging; shrubs or trees over or surrounded by water for colonial nesting

											X			X				X	X	X	X				X	X		X			X		over or surrounded by water for colonial nesting
				X	X			X	X	X		X			X	X	X	X	X	X				X				X				and marshes
								X	X	X		X						X	X	X								X				Riverbanks, streams, banks, alder zones
							X	X	X	X	X			X				X	X	X	X			X	X	X		X			X		shallow water or mudflats for foraging on crustaceans; wet meadows or mudflats for probing; thickets or trees over or surrounded by fresh water for colonial nesting
								X	X	X			X				X	X	X	X		X	X		X	X		X				swamps and margins; wet thickets near hardwoods
																																			open areas for foraging; cliff for nesting
	X		X		X										X	X								X									for foraging
									X	X								X	X					X	X		X						open shallow fresh water such as lakes, ponds, and bays for foraging
			X				X			X	X							X	X	X			X		X		X						boggy areas; wet meadows with short grass; along pond and marsh margins for probe foraging
									X	X								X	X					X	X		X						open freshwater with marsh vegetation for foraging and nesting
																													X						dive for fish
																								X	X	X									large winter flocks; nests on shell rakes and front beaches
										X		X						X		X				X	X		X	X		X				tall living trees, especially pines for nesting; perches near large open water where foraging occurs
																																			ravines and slopes in decidupus or mixed forests with diverse understory, especially rhododendron and mountain laurel
	X					X		X	X	X		X	X				X	X	X	X		X	X						X					litter
	X		X	X	X							X			X	X								X						X				old fields, briar thickets, dry woodland margins;
																																			open, scattered hardwoods
	X		X	X	X							X			X	X								X						X				orchard-like sttings; woodland margins
							X		X	X			X						X	X		X	X		X	X		X						shallow water bodies for foraging; marsh vegetation
			X	X	X										X	X								X										short grass openings near conifer woodlands
			X													X								X										open areas with perches
																			X		X			X	X		X							thick brackish marshes or wet meadows
																					X	X	X	X										most common in brackish to salt wetlands; uncommon inland
		X												X							X	X		X										most common in fresh coastal wetlands
X						X		X	X	X		X	X				X	X	X	X			X		X	X	X								in mountains: deciduous or mixed forest ravines with thick understory of rhododendron or mountain laurel; at coast: cane stands in hardwoods
																								X	X	X	X				X				often roosts on docks
																																			hemlock or white pine forests

	X			X	X	X	X	X	X	X		X	X			X	X	X	X	X		X	X						X			X	open, mature woods with dead snags for nest cavities; man-made poles with cavities
	X			X	X	X		X	X	X		X	X			X	X	X	X	X		X	X						X			X	open, mature woods with dead snags for nest cavities; man-made poles with cavities
																									X							estuarine/marine shellfish beds; nearshore during winter
																									X					X		estuarine/marine shellfish beds; nearshore during winter
						X		X	X	X																						mature hardwood forests; coves
		X					X	X	X	X	X			X				X	X	X	X				X	X		X			X		shallow water with concentrated prey (6-10 in. deep) for foraging; trees over or surrounded by water for colonial nesting, particularly cypress swamps and trees on small islands
																									X		X						rare; most frequent in Cape Romain NWR
																									X	X	X						roosts in salt marsh so difficult to document numbers
		X					X	X	X	X	X			X				X	X	X	X				X	X		X			X		shorelines of water bodies for foraging, especially for crustaceans; trees or thickets near water for colonial nesting, will nest in trees that are on dry lands
							X	X	X	X			X					X	X	X		X	X		X	X		X					shorelines of water bodies for foraging; shrubs or trees over or surrounded by water for colonial nesting
X						X		X	X	X			X				X	X	X	X		X	X						X					moist hardwood forests with rich understory
						X		X	X	X			X				X	X	X	X		X	X										mature, moist forests; hemlock forests in mountains and swamps or bottomlands with Spanish moss near coast
			X	X								X			X	X								X					X				hardwood saplings or shrubs for nesting; open areas
	X		X	X								X	X		X							X	X	X			X						woodland margins; dense thickets in openings
			X	X	X							X			X	X								X				X					woodland margins; shrubby thickets in openings
																									X	X	X			X				ephemeral islands with shrubs and grasses for nesting; shallow marine waters for foraging
				X	X											X																		open pine woods with little to no understory; prefers longleaf; heartwood disease for nest cavity excavation
	X			X	X	X	X	X	X	X		X	X			X	X	X	X	X		X	X						X					nest cavities
	X		X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X		X	X	X						X					brushy areas; woodland margins and understory
	X																																	mature deciduous forests
	X			X	X	X		X	X	X		X				X	X	X	X	X								X	X					dry, mixed woodlands
		X													X			X	X	X	X				X	X		X						shallow water for tactile feeding; shrubs or trees over or surrounded by water for colonial nesting, particularly thickets of small trees on coastal islands
		X													X			X	X	X	X			X	X	X		X			X			shallow water, mudflats, or wet meadows for probing and foraging; shrubs or trees over or surrounded by water for colonial nesting, particularly dense thickets on coastal islands
		X													X									X	X	X	X							rare migrant

															X									X	X	X	X					common coastal migrant
														X										X	X					X		small fish as prey
							X							X													X			X		fresh or slightly brackish water with emergent vegetation within used for nesting; open water in winter for foraging
	X			X	X	X		X	X	X		X	X			X	X	X	X	X		X	X					X			X	boxes
										X				X					X						X							foraging and nesting
							X		X	X									X	X				X	X		X					freshwater marshes for foraging and nesting
			X								X				X					X		X		X	X	X					X	forage over open areas near or over water; nest in man-made houses or gourds
						X		X	X	X			X				X	X		X	X											near standing water; open swamps with cavities for nesting; willow thickets near lakes and ponds; old stumps and other rotting logs
									X	X								X	X					X	X		X					mudflats and shallow fresh or brackish water for foraging
																			X					X	X		X					extensive fresh or brackish marshes for foraging and nesting
																									X								salt marshes for foraging and nesting
														X										X	X		X					most frequent in managed impoundments
	X			X	X	X		X	X	X		X				X												X				winter in coniferous or mixed woodlands
																								X	X	X	X					coastal waters for foraging; beaches for nesting
			X	X					X	X					X			X	X				X								moist soils and leaf litter for probe foraging; woodlands for nesting; openings for mating displays
						X	X	X	X	X							X	X	X													deciduous or mixed forests with rocky streams
	X			X	X					X		X	X			X				X	X							X				moderately open, mature, moist forests; pines, mixed forests; Spanish moss
																																	moist forests with conifers like hemlock and white pine
								X	X	X			X			X	X	X	X	X		X	X										coastal moist forests like swamps and bottomlands with cypress and white cedar
																																	winters in dense coniferous woods
				X	X										X																	mature, open pines for foraging; nest cavities in snags
			X													X								X								open, grassy areas
			X	X																				X								saplings and shrubs in weedy thickets and woodland margins
																								X	X	X	X				X	can use pebble rooftops for nesting
																								X	X	X						most frequent in Cape Romain NWR

																							X	X	X						most frequent in Cape Romain NWR
																							X	X	X						nests on beaches with other seabird colonies
																							X	X	X						nests on beaches often with black skimmers
																							X	X	X						nests on beaches with other seabird colonies
			X	X											X								X								short to medium-height grasses for nesting and foraging
																																scrub-shrub near open areas like farms in mountain valleys
	X			X	X	X	X	X	X	X		X	X			X	X	X	X	X		X	X					X			X	woodland thickets; leaf litter; cavities or ledges for nesting; will use bird boxes and many other human material
	X		X	X	X	X		X	X	X		X	X		X	X	X	X	X	X			X	X					X				moderate to dense brush and saplings
																						X	X		X						most frequent in impoudments
																						X	X		X						most frequent in impoudments
																						X	X	X	X						nest on front beaches in dunes
																						X	X	X	X						rarely in tidal areas; fresh to brackish wetlands
		X												X								X	X		X						may be seen in pastures and golf courses; rare migrant; most common in interior
																			X		X											open areas with scattered trees and other perches
			X												X						X											open areas with scattered trees and other perches
			X	X											X				X		X										X	cover
																																old fields with scattered saplings; open woods or margins higher up on slopes
																																streamside shrub thickets; open areas like overgrown fields
						X		X	X	X			X				X	X	X	X			X									open, moist, mature, deciduous woodlands with tall trees; near water
	X					X	X	X	X	X		X	X				X	X	X	X		X	X					X				dense, moist thickets
						X		X	X	X			X				X	X	X	X			X									mature, moist deciduous forests; some mixed forests; rich understory layer
						X	X	X	X	X	X			X																		mesic forests near water
																																habitat preferences unknown; specimens collected in a suburban area in Blue Ridge/Piedmont Ecoregions
X		X																														mesic forests near water
																																mesic forests near water
			X	X	X										X																	specialist in seasonally wet to dry grassland and pine savannah habitats; regenerating burn sites; host plants: Little Bluestem, Pine Barrens Reed Grass, and Lopsided Indian Grass; nectar plants

X		X																																		mesic forests near water
																											X								large expanses of naturally shifting ocean beach with little to no disturbances
X		X				X	X	X	X	X	X			X																					mesic forests near water
			X		X										X										X										prefer sandy soils in highly disturbed areas like pastures, open fileds, open scrub, sandhills, dunes, lawns, and roadsides
			X		X										X										X										prefer sandy soils in highly disturbed areas like pastures, open fields, open scrub, sandhills, dunes, lawns, and roadsides
																																			mesic forests near water
							X				X																								isolated wetlands: open bogs, fens, and marshes with *Carex* sp.; nectar plants like iris
																																			mesic forests near water
						X	X	X	X	X	X			X																						mesic forests near water
																																			mesic forests near water
X	X																																		specialist of upland swamp privet and swamp privet; swamp forests over calcareous substrates or shell middens; upland forests or slopes along streams
X	X																																		specialist of upland swamp privet and swamp privet; swamp forests over calcareous substrates or shell middens; upland forests or slopes along streams
																																			mesic forests near water
																																			mesic forests near water
	X				X																														restricted to deep, well-drained xeric sands of Fall-line Sandhills; mostly fossorial
																																			mesic forests near water
																																			mesic forests and forest margins; edges of openings; females need clumps of grasses and herbs under which to lay eggs in soil
X		X																																	mesic forests near water
					X		X	X	X	X	X		X			X		X	X	X	X														dependent upon host plant: Death Camas (*Zigadenus densus*)
						X	X	X	X	X	X			X																						mesic forests near water
						X	X	X	X	X	X	X		X																						boggy forest seepages for breeding; forest openings for foraging
																																			forest specialists; larval host: violet species; leaf litter for pupation; nectar plant hosts: milkweed, buttonbush, coneflower, compassplant, and others

																																				undisturbed woodlands; trees for nest construction
						X	X	X	X	X	X			X																					mesic forests near water
						X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X						X		X	X	tree holes and artificial basins for breeding; nectar producing plants for foraging
						X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X						X		X	X	tree holes and artificial basins for breeding; nectar producing plants for foraging
																																				mesic forests near water
							X	X	X	X	X			X				X	X	X	X															moist areas near water sources; feeds on earthworms; only known from Georgetown County but probably more widespread in Pee Dee region of Coastal Plain

Appendix 1-B: Freshwater Priority Species and Their Habitats

SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK	LEGAL STATUS	PRIORITY	BLUE RIDGE ECOBASIN		PIEDMONT ECOBASIN			SOUTHEASTERN PLAINS/SANDHILLS ECOBASIN				COASTAL PLAIN TO COASTAL ZONE ECOBASIN				SPECIFIC HABITAT REQUIREMENTS
						Santee	Savannah	Santee	Savannah	Pee Dee	Santee	Savannah	Pee Dee	ACE	Santee	Savannah	Pee Dee	ACE	
FRESHWATER & DIADROMOUS FISH																			
Acipenser brevirostrum	Shortnose Sturgeon	G3	S3	Federal and State Endangered	Highest							X	X		X	X	X	X	Moderate flows; sand or gravel substrates for spawning
Acipenser oxyrinchus	Atlantic Sturgeon	G3	S3	Federal and State Endangered	Highest							X	X		X	X	X	X	Moderate flows; sand or gravel substrates for spawning
Alosa aestivalis	Blueback Herring	G3	S3	Of Concern, State	Highest		X		X		X	X	X		X	X	X	X	
Alosa mediocris	Hickory Shad	G5	S4	Of Concern, State	Highest				X		X	X	X		X	X	X	X	
Alosa sapidissima	American Shad	G5	S5	Of Concern, State	Highest						X	X	X		X	X	X	X	
Ameiurus brunneus	Snail Bullhead						X	X	X	X	X	X	X	X		X	X	X	Rocky riffles, runs, shoals, and pools in streams and rivers
Anguilla rostrata	American Eel	G5	SNR	Of Concern, State	Highest			X	X	X	X	X	X	X	X	X	X	X	
Ameiurus catus	White Catfish					X	X	X	X	X	X	X	X	X	X	X	X	X	Warm ponds, reservoirs, and medium to large rivers in freshwater and brackish habitats
Ameiurus platycephalus	Flat Bullhead							X	X	X	X	X	X	X	X	X	X	X	Streams, rivers, and impoundments; slow-flowing water along banks and in pools; mud, sand, or rock substrates
Campostoma anomalum	Central Stoneroller					X	X	X	X										Cool, clear water, moderate to rapid current; gravel or rubble substrate; pools with a current and small rocky streams
Carpiodes cyprinus	Quillback						X	X	X		X	X							Warm, calm rivers with low to moderate-gradient reaches; spawn in riffles; variable substrate
Carpiodes velifer	Highfin Carpsucker							X		X	X	X							Rivers with moderate to swift current; sand or gravel substrate
Chologaster cornuta	Swampfish										X	X	X	X	X	X	X	X	Calm, acidic blackwater streams; organic matter and aquatic vegetation and woody debris
Clinostomus funduloides	Rosyside Dace					X	X	X	X	X	X		X	X					Clear flowing pools of headwater streams and occasionally larger streams
Cottus bairdii complex	"Smoky" Sculpin						X		X										Clear, cool/cold headwaters, creeks, springs, and small montane rivers of high to moderate-gradient; rubble and gravel substrates
Cyprinella analostana	Satinfin Shiner									X			X				X		Pools and runs of creeks and small to medium weed-free rivers, sand to gravel/rubble substrates; branches, stumps, rock crevices
Cyprinella chloristia	Greenfin Shiner					X		X		X	X		X						Cool, clear creeks or small to moderately-sized rivers; slower grass and margins of pools and runs; clean sand and rocky
Cyprinella galactura	Whitetail Shiner						X		X										Clear, cool water streams and rivers with moderate to high gradients; gravel and rubble substrates; deep pools near riffles
Cyprinella pyrrhomelas	Fieryblack Shiner					X		X		X	X		X				X		runs and pools below riffles; coarse substrate; logs and rocks for
Cyprinella sp.(c.f. zanema)	"Thinlip" Chub									X			X				X		or current-swept pools
Elassoma boehlkei	Carolina Pygmy Sunfish										X						X		streams; abundant aquatic vegetation
Elassoma evergladei	Everglades Pygmy Sunfish										X	X	X	X		X		X	Swamps and backwaters; dense vegetation
Elassoma okatie	Bluebarred Pygmy Sunfish											X				X		X	and rivers; abundant vegetation; soft, detritus-rich substrate
Enneacanthus chaetodon	Blackbanded Sunfish									X	X	X	X	X	X	X	X	X	roadside ditches, streams; sand or mud substrate; stained, acidic
Ennaecanthus obesus	Banded Sunfish										X	X	X	X	X	X	X	X	often over silt or sand; very low current velocities
Etheostoma collis	Carolina Darter							X											or bedrock substrates
Etheostoma brevispinum	Carolina Fantail Darter					X	X	X		X									currents; gravel or rubble substrate for benthic feeding and
Etheostoma fricksium	Savannah Darter											X		X				X	sand or gravel substrates; aquatic vegetation and woody debris
Etheostoma hopkinsi	Christmas Darter						X		X			X							rivers with strong currents; also in slower flows with submerged
Etheostoma inscriptum	Turquoise Darter						X		X			X		X					currents; depth 10-30cm
Etheostoma mariae	Pinewoods Darter												X						current; gravel or rubble substrates; young in pools with
Etheostoma serrifer	Sawcheek Darter							X		X	X	X	X	X	X	X	X	X	current velocity
Etheostoma thalassinum	Seagreen Darter					X		X			X								variations in water temperature and clarity; rock, rubble, or gravel
Fundulus diaphanus	Banded Killfish																X		20ppt; lakes, ponds, slow velocity streams; sand, gravel, or
Hybopsis hypsinotus	Highback Chub					X		X			X								riffles and runs; with sand, gravel and rock substrates
Cyprinella labrosa	Thicklip Chub					X		X											water; riffles and runs; sand, gravel and rock substrates
Hybopsis rubrifrons	Rosyface Chub					X	X	X	X			X		X					large streams; sand or clean gravel
Cyprinella zanema	Santee Chub					X		X											swept pools
Lepisosteus platyrhinchus	Florida Gar											X				X			areas; mud and sand substrates; flooded bottomlands are
Lucilus coccogenis	Warpaint Shiner						X		X										gradients; gravel and rubble substrates; pools, slow runs, and
Micropterus coosae	"Bartram's" Redeye Bass					X	X	X	X			X							also be in large rivers and reservoirs
Morone saxatilis	Striped Bass							X	X		X	X	X	X	X	X	X	X	and rock; shallow rocky and gravely areas with strong current for
Moxostoma collapsum	Notchlip Redhorse					X	X	X	X	X	X	X	X	X			X		streams; also in natural and artificial lakes
Moxostoma pappillosum	V-lip Redhorse					X		X											gentle gradient; rocky runs and silty to firm-bottomed pools;
Moxostoma robustum	Robust Redhorse										X	X	X			X	X		water near shore; course gravel substrate for spawning; cooler
Moxostoma sp.(c.f. erythrurum)	"Carolina" Redhorse												X						areas for spawning
Notropis alborus	Whitemouth Shiner									X			X						creeks, and small rivers; clear to slightly-stained/turbid; no
Notropis altipinnis	Highfin Shiner							X	X	X	X		X						substrates
Notropis amoenus	Comely Shiner									X			X						especially in channels; sand, gravel, or rubble substrate
Notropis bifrenatus	Bridle Shiner										X				X				water; abundant aquatic vegetation for feeding and breeding;
Notropis chalybaeus	Ironcolor Shiner							X			X	X	X	X	X	X	X	X	Low-velocity blackwater streams and swamps; woody debris
Notropis chiliticus	Redlip Shiner									X			X						gravel to rubble substrates; spawns on nests of Bluehead Chub
Notropis leedsi	Bannerfin Shiner											X		X		X		X	woody debris; logs and rocks for crevice spawning
Notropis leuciodus	Tennessee Shiner						X		X										and swift current; usually dependent on chub nests for nesting
Notropis procne	Swallowtail Shiner							X		X	X		X						Sandy pools of small to medium streams
Notropis scepticus	Sandbar Shiner					X	X	X	X	X	X		X						Flowing poolss over a sand substrate in moderate to large streams
Notropis spectrunculus	Mirror Shiner						X		X										gradients; gravel and rubble substrates; pools, slow runs and riffle
Noturus spp. (c.f. insignis)	"Broadtail" Madtom												X	X			X	X	woody debris
Percina crassa	Piedmont Darter					X		X		X	X		X				X		moderate currents
Pteronotropis stonei	Lowland Shiner										X	X	X	X	X	X	X	X	like slow riffles, runs, and flowing pools; clean sand substrate;
Rhinichthys obtusus	Blacknose Dace					X	X	X											sand, gravel and rock substrate
Salvelinus fontinalis	Eastern Brook Trout					X	X												creeks or beaver ponds or lakes at or below 20 C at 490-600+m
Semotilus lumbee	Sandhills Chub										X		X						gravel or sand substrates
MUSSELS																			
Alasmidonta arcula	Altamaha Arcmussel	G2	S2 recom.		High											X			Savannah River; Largemouth Bass host fish
Alasmidonta undulata	Triangle Floater	G4	S1		Highest				X										substrates but some silt tolerated; multiple host fish species used
Alasmidonta varicose	Brook Floater	G3	S1 recom.	Of Concern, State	Highest				X	X			X						High relief streams among boulders in sand
Anodonta couperiana	Barrel Floater	G4	S1	Of Concern, State	Highest							X	X	X		X	X	X	substrates
Anodonta implicata	Alewife Floater	G5	S1 recom.		High			X		X	X	X			X		X		fish, alewife (*Alosa pseudoharengus)*and possibly other clupeids
Elliptio angustata	Carolina Lance	G4	S3		Moderate			X	X	X	X	X	X	X	X	X	X	X	vegetation
Elliptio complanata complex	Eastern Elliptio	G5	S5		Moderate			X	X	X	X	X	X	X	X	X	X	X	fish hosts; no specific flow volume or substrate requirements
Elliptio congaraea	Carolina Elephantear	G3	S3	Of Concern, State	Moderate	X		X	X		X	X	X	X		X	X	X	Rivers and small streams with sandy substrates
Elliptio fisheriana/nasutilus	Northern Lance	G4	SNR		High					X	X				X		X		stable banks with intact riparian zone

Elliptio folliculata	Pod Lance	G2/G3Q	S2/S3		High			X	X				X				X		1m sand or clay substrates
Elliptio fraterna	Brother Spike	G1	S1	State Endangered	Highest				X										Sand bars in swift flowing sections of streams and rivers
Elliptio icterina complex	Variable Spike	G5Q	S4		Moderate	X		X	X		X	X	X	X	X	X	X	X	rivers; clear or tannic water; sand, gravel, bedrock, mud, and
Elliptio producta	Atlantic Spike	G3Q	S3		High				X			X		X		X	X		Streams or rivers in mild current; sand, rock, and mud substrate
Elliptio roanokensis	Roanoke Slabshell	G3	S2		High			X			X	X	X			X	X		temperatures; host fish unknown
Elliptio waccamawensis	Waccamaw Spike	G2/G3Q	S1		Highest												X		turbidity; compact sand substrate
Fusconaia masoni	Atlantic Pigtoe	G2	SH	State Endangered	Highest				X	X		X					X		flowing, well-oxygenated, pristine streams
Lampsilis cariosa	Yellow Lampmussel	G3/G4	S2		Highest			X	X		X	X	X			X	X	X	cracks in bedrock of large rivers and small streams
Lampsilis radiata	Eastern Lampmussel	G5	S2	Of Concern, State	High			X			X	X				X	X	X	Streams, rivers, and blackwater swamps; mud or sand substrates
Lampsilis splendida/radiata	Rayed Pink Fatmucket	G3	S2	Of Concern, State	High			X			X	X				X	X	X	Laregmouth Bass host fish
Lasmigona decorata	Carolina Heelsplitter	G1	S1	Federal and State Endangered	Highest			X	X	X									gradient; stable streambanks and channels; pool, riffle, and run sequences; little to no fine sediment; periodic natural flooding
Leptodea ochracea	Tidewater Mucket	G3/G4	S2		High						X	X				X	X		Pristine freshwater rivers with tidal influence
Ligumia nasuta	Eastern Pondmussel	G4	S2		High			X			X				X		X		substrates; very shallow water near river banks
Strophitus undulatus	Creeper	G5	S2	Of Concern, State	Highest			X	X	X			X						field substrates; with or without fish or salamander species as
Toxolasma pullus	Savannah Lilliput	G2	S1	Of Concern, State	Highest			X			X	X					X		backwaters; mud or silty sand substrates; host fish sunfish
Villosa constricta	Notched Rainbow	G3	S1	Of Concern, State	Highest			X		X			X						quality water; sand and sand/gravel substrates
Villosa delumbis	Eastern Creekshell	G4	S4	Of Concern, State	Moderate			X	X	X		X	X	X		X	X	X	streambanks often among tree roots; Largemouth Bass host fish
Villosa modioliformis	Eastern Rainbow	G5Q	S2	Of Concern, State	Highest			X	X					X	X		X	X	current; depths of less than 1m
Villosa vaughaniana	Carolina Creekshell	G2	S1		Highest			X											in the main channel of streams and medium rivers
CRAYFISH																			
Cambarus (Puncticambarus) aldermanorum	Carolina Needlenose Crayfish				Moderate			X											lower order to higher order streams with rock outcrops, woody debris, and other habitat structure
Cambarus carolinus	Red Burrowing Crayfish	G4	S2?		Highest			X	X										may be dependent on a high water table
Cambarus chaugaensis	Chauga Crayfish	G2	S2/S3		Highest	X?	X	X	X?										or boulder substrate with little sediment accumulation
Cambarus hobbsorum	Rocky River Crayfish	G4	S4		Moderate			X											Creeks with pools and riffles; sand and gravel substrate
Cambarus reflexus	Pine Savannah Crayfish	G4	S3		Highest						X	X	X					X	lying seepages and bogs with black soil; also in mixed hardwood
Cambarus sp. "B"	"a crayfish"				Highest		X												gravel and cobble substrate over fractured bedrock; crevices in
Cambarus spicatus	Broad River Spiny Crayfish	G3	S3		High			X											jams and other debris for cover
Distocambarus carlsoni	Mimic Crayfish	G3	SNR		Highest			X	X										Terrestrial obligate burrower
Distocambarus crockeri	Piedmont Prairie Burrowing Crayfish	G3	S3		High			X	X										than 2 m; primary burrower
Distocambarus hunteri	Saluda Burrowing Crayfish	G1?	SNR		Highest			X											overstory of pine-hardwoods (maple/oak/elm); digs burrows
Distocambarus youngineri	Newberry Burrowing Crayfish	G1	S1	Of Concern, State	Highest			X											overstory near stream headwaters or intermittent streams; primary
Faxonella clypeata	Ditch Fencing Crayfish	G5	S2?		Moderate			X	X			X							ditches, burrow pits, and cypress ponds
Procambarus ancylus	Coastal Plain Crayfish	G4/G5	S4/S5		Moderate								X	X	X		X	X	Lenthic and lotic waters and burrows
Procambarus barbatus	Wandering Crayfish	G5	S4		Moderate											X			table
Procambarus blandingii	Santee Crayfish	G4	S4		Moderate						X		X		X				woody debris when found in swamps
Procambarus braswelli	Waccamaw Crayfish	G2/G3	SNR		High												X		Clear streams with sand substrate flowing through swampy areas
Procambarus chacei	Cedar Creek Crayfish	G4	S4		Moderate						X	X	X	X	X		X?	X	springs, and streams; primary burrower
Procambarus echinatus	Edisto Crayfish	G3	S3		High									X				X	grass beds in submerged root wads along stream banks
Procambarus enoplostermum	Black Mottled Crayfish	G4/G5	SNR		Moderate						X	X			X	X		X	in shaded streams with dense beds of macrophytes or in shallow
Procambarus hirsutus	Shaggy Crayfish	G4	S4		Moderate						X	X		X		X		X	Clear streams with good flow
Procambarus lepidodactylus	Pee Dee Lotic Crayfish	G4	S4		Moderate						X		X				X	X?	often among tree roots; sandy substrate
Procambarus lunzi	Hummock Crayfish	G4	S2/S3		Moderate										X	X			Lenthic and sluggish lotic environments; sometimes burrows
Procambarus pearsei	Carolina Sandhills Crayfish	G4	S3		Moderate												X		secondary burrower
Procambarus pubescens	Brushnose Crayfish	G4/G5	S3?		Moderate							X				X			sparse; muddy, sandy, or rocky substrates; variety of water
LEECHES																			
Macrobdella sestercia	New England Medicinal Leech	G2	S1		High				X			X?							Edgefield County streams
Placobdella biannulata	Biannulate Leech				Moderate	X	X												free-living or parasite of salamanders in genus *Desmognathus*
FRESHWATER SHRIMP																			
Macrobrachium ohione	Ohio River Shrimp	G4	SNR		Moderate					X			X		X	X	X	X	particulate matter; saline for larval development
SNAILS																			
Gillia altilis	Buffalo Pebblesnail	G5	S1		High												X		Cold, clear lakes, streams, and rivers
Lioplax subcarinata	Ridged Lioplax	G5	S1		High												X		Burrower that prefers sandy substrates in rivers
Somatogyrus virginicus	Panhandle Pebblesnail	G2/G3	SNR		High		X	X	X										a rocky substrate
INSECTS																			
Acanthametropus pecantonica	A Mayfly															X			sand-bottomed streams
Alloperla furcula	Blackwater Sallfly	G2	SNR						X										clean shifting sand substrate in blackwater streams
Arthroplea bipunctata	A Mayfly						X												course organic material
Barbaetis benefieldi	A Mayfly					X	X	X	X										associated with hornleaf riverweed in rapidly-flowing streams
Dolania americana	American Sand Burrowing Mayfly	G4	S3						X							X		X	require midges as prey
Ectemnia invenusta	Black Fly						X												rapids in streams and rivers; rocky substrate
Heterocloeon berneri	A Mayfly						X												water streams; rock crevices; sandy and gravelly substrate
Homoeoneuria dolani	A Mayfly					X										X		X	sand-bottomed streams
Isoperla bellona	Smokies Stripetail						X												small, stream-fed springs
Maccaffertium lenati	A Mayfly					X	X												large rocks in slow current near head of a riffle or banks
Megaleuctra williamsae	Smokies Needlefly	G2	SNR				X												forests;decaying leaves and other debris covered with a thin film
Oconoperla innubila	Hairy Springfly	G2	SNR				X												mostly in splash zones away from direct current
Protoptila morettii	Moretti's Protoptila Caddisfly	G1	SNR						X										relatively warm, large, slow-flowing streams
Siphlonurus decorus	A Mayfly																	X	swamps
Somatochlora calverti	Calvert's Emerald	G3	SNR													X			very shallow water
Taeniopteryx robinae	Savannah Willowfly	G1	SNR													X			pools; coarse sand substrate
Toxorhynchites rutilus rutilus	Elephant (Tree Hole) Predatory Mosquito					X	X								X			X	receptacles like old tires, etc.
Toxorhynchites rutilus septentrionalis	Elephant (Treehole) Predatory Mosquito					X	X											X	receptacles like old tires, etc.
Tsalia berneri	A Mayfly						X												(*Fontinalis* sp.); rootmats; rocks in riffles; cool streams with
REPTILES &AMPHIBIANS																			
Acris crepitans	Northern Cricket Frog	G5	S5	Of Concern, State	Moderate	X	X	X	X	X	X	X	X	X		X			isolated, temporary wetlands with no fish
Alligator mississippiensis	American Alligator	G5	S5	Federal Threatened	Moderate						X	X	X	X	X	X	X	X	abandoned rice fields, brackish water marshes, and estuarine tidal
Ambystoma cingulatum	Flatwoods Salamander	G2/G3	S1	Federal Threatened; State Endangered	Highest										X	X	X	X	isolated, temporary wetlands with no fish that have open canopy above and abundant grasses and sedges
Ambystoma tigrinum	Tiger Salamander	G5	S2/S3	Of Concern, State	Highest			X	X	X	X	X	X	X	X	X	X	X	above and abundant grasses and sedges

Aneides aeneus	Green Salamander	G3/G4	S1	Of Concern, State	Highest	X	X												adjacent to rock outcrops
Apalone ferox	Florida Softshell Turtle	G5	SNR	State Threatened	High											X		X	wetlands like rivers, ponds, and lakes
Apalone spinifera	Spiny Softshell Turtle	G5	SNR	State Threatened	Moderate	X	X	X	X	X	X	X	X	X	X	X	X	X	sandy substrates
Chelydra serpentina	Snapping Turtle (Common)	G5	SNR	State Threatened	Moderate	X	X	X	X	X	X	X	X	X	X	X	X	X	wetlands like rivers, ponds, and lakes
Chrysemys picta picta	Painted Turtle (Eastern)	G5	S?	State Threatened	Moderate	X													basking sites
Clemmys guttata	Spotted Turtle	G5	S5	State Threatened	High		X	X	X	X		X	X				X		water bodies
Deirochelys reticularia	Chicken Turtle	G5	SNR	State Threatened	Moderate						X	X	X	X	X	X	X	X	and surrounding upland habitat of live oak/pine
Desmognathus aeneus	Seepage Salamander	G3/G4	S?	Of Concern, State	High		X												and other debris
Desmognathus folkerstii	Dwarf Black-bellied Salamander	G2	S?		High		X												areas; rocky substrate for cover
Desmognathus marmoratus	Shovel-nosed Salamander	G4	S2	Of Concern, State	Highest	X	X												for hiding under
Eurycea chamberlainii	Chamberlain's Dwarf Salamander	G4	SNR		Highest	X		X	X		X	X	X	X					small debris
Glyptemys muhlenbergii	Bog Turtle	G3	S1	Federal and State Threatened	Highest	X	X	X	X										streamside bogs, seeps, beaver ponds, and other wetlands
Hemidactylium scutatum	Four-toed Salamander	G5	SNR	Of Concern, State	High	X	X	X	X	X	X	X	X	X					edges of wetlands and seepage slopes with abundant *Sphagnum*
Hyla andersonii	Pine Barrens Treefrog	G4	S2/S3	State Threatened	Highest			X		X	X		X						seepage zones
Hyla avivoca	Bird-voiced Treefrog	G5	S5	Of Concern, State	Moderate							X				X			southern portion of Savannah River floodplain swamp
Kinosternon baurii	Striped Mud Turtle	G5	S?	Of Concern, State	Moderate						X	X	X	X	X	X	X	X	in and around the floodplain swamps of rivers
Nerodia floridana	Florida Green Watersnake	G5	S2	Of Concern, State	Highest						X	X		X	X	X	X	X	with "pad plants"
Plethodon websteri	Webster's Salamander	G3/G4	S2	State Endangered	Highest				X										rocky substrate and course woody debris; dense canopy
Pseudacris feriarum	Upland Chorus Frog	G5	S3/S4	Of Concern, State	Moderate	X	X	X	X	X	X	X	X	X	X	X	X	X	isolated, temporary wetlands with no fish
Pseudemys concinna	River Cooter	G5	SNR	State Threatened	Moderate			X	X	X	X	X	X	X	X	X	X	X	Restricted to reservoirs and associated rivers
Pseudemys floridana	Florida Cooter	G5	SNR	State Threatened	Moderate						X	X	X	X	X	X	X	X	small lakes with soft bottoms, basking sites, and aquatic
Pseudobranchus striatus striatus	Broad-striped Dwarf Siren	G5	S2	State Threatened	Highest										X	X	X	X	above and abundant grasses and sedges; small streams with no
Pseudotriton montanus flavissimus	Mud Salamander (Gulf Coast)	G5	S3/S4	Of Concern, State	High											X		X	forests, and seepage slopes
Rana capito capito	Gopher Frog (Carolina)	G3/G4	S1	Federal Threatened; State Endangered	Highest						X	X	X	X	X	X	X	X	isolated, temporary wetlands with no fish that have open canopy above and abundant grasses and sedges
Rana palustris	Pickerel Frog	G5	SNR	Of Concern, State	High	X	X	X					X		X	X	X	X	near shaded streams or standing water
Rana sylvatica	Wood Frog	G5	S3	Of Concern, State	High	X	X												wetlands such as small ponds and bogs
Seminatrix pygaea	Black Swamp Snake	G5	S?	Of Concern, State	High						X	X	X	X	X	X	X	X	wetlands with abundant aquatic vegetation
Trachemys scripta	Yellow-bellied Slider	G5	SNR	State Threatened	High			X	X	X	X	X	X	X	X	X	X	X	non-flowing wetlands like ponds and small lakes
Urspelerpes brucei	Patch-nosed Salamander	G1	S?		Highest		X												substrate with rocks and woody debris