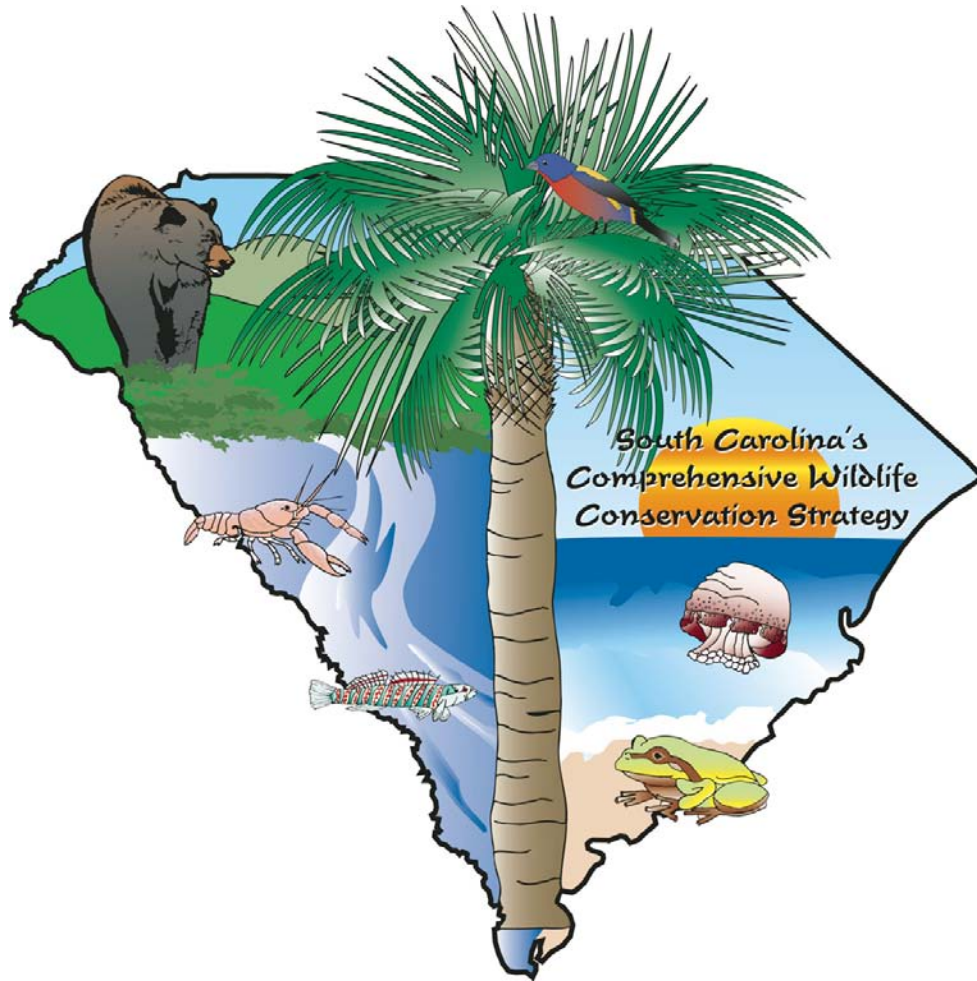


SOUTH CAROLINA COMPREHENSIVE WILDLIFE CONSERVATION STRATEGY 2005-2010



**SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES
1000 ASSEMBLY STREET
P.O. Box 167
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**FINAL
SEPTEMBER 28, 2005**

FOREWORD

Abundant fish and wildlife, unbroken coastal vistas, miles of scenic rivers, swamps and mountains open to exploration, and well-tended forests and fields...these resources enhance the quality of life that makes South Carolina a place people want to call home. We know our state's natural resources are a primary reason that individuals and businesses choose to locate here. They are drawn to the high quality natural resources that South Carolinians love and appreciate.

The quality of our state's natural resources is no accident. It is the result of hard work and sound stewardship on the part of many citizens and agencies. The 20th century brought many changes to South Carolina; some of these changes had devastating results to the land. However, people rose to the challenge of restoring our resources. Over the past several decades, deer, wood duck and wild turkey populations have been restored, striped bass populations have recovered, the bald eagle has returned and more than half a million acres of wildlife habitat has been conserved. We in South Carolina are particularly proud of our accomplishments as we prepare to celebrate, in 2006, the 100th anniversary of game and fish law enforcement and management by the state of South Carolina.

Since its inception, the South Carolina Department of Natural Resources (SCDNR) has undergone several reorganizations and name changes; however, more has changed in this state than the department's name. According to the US Census Bureau, the South Carolina's population has almost doubled since 1950 and the majority of our citizens now live in urban areas. The stewardship of our land has also passed to a new generation that has different needs and faces new problems. As our rural lands are converted to developed areas, South Carolina's citizens continue to seek the high-quality natural resources that characterize this state. The SCDNR strives to support a broader array of wildlife species and habitats while providing more opportunities for outdoor recreation. We must once again rise to a challenge: we need to find a way to manage our resource base in order to do more things for more people, while enhancing the values that sustain our quality of life.

New challenges call for new approaches. In response to a congressional mandate, the SC DNR has concluded a major planning effort to identify the challenges facing the state's diverse wildlife species and devise strategies to conserve those species and their habitats. Known as South Carolina's Comprehensive Wildlife Conservation Strategy, the result is a guide to conserving the 1,240 species of fish and wildlife that have immediate conservation needs or are key indicators of the diversity and health of the state's wildlife. Without attention, many of these species could become endangered or disappear altogether.

The Comprehensive Wildlife Conservation Strategy emphasizes a cooperative, proactive approach to conservation, inviting local governments, businesses and conservation-minded organizations and individuals to join in the task of maintaining the fish and wildlife resources that are so important in our lives. I hope you will study the Strategy carefully and join us in working to protect our fish and wildlife for current and future generations.

John Frampton
Director
South Carolina Department of Natural Resources



EXECUTIVE SUMMARY

In May of 2002, the South Carolina Department of Natural Resources (SCDNR) began a process to develop the Comprehensive Wildlife Conservation Strategy (CWCS) that was funded through the State Wildlife Grants (SWG) program. The SCDNR committed to developing the Strategy and begin implementing the conservation actions by October 1, 2005. The goal of the Strategy is to emphasize a cooperative, proactive approach to conservation while working with federal, state and local governments; local businesses; and conservation-minded individuals to join in the effort of maintaining the fish and wildlife resources of South Carolina.

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 implementation of these strategies; and (4) create public-private partnerships and educational outreach programs for broad-scale conservation efforts. South Carolina's CWCS is a first step toward instituting these actions.

The diversity of animals in South Carolina is vast. 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 for the CWCS; as such, twelve taxonomic groups are included in the Strategy: mammals, birds, reptiles, amphibians, freshwater fishes, diadromous fishes, marine fishes, marine invertebrates, crayfish, freshwater mussels, freshwater snails, and insects (both freshwater and terrestrial).

The SCDNR identified 1,240 species to include on the state's Priority Species List. Reports were prepared for each species, guild or indicator; in these reports, authors described the species, their status, population and abundance, habitat needs, challenges, conservation accomplishments and conservation actions. This approach allows 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. A separate volume, Supplemental Volume: Species and Habitat Accounts, contains these reports in their entirety. The SCDNR also identified habitats critical for the priority species considered in the CWCS. Both terrestrial and aquatic habitats were considered and reports were prepared for 38 habitats (terrestrial and marine) organized within five ecoregions, as well as 13 ecobasins, which characterize the freshwater aquatic habitats of the state. These reports are also presented in the Supplemental Volume.

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). These eight CAAs are: Education and Outreach; Habitat Protection; Invasive and Non-native Species; Private Land Cooperation; Public Land Management; Regulatory Actions; Survey and Research Needs; and Urban and Developing Lands. 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 CWCS; others may affect only a few species. Each of these actions was prioritized and measures that indicate success of implementing the action were identified.

It is also critical that we monitor priority species, their habitats and the effectiveness of the actions that are implemented to conserve them. With the information gathered in this program, project leaders will be required to produce annual progress reports for review by a steering committee and the CWCS coordination team. These reports will be evaluated for insight into adaptive management needs and reassessments of the CWCS.

From the beginning of the CWCS effort, SCDNR and the planning team sought to realize successful partnerships and public involvement in the development of the strategy. 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 nongovernmental. Task forces were convened to assist in determining important natural resource issues in South Carolina. Taxa teams were assembled to determine challenges to species and conservation actions to address those challenges. Public meetings were held to gather input from the citizens of the state. Prior to submission of the CWCS, the SCDNR began creating Conservation Action Committees around the CAAs identified above; two of these committees have convened and have begun working toward identifying statewide strategies for species and habitat conservation. Partnerships will continue to be critical in implementing the actions identified in South Carolina's CWCS.

TABLE OF CONTENTS

Foreword.....	i
Executive Summary	iii
Table of Contents	v
Chapter 1: Introduction	
Problem and Need	1-1
Legislative Mandate and Guidance	1-2
Roadmap to Required Elements in South Carolina’s CWCS	1-3
CWCS Organization	1-6
Authority and Capability of the SCDNR to Prepare and Implement the CWCS	1-7
Chapter 2: South Carolina Priority Species	
Mammals	2-6
Birds	2-8
Amphibians and Reptiles	2-11
Freshwater Fishes	2-16
Diadromous Fishes	2-19
Marine Fishes and Invertebrates	2-23
Crayfish	2-27
Freshwater Mussels	2-30
Freshwater Snails	2-34
Insects	2-35
Chapter 3: South Carolina’s Landscape	
Introduction	3-1
Introduction to South Carolina’s Ecoregions	3-3
Blue Ridge Ecoregion	3-5
Piedmont Ecoregion	3-7
Sandhills Ecoregion	3-8
Coastal Plain Ecoregion	3-11
Marine and Coastal Zone Ecoregion	3-13
Chapter 4: Statewide Conservation Strategies	
Education and Outreach	4-2
Habitat Protection	4-8
Invasive and Non-native Species	4-11
Private Land Cooperation	4-13
Public Land Management	4-14
Regulatory Actions	4-15
Survey and Research Needs	4-15

Urban and Developing Lands	4-16
Prioritized Conservation Actions and Measures of Success	4-19
Chapter 5: South Carolina Comprehensive Monitoring Program	
Purpose and Justification for Monitoring	5-1
Monitoring Programs in South Carolina	5-2
Strategies for South Carolina’s Comprehensive Monitoring Program	5-4
Monitoring Program Defined.....	5-6
Chapter 6: Partnership Development	
The Initial Stages: Drawing Plans	6-1
Planning the Strategies: Building Bridges.....	6-2
Implementation: Shaking Hands and Cutting Ribbons	6-3
Chapter 7: Prioritization, Implementation and Adaptive Management	
Setting Priorities	7-1
Implementation of the CWCS	7-3
Adaptive Management, Maintenance and Communication Plan	7-5
Review and Revision: Considering Lessons Learned	7-5
Literature Cited	LC-1
Glossary	G-1
Appendices	
1.Priority Conservation Species of South Carolina	
2.Selected List of Existing Conservation Plans	
3.Bird Prioritization Tables	
4.Existing Monitoring Programs that include South Carolina Coverage	
5.Nonexhaustive List of SCDNR Partnerships and Existing Collaborative Agreements	
6.List of Acronyms and Abbreviations	
7.Terrestrial Species Habitat Association Tables	
8.Marine Species Habitat Association Tables	
9.Freshwater Species Habitat Association Tables	
Supplemental Volume: Species and Habitat Accounts	
(under separate cover)	

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 1960's and early 1970's and were largely game-oriented.

Beginning in the 1970's, the challenges associated with sustaining wildlife populations began to change dramatically. Many states, including South Carolina, entered a period of rapid economic expansion and human population growth. During this period, the state's economy began to shift away from agriculture. Migration into the state increased greatly and a shift away from rural communities toward urban population dominance began.

Statewide, over 100,000 acres per year were converted to urban uses from 1992 to 1997, making South Carolina the ninth-ranked state in terms of total land area developed annually (USDA 1997). According to the same report, the growth rate from 1982 to 1992 was only 40,000 acres per year. The recent urban land conversion rates represent a major burst of growth; this development trend continues today.

Strong economic forces are also transforming South Carolina's agricultural economy. Rising costs, coupled with falling prices are creating hardships for many family farms. As of 1997, there were approximately 4.5 million acres in agricultural production in South Carolina, representing an 18 percent drop since 1982. Long-term declines in farmland are even more dramatic: in 1954, 124,203 farms were producing goods in South Carolina and 57.1 percent of the land in the state consisted of farms. By 1992, the number of farms in the state had been reduced to 20,242, representing 23.2 percent of South Carolina's land use (SC Department of Research & Statistical Services 1998).

As land use is converted from rural to urban uses and the population of South Carolina increases, new challenges are evident to fish and wildlife species in the state. Additionally, long-standing downward trends in numbers of some species that previously had been overlooked have become evident. In a recent state-by-state analysis of biodiversity conducted for The Nature Conservancy, South Carolina ranked 14th among all states in total number of native plant and animal species and 15th in terms of risks to native species (NatureServe 2002). In a planning

exercise conducted in 1994, DNR 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).

As times and conditions changed, new laws were enacted. In the early 1970's, 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, reptiles and amphibians, fish) were formed to provide information about species that had uncertain status or were believed to be in jeopardy (Forsythe and Ezell 1976). These expert committees have continued to meet periodically and update these lists.

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. 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 implementation of these strategies; and (4) create public-private partnerships and educational outreach programs for broad-scale conservation efforts. This Strategy is a first step toward instituting these actions.

Legislative Mandate and Guidance

The charge to state wildlife agencies to develop comprehensive strategies has 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 is referred to as a Comprehensive Wildlife Conservation Strategy (CWCS).

Roadmap to Required Elements in South Carolina’s CWCS

Congress 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 CWCS, so one document will satisfy both needs. The CWCS 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 CWCS 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.

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 CWCS. Therefore, Table 1-1: Roadmap to the Required Elements presents this information. As will become more evident in later chapters of this CWCS, the Supplemental Volume submitted with this Strategy contains reports for the species included on South Carolina's Priority Species List as well as reports for the habitats of each of the five ecoregions in this state. Each of these reports includes a description of the distribution and abundance of the species/habitat, the challenges that the species/habitats face 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. All of the information presented in these reports is summarized in the body of South Carolina's CWCS in the chapters and, in some cases, page numbers identified in Table 1-1.

TABLE 1-1: ROADMAP TO THE REQUIRED ELEMENTS

Element	NAAT Statement	SC CWCS Chapter	Page Number
1: Distribution and abundance of species	a. Sources of information	Chapter 2; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	b. Abundance and distribution	Chapter 2; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	c. Low and declining populations	Chapter 2; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	d. All wildlife groups included or statement of why not included	Chapter 2; Supplemental Volume	Page 2-1, 2-2; Entire Supplemental Volume
	e. Processes for species selection	Chapter 2	Pages 2-6, 2-9, 2-13, 2-17, 2-21, 2-24, 2-28, 2-32, 2-34, 2-36
2: Location/relative condition of key habitats	a. Explanation of level of detail	Chapter 3; Supplemental Volume	3-3, 3-5 Habitat Accounts
	b. Key habitats and their condition described	Chapter 3; Supplemental Volume	3-4 through 3-15 Habitat Accounts
3: Problems that affect species	a. Sources of information	Chapter 2; Supplemental Volume	Throughout chapter Literature Cited in Supplemental Volume
	b. Threats described in detail to allow focused conservation actions	Chapter 4; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	c. Considers threats regardless of origins	Chapter 4; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	d. Research and survey efforts identified	Chapter 4; Supplemental Volume	Page 4-15 through 16; Entire Supplemental Volume
	e. Priority research and survey needs described to allow development of projects	Chapter 4; Chapter 5; Supplemental Volume	Page 4-15 through 16 Page 5-3 through 5-6 Entire Supplemental Volume

TABLE 1-1: ROADMAP TO THE REQUIRED ELEMENTS (CONTINUED)

Element	NAAT Statement	SC CWCS Chapter	Page Number
4: Conservation actions described	a. Conservation actions address threats to species and habitats	Chapter 5; Supplemental Volume	Throughout chapter; Entire Supplemental Volume
	b. Conservation actions guide implementation through development and execution of projects and programs	Chapter 7 Supplemental Volume	7-3 through 7-5 Entire Supplemental Volume
	c. Conservation actions linked to objectives and indicators	Chapter 4; Supplemental Volume	Table 4-3, pages 4-20 through 4-34; Entire Supplemental Volume
	d. Conservation actions that can be addressed by other agencies described	Chapter 4; Supplemental Volume	Entire Chapter Entire Supplemental Volume
	e. Research or survey needs for obtaining information to develop actions is described	Chapter 4; Chapter 5; Supplemental Volume	Page 4-15 through 16 Page 5-3 through 5-6 Entire Supplemental Volume
	f. Priority of conservation actions	Chapter 4; Chapter 7	Table 4-3, pages 4-20 through 4-34 Pages 7-1 through 7-3
5: Plans for monitoring and adaptive management	a. Monitoring species and habitats	Chapter 5; Supplemental Volume	Pages 5-6 through 5-8 Supplemental Volume
	b. Monitoring outcomes of conservation actions	Chapter 5; Supplemental Volume	Page 5-10 Supplemental Volume
	c. Explanation for not monitoring a species or species group	Chapter 5	Pages 5-6 through 5-10
	d. Levels of monitoring	Chapter 5	Pages 5-6 through 5-10
	e. Utilizing existing programs or obtaining new information for effectiveness of conservation actions	Chapter 5; Appendix 4	Pages 5-2 through 5-3 Appendix 4
	f. Monitoring considers geographic scale	Chapter 5	Page 5-5
	g. Strategy is adaptive	Chapter 5; Chapter 7	Pages 5-6 through 5-10 Page 7-5
6: Review/revise Strategy	a. Process for reviewing Strategy	Chapter 7	Pages 7-5 through 7-6
7: Coordinating with federal, state and local agencies and Indian tribes	a. Coordination efforts for development of the Strategy described	Chapter 6	Entire Chapter
	b. Continued coordination efforts described	Chapter 6	Entire Chapter

TABLE 1-1: ROADMAP TO THE REQUIRED ELEMENTS (CONTINUED)

Element	NAAT Statement	SC CWCS Chapter	Page Number
8: Public participation	a. Efforts to involve the public in development of the Strategy described	Chapter 6	Page 6-1 through 6-2
	b. Continued public involvement is described	Chapter 6; Supplemental Volume	Pages 6-2 through 6-4

CWCS Organization

The CWCS is organized to first make the reader aware of the need for the Strategy then to discover how the actual CWCS was developed and presented. In the **Introduction**, a discussion of the need for the CWCS 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 the **Priority Species** chapter, along with the methods for prioritizing those species and the challenges they face. The condition and location of habitats and challenges to management of those habitats is presented in **South Carolina's Landscape**. The conservation strategies that will be implemented to address the challenges identified in the two previous chapters is discussed in detail in **Statewide Conservation Strategies**; the eight conservation action areas around which strategies will be 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 the **Comprehensive Monitoring Program** chapter. Strategies for monitoring the effectiveness of conservation actions are also discussed. SCDNR has formed extensive partnerships during development of the CWCS; these partnerships are discussed in the **Partnership Development** chapter. The manner in which SCDNR prioritized conservation actions, will implement the conservation actions in the CWCS and adapt the Strategy as new information becomes available is presented in the **Prioritization, Implementation and Adaptive Management** chapter. Finally, we include a list of references in the **Literature Cited**, a **Glossary** and **Appendices** associated with the CWCS.

As stated above, a **Supplemental Volume: Species and Habitat Accounts** is submitted with this Strategy. The Supplemental Volume contains reports for the species included on South Carolina's Priority Species List as well as reports for the habitats of each of the ecoregions in this state. Each of these reports includes a description of the distribution and abundance of the species/habitat, the challenges that the species/habitats face 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 CWCS 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 SC DNR can use the CWCS 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 SC DNR or its partners to easily convert those actions to project proposals/plans.

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

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, 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 34 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 is well equipped to lead the development and execution of the CWCS.

CHAPTER 2: SOUTH CAROLINA PRIORITY SPECIES

The State Wildlife Grants 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 with a focus on “species of greatest conservation concern;” guidance was provided to the states to begin identifying these species. 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; as such, changes in their population status are likely to indicate stress to other species that occur in the same habitat.

The diversity of animals in South Carolina is vast. 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 for the CWCS; as such, twelve taxonomic groups are included in the Strategy: mammals, birds, reptiles, amphibians, freshwater fishes, diadromous fishes, marine fishes, marine invertebrates, crayfish, freshwater mussels, freshwater snails, and insects (both freshwater and terrestrial). However, taxonomic groups that are excluded from this version of the SC CWCS may be included in future revisions of the Strategy, as additional information and experts specific to those groups are identified.

After the twelve taxonomic groups were identified, a taxa leader was appointed that managed the process for identifying priority species 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 S.C. 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.

Next, SCDNR developed a list of criteria for consideration in determination of priority species. Eight criteria were developed for this process and are presented in Box 2-1.

The process for determining priority species by each taxa committee is identified herein. 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. The species in two taxa groups, marine fishes and marine invertebrates were not categorized into priority groups due to the large number of species and the limited knowledge for those species.

Further, the insect taxa committee did not develop a comprehensive list of priority insects in South Carolina. Because even the number of species of insects in this state is not known, the taxa committee completed their work by developing a table indicating the number of species within each insect order in South Carolina. As such, numbers of insect species are not included in the total number of species on South Carolina's Priority Species List, which is presented in its entirety in Appendix 1.

BOX 2-1: EIGHT CRITERIA USED FOR DETERMINATION OF PRIORITY SPECIES

- 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 total number of species included in South Carolina's CWCS is 1,240. 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; this list excludes marine fishes, marine invertebrates and insects. Refer to Appendix 1 for lists of marine fishes and marine invertebrates.

TABLE 2-1: NUMBER OF SOUTH CAROLINA PRIORITY SPECIES

Taxa	Number of Species
Mammals (Terrestrial and Marine)	24
Birds	111
Reptiles and Amphibians	52
Freshwater Fishes	56
Diadromous Fishes	6
Crayfish (Freshwater and Terrestrial)	23
Freshwater Mussels	26
Freshwater Snails	4
Marine Fishes	163
Marine Invertebrates	775
Total Number of Species	1,240

TABLE 2-2: CATEGORIZED PRIORITY SPECIES

Taxa	Highest Priority	High Priority	Moderate Priority
Mammals	Black Bear Florida Manatee Northern Yellow Bat	Appalachian Cottontail Atlantic Right Whale Bottlenose Dolphin Carolina Red-backed Vole Dwarf Sperm Whale Eastern Small-footed Myotis Hairy-tailed Mole Humpback Whale Masked Shrew Meadow Vole Mink Pygmy Sperm Whale Rafinesque's Big-eared Bat Southeastern Bat Star-nosed Mole Swamp Rabbit	Eastern Fox Squirrel Eastern Spotted Skunk Eastern Woodrat Southern Pygmy Shrew Woodland Jumping Mouse
Birds	American Avocet American Bittern American Coot American Golden Plover American Kestrel American Oystercatcher Bachman's Sparrow Black-crowned Night Heron Black Duck Black Rail Black Skimmer Black-throated Green Warbler Brown-headed Nuthatch Buff-breasted Sandpiper Common Ground-dove Common Loon Dunlin Eastern Brown Pelican Eastern Meadowlark Eastern Wood Peewee Field Sparrow Glossy Ibis Grasshopper Sparrow Gull-billed Tern Henslow's Sparrow Kentucky Warbler King Rail Least Bittern Least Sandpiper Least Tern Lesser Scaup Lesser Yellowlegs Little Blue Heron Loggerhead Shrike Long-billed Curlew Mallard Marbled Godwit Northern Bobwhite Northern Pintail Painted Bunting Pied-billed Grebe	Acadian Flycatcher Bald Eagle Barn Owl Black-bellied Plover Black Scoter Black-throated Blue Warbler Blue-winged Teal Canvasback Forster's Tern Peregrine Falcon Redhead Semipalmated Plover Spotted Sandpiper White-winged Scoter	American Woodcock Bewick's Wren Chestnut-sided Warbler Common Loon Common Raven Dark-eyed Junco Golden-crowned Kinglet Gray Kingbird Great Blue Heron Great Egret Greater Scaup Greater Yellowlegs Green Heron Horned Grebe Long-billed Dowitcher Louisiana Waterthrush Mottled Duck Pectoral Sandpiper Purple Sandpiper Red-breasted Nuthatch Red Crossbill Ringneck Ruffed Grouse Scarlet Tanager Tundra Swan White-rumped Sandpiper Wood Duck

Taxa	Highest Priority	High Priority	Moderate Priority
Birds (continued)	Prairie Warbler Purple Gallinule Red-cockaded Woodpecker Red Knot Royal Tern Rusty Blackbird Sanderling Sandwich Tern Seaside Sparrow Semipalmated Sandpiper Short-billed Dowitcher Snowy Egret Solitary Sandpiper Stilt Sandpiper Swaison's Warbler Swallow-tailed Kite Tricolor Heron Western Sandpiper Whimbrel White Ibis Willet Wilson's Plover Wilson's Snipe Wood Stork Wood Thrush Worm-eating Warbler Upland Sandpiper Yellow-crowned Night Heron Yellow Rail		
Reptiles and Amphibians	Bog Turtle Broad-striped Dwarf Siren Carolina Gopher Frog Chamberlain's Dwarf Salamander Coal Skink Coral Snake Eastern Milk Snake Flatwoods Salamander Florida Green Watersnake Florida Pine Snake Green Salamander Green Turtle Gopher Tortoise Hawksbill Turtle Island Glass Lizard Kemp's Ridley Turtle Leatherback Turtle Loggerhead Turtle Pine Barrens Treefrog Shovel-nosed Salamander Southern Hognose Snake Tiger Salamander Timber Rattlesnake Webster's Salamander	Black Swamp Snake Canebreak Rattlesnake Chicken Turtle Diamondback Terrapin Eastern Diamondback Rattlesnake Florida Cooter Florida Softshell Turtle Four-toed Salamander Gulf Coast Mud Salamander Hellbender Mimic Glass Lizard Pickerel Frog Pine Snake Pine Woods Snake River Cooter Seepage Salamander Spiny Softshell Turtle Striped Mud Turtle Upland Chorus Frog Wood Frog Yellowbelly Turtle	American Alligator Bird-voiced Treefrog Common Snapping Turtle Northern Cricket Frog Slender Glass Lizard Southern Dusky Salamander Spotted Turtle
Freshwater and Diadromous Fishes	American Eel American Shad Atlantic Sturgeon Blueback Herring Bluebarred Pygmy Sunfish Bridle Shiner	Bannerfin Shiner Blackbanded Sunfish Carolina Darter Carolina Fantail Darter "Carolina" Redhorse Greenhead Shiner	Banded Darter Banded Killifish Blacknose Dace Bluefin Killifish Central Stoneroller Comely Shiner

Taxa	Highest Priority	High Priority	Moderate Priority
Freshwater and Diadromous Fishes (continued)	"Broadtail" Madtom Carolina Pygmy Sunfish Christmas Darter Hickory Shad Highfin Carpsucker Redeye Bass Robust Redhorse Saluda Darter Sandhills Chub Savannah Darter Shortnose Sturgeon "Thinlip" Chub	Piedmont Darter Pinewoods Darter Quillback Santee Chub Seagreen Darter Smoky Sculpin Turquoise Darter	Eastern Brook Trout Fireblack Shiner Flat Bullhead Florida Gar Greenfin Shiner Highback Chub Longnose Dace Lowland Shiner Mirror Shiner Mud Sunfish Notchlip Redhorse Pugnose Minnow Redlip Shiner River Chub Rosyface Chub Satinfish Shiner Snail Bullhead Striped Bass Tennessee Shiner Thicklip Chub V-lip Redhorse Warpaint Shiner White Catfish Whitemouth Shiner Whitetail Shiner
Crayfish	Mimic Crayfish Oconee Stream Crayfish <i>Cambarus reflexus</i> <i>Cambarus</i> sp. "B" <i>Distocambarus hunteri</i> <i>Distocambarus youngineri</i> <i>Procambarus echinatus</i> Red Burrowing Crayfish	Broad River Spiny Crayfish <i>Distocambarus crockeri</i> Pee Dee Lotic Crayfish Sandhills Crayfish Waccamaw Crayfish	Ditch Fencing Crayfish Edisto Crayfish <i>Procambarus barbatus</i> <i>Procambarus chacei</i> <i>Procambarus enoplosternum</i> <i>Procambarus hirsutus</i> <i>Procambarus lunzi</i> <i>Procambarus pubescens</i> Rocky River Stream Crayfish Santee Crayfish
Freshwater Mussels	Atlantic Pigtoe Barrel Floater Brook Floater Brother Spike Carolina Creekshell Carolina Heelsplitter Creeper Notched Rainbow Savannah Lilliput Southern Rainbow Triangle Floater Waccamaw Spike Yellow Lampmussel	Alewife Floater Eastern Pondmussel Northern Lance Pod Lance Rayed Pink Fatmucket/ Eastern Lampshell Roanoke Slabshell Tidewater Mucket	Atlantic Spike Carolina Lance Carolina Slabshell Eastern Creekshell Eastern Elliptio Variable Spike
Freshwater Snails	<i>Somatogyrus</i> spp.	Buffalo Pebblesnail Ridged Lioplax	<i>Physa</i> sp. nov "A"

Once the lists were complete, species, group or guild accounts were prepared for each animal on South Carolina's Priority Species List, with the exception of marine animals and insects. Specific accounts were not prepared for every animal on the marine fishes and invertebrate and insect lists due to the large number of species and the limited knowledge for those species. Reports were prepared for marine and insect species with known threats and/or for species that are considered indicators of challenges in a specific habitat.

In each account, authors described the species, their status, population and abundance, habitat needs, challenges, conservation accomplishments and conservation actions. This approach allows 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. A separate volume, Supplemental Volume: Species and Habitat Accounts, contains these reports in their entirety.

This chapter contains an introduction to each taxonomic group considered in the Strategy. The species selection process used by each committee is also included. 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 CWCS.

Mammals

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 four 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 Strategy, 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.

Species Selection Process

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 Strategy 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 Strategy 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.

Because South Carolina started the prioritization process after the same process was well underway in North Carolina and Georgia, we were able to benefit from the information those states had accumulated and shared.

Reviewers were asked to rank each species using the eight criteria for consideration in species prioritization. Species or subspecies were added or dropped from the list if two or more reviewers suggested the addition/deletion. If one reviewer clearly stated we 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. The intent of the conservation planning process is to periodically revisit the priority list and adjust it as more is learned about each species.

TABLE 2-3: MAMMAL TAXONOMIC COMMITTEE

Name	Affiliation
Craig Allen	SC Cooperative Fish and Wildlife Res. Unit
Mary Bunch	South Carolina Department of Natural Resources
John Cely	South Carolina Department of Natural Resources
David Cupka	South Carolina Department of Natural Resources
Rudy Mancke	University of South Carolina
Alex Menzel	US Fish and Wildlife Service
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	US Forest Service
Oscar Stewart	US Forest Service
Johnny Stowe	South Carolina Department of Natural Resources
Heather Thomas	Auburn University

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 loss 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.

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 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.

Two diseases, raccoon roundworm and Sudden Oak Death (SOD) can adversely affect mammals in South Carolina. Raccoon roundworm can infect other mammals, resulting in death. SOD attacks and destroys oak trees; these trees produce mast used as food sources for several mammals on South Carolina's Priority Species List.

Introduced and non-native species can adversely affect South Carolina's mammals. Predation by domestic or feral cats and dogs can reduce population numbers. Feral hogs can destroy habitat for many species, particularly those found in wetland habitats. Gypsy moths, like SOD can eliminate food sources for mammals.

Several species of mammals are regarded by humans as "pests;" this view can lead to persecution of these species.

One of the greatest challenges to marine mammals and manatees is boat strikes. An additional threat to these animals is entrapment in fishing devices, including hook and line and trawls.

Birds

As of 2001, 390 species of birds have been documented in South Carolina of which 179 are classified as breeders (Cely 2003). 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). Ultimately, 111 bird species were chosen for inclusion on South Carolina's Priority Species List.

Three different bird conservation regions (BCRs) transect South Carolina: 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). 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 Appalachian mountain BCR is not as important for waterfowl and shorebirds as coastal regions but it does contain the headwaters of several major river systems (US NABCI 2000).

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 short-leaf 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 comprised of 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).

Species Selection Process

The information about birds contained in the Strategy was mostly supplied by the expertise of several biologists who formed our Bird Taxonomic Committee. The members of that committee invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-4. Other sources of information included published literature and unpublished data from a variety of sources.

TABLE 2-4: BIRD TAXONOMIC COMMITTEE

Name	Affiliation
John Cely	South Carolina Department of Natural Resources (retired)
Elizabeth Ciuzio	Kentucky Dept for Natural Resources
Nathan Dias	Cape Romain Bird Observatory
Dennis Forsythe	The Citadel
Lex Glover	South Carolina Department of Natural Resources
Anna Huckabee Smith	North Carolina Department of Environmental and Natural Resources
Chuck Hunter	US Fish and Wildlife Service
Drew Lanham	Clemson University
Steve Lohr	US Forest Service
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
Felicia Sanders	South Carolina Department of Natural Resources
Craig Watson	US Fish and Wildlife Service

Species prioritization for birds relied heavily upon the Partners in Flight prioritization process. Partners in Flight (PIF) was initiated in the early 1990's and drew together many groups and individuals focused on bird conservation, knowledge and people to keep 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 six 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. The PIF scores and conservation tiers for South Carolina's priority bird species are summarized in Appendix 3: Bird Prioritization Table.

Waterbird, shorebird and waterfowl conservation priority selections depended heavily on national and international conservation plans. Birds were chosen based on their continental priorities as well as professional review of South Carolina's ecological role in the continued conservation of these birds. Plans consulted include the North American All 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.

Challenges

One of the major challenges to birds in South Carolina is loss, fragmentation and/or alteration of habitat. Birds in this state depend upon varied habitats from the mountains to the coast; changes to habitats can result in loss of feeding, breeding 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. Conversion of habitat for birds to agricultural purposes 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 plantation 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 or fragmented as a result of urban development.

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. 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.

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.

Chemical contamination threatens many carnivorous birds, particularly those that consume fish. Persistent organo-chlorine pesticides, such as DDT and heavy metals, such as lead and mercury can result in poisoning.

Several diseases and parasites can affect bird populations and/or food sources for birds. These include West Nile virus, Avian Vacuolar Myelinopathy, cholera, botulism, soft tick infestation and hemlock wooly adelgid infestations.

Non-native predators can also decimate bird populations; predation by domestic and feral cats is particularly problematic for songbirds.

Amphibians and Reptiles

Currently, 142 species of amphibians and reptiles are known to occur in South Carolina. Continued controversy over the taxonomic status of certain species or species complexes results in a lack of certainty in a fixed number of species for the state. New species have been recently discovered or described, which results in a dynamic species list.

To emphasize the way in which the species list can change, consider the following recent additions. Just in the past 30 years, the striped mud turtle, bog turtle and seepage salamander have been verified as occurring in South Carolina. In addition, two newly described species, the mimic glass lizard and Chamberlain's dwarf salamander have been added to the state's list of native herpetofauna.

More changes may be in store for South Carolina's lists of amphibians and reptiles. Several taxonomic issues involving herpetofauna in South Carolina are currently unresolved, including 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 resemble either *Desmognathus apalachicola* or *Desmognathus fuscus conanti*, neither of which has been documented for coastal South Carolina.

Ultimately, 52 reptile and amphibian species were chosen for inclusion on South Carolina's Priority Species List.

South Carolina'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. One area of South Carolina's southern coastal plain supports more frog species (25) than any other place in North America (Duellman 1999).

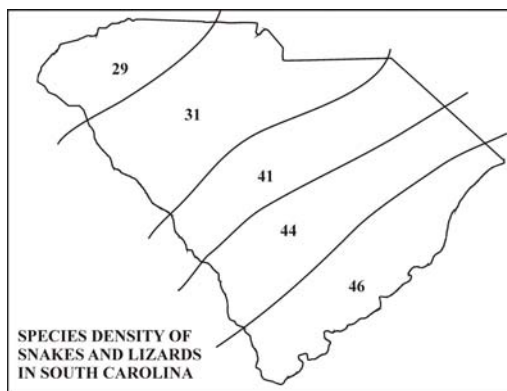


FIGURE 2-1: Species density of snakes and lizards in ecological regions of South Carolina

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 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.

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 142 species of amphibians and reptiles found in the state, 113 occur in the coastal plain and 50 of these are endemic to this province, at least in 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 sand hills, are home to the pine barrens treefrog.

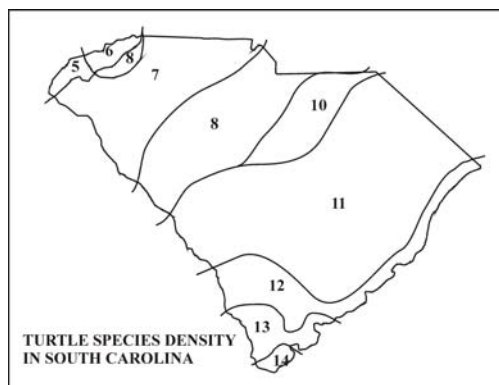


FIGURE 2-2: Species density of turtles in ecological regions of South Carolina

Species Selection Process

The amphibian and reptile portion of the Strategy has been written in a manner that incorporates a regional as well as a 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 Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-5.

TABLE 2-5: AMPHIBIAN AND REPTILE TAXONOMIC COMMITTEE

Name	Affiliation
C.L. Abercrombie	Wofford College
Steve Bennett	South Carolina Department of Natural Resources
Eric Billings	
Denise Billings	
Kurt Buhlmann	South Carolina Department of Natural Resources
Jeffrey Camper	Francis Marion University
Heyward Clamp	Edisto Island Serpentarium
John Fauth	Central Florida University
Dr. J.W. Gibbons	Savannah River Ecology Laboratory
Judy Greene	Savannah River Ecology Laboratory
Julian R. Harrison	College of Charleston (ret.)
Joey Holmes	
Jeff Humphries	Clemson University
Kevin Messenger	North Carolina State University
Brian Metts	Savannah River Ecology Laboratory
Tony Mills	Savannah River Ecology Laboratory
Richard Montanucci	Clemson University (ret.)
Zach Orr	
Gene Ott	
Corey Roelke	
David Scott	Savannah River Ecology Laboratory
Keith Taylor	
Tracey Tuberville	Savannah River Ecology Laboratory
Jayne Waldron	Clemson University
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 habitat regions of the state. A number of species did not fit easily into a functional group and are addressed individually in the CWCS. All species, whether addressed individually or in a functional group are related to a specific habitat type or several habitat types.

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 most recently in 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 the Department and Riverbanks Zoo 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 CWCS 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 CWCS. 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 have been identified as priority species, representing 37 percent of the state's species. While these 52 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 plan must take the full spectrum of South Carolina's amphibian and reptile fauna into account, documenting occurrences for all species. There are a number of amphibian and reptiles 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, southern Appalachian salamander, mole kingsnake and glossy crayfish snake are examples of species that are not well known in the state and that may be of future conservation concern.

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.

Challenges

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 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 for these species 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 plantation 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 area can disorient turtles and result in nesting failure. Road mortality is also a significant threat; urban development requires that additional roads be constructed. 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.

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; 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. Westbrook pers. com.).

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, in press). 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. Incidental take of loggerhead turtles from 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). The shark longline fishery, which operates all year long off the south Atlantic, may impact loggerheads in the neritic environment (Lewison et al. 2004).

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 the distributions of approximately 22 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.

The southeastern US is rich in aquatic fauna diversity, but some species are increasingly at risk of extinction. More than two decades ago a fish assessment of the southeastern US identified 85 fishes in jeopardy of imperilment (Deacon et al. 1979). A decade later, Williams et al. (1989)

recognized 109 southeastern fishes as in jeopardy. The most recent assessment of southeastern fishes (Warren et al. 2000) identified 187 taxa as extinct, endangered, threatened or vulnerable, which represents a 125 percent 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 in the latest assessment of southeastern fishes (Warren et al. 2000). An additional 38 fish species were determined to be of conservation concern in South Carolina; a total of 56 freshwater fishes are included on South Carolina's Priority Species List. Although many of those 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.

Species Selection Process

The information about freshwater fishes contained in the Strategy was supplied by the expertise of the biologists who formed our Freshwater Fish Technical Team (FFTT). The members of that team invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-6. Other sources of information included published literature and unpublished SCDNR and Clemson University data.

TABLE 2-6: FRESHWATER FISHES TECHNICAL TEAM

Name	Affiliation
Ron Ahle	South Carolina Department of Natural Resources
Jason Bettinger	South Carolina Department of Natural Resources
Jeff Foltz	Clemson University
Eric Krueger	The Nature Conservancy
Doug Martin	Savannah River National Laboratory
Joe Quattro	University of South Carolina
Fritz Rohde	North Carolina Division of Marine Fisheries
Jeannie Riley	United States Forest Service
Mark Scott	South Carolina Department of Natural Resources
Wayne Starnes	North Carolina State Museum of Natural Sciences
Lora Zimmerman	United States Fish and Wildlife Service

During December 2003, twelve biologists were asked to review a list of South Carolina fish 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 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.

The responses from all reviewers were then summarized to develop a preliminary list of species having the greatest conservation need in South Carolina. The summarization process was as follows. Initial trimming of the list was facilitated by asking reviewers to eliminate species that did not warrant special conservation status in South Carolina or were not primarily restricted to freshwater. A species was eliminated from the list when at least two reviewers suggested elimination and none of the other reviewers provided information for that species. All letter responses (multiple-choice questions) were assigned a numerical value (1 to 3). Within the

knowledge category, higher numbers were assigned to species with the least amount of knowledge (Knowledge of species population status; high (H) = 1, Medium (M) = 2, and Low (L) = 3). Within the conservation category, higher numbers were assigned to the species in greater conservation need (Population status; Increasing (I) = 1, Stable (S) = 2, and Decreasing (D) = 3). Among individual reviewers, the responses were averaged by species for the knowledge category and status category questions. The mean scores in both categories were then ranked by species for each reviewer. Mean ranks were then calculated for each category of questions by species when at least two reviewers provided input for that species.

The initial review by the FFTT resulted in a list of 68 freshwater fish species that warranted further discussion as to their conservation needs and status. FFTT members met on August 11, 2004 in Columbia, South Carolina to review the revised species list, make changes (species additions and deletions) and categorize the conservation needs of each fish species. The FFTT members, by consensus, ultimately identified 56 freshwater fish species of conservation concern in South Carolina and categorized them into three different levels of conservation need (highest, high, and moderate). The 56 species represent roughly 38 percent of the freshwater fishes in the state. While the fish species addressed here are thought to be the most imperiled or likely to become imperiled fish species in the state, it is not an indication that the other species that inhabit the state are stable and secure.

Challenges

One of the major challenges to freshwater fishes in South Carolina is degradation and loss of habitat. As development and urbanization 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 and 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 increased water temperature (Aust and Lea 1991; Perison et al. 1993). Forestry BMPs for bottomland forests are recommendations to landowners in order to conserve site productivity, primarily for silviculture, and are voluntary (South Carolina Forestry Commission 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, 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 1999). 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, which can reduce survival of eggs, larvae or juveniles (Rogers and Weber 1995; NMFS 1998; USFWS 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 fish (ASMFC 1990; NMFS 1998; USFWS 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 nonpoint 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).

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 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 will be addressed in a guilded approach.

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 to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-7. Other sources of information included published literature and unpublished SCDNR data.

TABLE 2-7: DIADROMOUS FISHES TAXONOMIC COMMITTEE

Name	Affiliation
Mel Bell	South Carolina Department of Natural Resources
Jason Bettinger	South Carolina Department of Natural Resources
Mark Collins	South Carolina Department of Natural Resources
Doug Cooke	South Carolina Department of Natural Resources
Billy McCord	South Carolina Department of Natural Resources
Bill Post	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) for which species reports are written are considered to be high 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 ASMFC or the 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 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, 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. 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. 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 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 decade or more has been funded by various federal grants and has 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 sufficiently 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 NMFS recovery plan for shortnose sturgeon (NMFS 1998) and other management plans, make numerous recommendations for data collection needs

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.

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.

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 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

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 3-mile territorial jurisdictional limit of the Atlantic continental shelf.

The information about marine and brackish fishes and marine invertebrates contained in the Strategy was supplied by the expertise of biologists who formed the Marine Taxonomic Committees. The members of these committees invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-8 and Table 2-9. Other sources of information included published literature, and unpublished data from various sources.

TABLE 2-8: MARINE FISHES TAXONOMIC COMMITTEE

Name	Affiliation
William Anderson	College of Charleston
Mel Bell	South Carolina Department of Natural Resources
Jason Bettinger	South Carolina Department of Natural Resources
Mark Collins	South Carolina Department of Natural Resources
Don Hammond	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
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

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. 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 would be facilitated by asking reviewers to eliminate species that did not warrant special conservation concern in South Carolina. A species was to be eliminated from the list if at least two of the reviewers suggested elimination and none of the other reviewers provided information for that species.

TABLE 2-9: MARINE INVERTEBRATES TAXONOMIC COMMITTEE

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
Pam Jutte	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
Jennifer Price	South Carolina Department of Natural Resources
Steve Stancyk	University of South Carolina
Betty Wenner	South Carolina Department of Natural Resources
David Whitaker	South Carolina Department of Natural Resources
Bob Van Dolah	South Carolina Department of Natural Resources

All identified experts were 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. Initially, reviewers were asked to eliminate species that did not warrant special conservation concern in South Carolina. A species was to be 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 changes or as indicators of population health for other species associated with similar habitats. The final list of marine and brackish fishes includes 163 species.

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 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 includes 775 species, or better, types. The classification of some "species" remains in question.

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.

One of the major challenges to marine organisms in South Carolina is degeneration and loss of habitat. As development and urbanization occurs along the coast, beaches and waterbodies 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. Stormwater runoff from developed areas contains sediment, nutrients and contaminants. These substances can substantially degrade water quality. As coastal areas are developed, more contaminants are carried in stormwater. 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 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.

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 damage sustained during harvest or stress related to harvest.

Unregulated harvest threatens some marine species. For example, South Carolina does not currently regulate a commercial cannonball jellyfish fishery. 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.

Crayfish

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 percent 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). South Carolina is the home to a diverse crayfish fauna of at least 36 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.

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, two of the species on our list are in the process of being described.

Commonly thought to inhabit strictly aquatic environments, crayfish can utilize a variety of aquatic, semiaquatic 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 and 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.

The conservation of American crayfishes has received little attention by regulatory agencies. The American Fisheries Society considered 65 species (19.2 percent) of North American crayfish as endangered, 45 (13.3 percent) as threatened and 50 (14.8 percent) as special concern (Taylor et al. 1996). Listing with the American Fisheries Society does not give species any protection. The US Fish and Wildlife service only lists four 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.

Species Selection Process

The information about aquatic and terrestrial crayfish contained in the Strategy was supplied by the expertise of five biologists. These people invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-10. Other sources of information included published literature and museum records.

TABLE 2-10: CRAYFISH TAXONOMIC COMMITTEE

Name	Affiliation
John Cooper	NC Museum of Natural Sciences
Arnold Eversole	Clemson University
Daniel Jones	Clemson University
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 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. 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.

In South Carolina's CWCS, 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 as the challenges these species face may be somewhat different than those to species inhabiting open water.

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.

The arrival of introduced species is probably the greatest challenge to crayfish (Lodge et al. 2000 a,b). The ranges and abundances of many native crayfish may have been reduced by invasive crayfish, both in the United States and in Europe (Lodge et al. 2000a; Hobbs et al. 1989). 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). 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.

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 as sensitive to water borne pollution than adults; early instars are about three times as sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were actually more abundant downstream of areas with large amounts of garbage or animal remains. Enrichment may be harmful to crayfish, however, when it results in oxygen depletion (Hobbs and Hall 1974). Pollution of groundwater may impact terrestrial burrowers, because they inhabit water trapped in their burrows.

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 Unionidae. 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, particularly genetic research, 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 improve water quality. 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 m² (19 to 37 per foot²), removing them from our rivers and streams can have drastic consequences for these ecosystems, particularly in terms of water filtering (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 1800's harvesting mussels for pearls was common. From the 1890's until the 1950's, 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).

Most freshwater mussels are dioecious (separate sexes), although a few species are hermaphroditic. After fertilization and hatching within the female, the larvae, 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 that 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 percent of mussel species were endangered and possibly extinct, 20.6 percent were endangered and extant, 14.5 percent were threatened, 24.2 were of special concern, 4.7 percent had an undetermined status; only 23.6 percent 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.

Records from the mid and early 1800's 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.

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 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. 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 the lack of researchers skilled in mussel identification and taxonomy, especially in South Carolina.

Species Selection Process

The information about freshwater mussels contained in the Strategy was supplied by the expertise of biologists who formed our Freshwater Mussel Taxonomic Expertise Committee. The members of that committee invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are listed in Table 2-11. Other sources of information included published literature and museum records.

TABLE 2-11: FRESHWATER MUSSEL TAXONOMIC EXPERTISE COMMITTEE

Name	Affiliation
John Alderman	Alderman Environmental Services
Art Bogan	NC Museum of Natural Sciences
Tom Dickinson	The Catena Group
John Fridell	US Fish and Wildlife Service
Eugene Keferl	Coastal Georgia Community College
Eric Krueger	The Nature Conservancy
Tim Savidge	The Catena Group
Jennifer Price	South Carolina Department of Natural Resources
James Williams	US Geological Survey
Lora Zimmerman	US Fish and Wildlife Service

During December 2003, biologists were asked to review a list of 29 mussel 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 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.

The Freshwater Mussel Taxonomic Expertise Committee members met on 6 August 2004 to review the revised species list, 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.

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 inch) 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, 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.

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 byproducts, 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). A recent 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 can also 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. 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 among high densities of *Corbicula*.

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*, but has not yet reached South Carolina. 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.

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 the 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 fish species is known for fewer than half of South Carolina's mussels (Bogan and Alderman 2004). Conservation of specific mussel species by protecting the host fish can only be practiced efficiently if the identity of the host fish is known. Conserving healthy aquatic environments will benefit both fish and mussels.

Freshwater Snails

Mollusks of the class Gastropoda, commonly known as snails and slugs, are found in freshwater, terrestrial and marine habitats. Terrestrial snails are not being included 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 all invertebrate groups, snails and other gastropods are in need of taxonomic and genetic work.

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, South Carolina Department of Natural Resources did not even 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 to the development of the Strategy 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.

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. 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). 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.

Insects

While insects are certainly numerous, broadly represented, and widely encountered in South Carolina, incorporating insects into the Strategy presented many challenges, most of which were unique to insects.

The foremost reason for treating insects differently from other, better-known taxa is the much larger number of insect species currently known. Approximately 1.5 million species of living organisms presently are known in the world, from bacteria to oak trees to blue whales (Hoffman and Frodsham 1993). Animals comprise 1.1 million described species; approximately three-quarters of those animal species (about 825,000) are insects. Not only are insects the single largest component of world biodiversity (Erwin 1982; 1983), they are important in human and environmental health.

Insects are divided into 32 orders, with the largest order, beetles, comprising around 500,000 different species in 125 families. It is estimated that one out of every four known animals is a beetle. Furthermore, scientists estimate that 10 percent of the animal biomass of the world is ants and another 10 percent is termites; therefore, “social insects” may account for an incredible 20 percent of the total animal biomass of our planet.

The most widely used estimate for the total number of living species is roughly three times the number currently described, around 3 to 5 million (Berry 1992). However, extrapolations of local diversity that include world rain forests elevates that figure to somewhere between 30 and 50 million (Erwin 1988, 1997; Odegaard 2000). This estimate is controversial because the larger the estimated number of species, the larger the estimated rate of species loss. It is important to note that Erwin did not present this as a definitive number, but provided his estimate in an effort to spur further research.

Species Selection Process

Ten biologically significant arthropod taxa for which sufficient knowledge exists to build a minimal database were selected, including beetles, (Coleoptera); flies (Diptera); mayflies (Ephemeroptera); true bugs (Hemiptera); wasps, ants, and their relatives (Hymenoptera); butterflies (Lepidoptera); dragonflies and damselflies (Odonata); stoneflies (Plecoptera); caddisflies (Trichoptera); and spiders (Araneae).

The task was to compile a comprehensive, multi-taxa list of South Carolina's insect species of concern, including those currently not having any listing status, those already having a State or Global Natural Heritage Ranking, and those listed as sensitive, threatened and/or endangered. Ideally, the list should include all known species within the state from which only the species of concern would be included in the CWCS. However, the lack of sufficient data to provide a valid ranking system made this master list impossible. Therefore, insect species were only tabulated and summarized, not categorized into the structured hierarchical system used for the other taxa groups. This tabulating was done for only selected taxa. The total number of species in those taxa reported in South Carolina is presented in Table 2-12.

There is a significant lack of data about insect species distribution, habitat requirements and life histories. This data deficiency made development of conservation actions highly problematic, since knowledge of a species' distribution and living requirements are fundamental to those actions. Additionally, serious data deficiency was also encountered at the genus and family levels. Therefore, this necessitated the following working model: insects will be protected whenever they live in habitats being protected for non-insects species. Rather than planning protections for a particular insect species, most of the very few State- or Federally-listed insect species are afforded protections by having their general habitat protected.

The data deficiency is complicated further by the small number of insect experts available for consultation. The members of the Insect Expert Committee invested considerable time to the development of the Strategy and are graciously thanked for their efforts; these individuals are also presented in Table 2-12.

Because of the paucity of data for most insect species, several taxonomic experts were concerned that their estimate of an insect species' rank (likelihood for survival) would be construed as legally binding and considered as "law." The consensus of the Insect Expert Committee was that this ranking would only indicate a working approximation of a species' status and range. The "S" ranking (species status in South Carolina) included in the insect species reports represents a best estimate at an insect species' status and range and has no legal standing. The number of times a species was cited from the literature, known from collection data, or was known by an acknowledged expert to occur in one or more locations would be the working basis for determining an insect's "S" ranking. This method has been used by others in similar endeavors and serves very effectively as a rough guide to the extent and level of knowledge of a species' status and range. While a low number of observations does not imply that a species is "a species of concern," the number does assist in making allocations for future research efforts.

TABLE 2-12: INSECT EXPERT COMMITTEE

Taxa Group	Family	Expert	Affiliation	Reported Species
Odonata	Dragonflies	Wade Worthen Lynn Smith	Furman University Columbia University	155
Plecoptera	Stoneflies	Boris Kondraieff	Colorado State University	84
Hemiptera	Lace Bugs	Al Wheeler	Clemson University	38
Lepidoptera	Butterflies	Brian Scholtens	College of Charleston	158
	Moths	John Snyder	Furman University	1,510
Ephemeroptera	Mayflies	Pat McCafferty	Purdue University	76
Trichoptera	Caddisflies	John Morse	Clemson University	243
		Bradley Goettle	Clemson University	
Diptera	Mosquitoes	Bill Willis	Clemson University	62
	Midge Flies	John Epler	Private Researcher	392
	Long-legged Flies	Harold Robinson	Smithsonian Institution	91
	Fruit Flies	Allen Norrbom	Smithsonian Institution	10
	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	746
	Bark Beetles	Don Bright	Agriculture Canada	64
	Fireflies	Jim Lloyd	University of Florida	37
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				4,847

Due to the large numbers of insect species, fifteen were chosen for which detailed species reports were prepared. Protection of species in other taxa and ultimate protection of ecosystems and habitats is expected to protect insects in South Carolina.

Challenges

Although we know little about most individual species, we do know that insects are incredibly adaptable and have evolved to live successfully in most environments on earth. Insects are by far the most diverse groups of animals and are a significant part of most ecosystems (Samways 1994). Yet insects are insufficiently studied and have received minimal attention from the scientific community. Insect biodiversity is being irreversibly lost through extinction caused by the alteration, degradation and destruction of natural habitats.

Identification of species is only the beginning, a fundamental necessity for all subsequent studies. Discovery of biological characteristics and living requirements of each species is the next step. Data are very scarce for most insect species beyond those observed and provided with their initial discoveries and descriptions. Closing the large data deficiency for insects is a necessary to fully understanding this taxa group.

CHAPTER 3: SOUTH CAROLINA'S LANDSCAPE

Introduction

Atop Sassafras Mountain, the highest peak in the state of South Carolina, a visitor can catch a glimpse of the splendid vistas of this state from above 3,000 feet. Mountains to the sea, South Carolina has a wide diversity of habitats, environmentally important areas and scenic resources within the boundaries of its 19.9 million acres of land and water (USDA 2000). It is the diversity of the lands and waters of South Carolina that create the myriad environments for South Carolina's varied fish and wildlife.

Demographics and Economics

In 1790, South Carolina's total resident population numbered 249,073 people. According to data collected in 2003, the US Census Bureau estimated the population of South Carolina to be 4,147,152 people, a 3.4 percent increase from 2000. South Carolina saw a 15.1 percent population increase from 1990 to 2000. The average population density in this state is 133.2 people per square mile (US Census Bureau 2005).

Of the over 19 million acres of land in the state, seven percent (over 1.3 million acres) is publicly owned, while 93 percent (17,912,789 acres) is privately owned. The vast majority of the state is characterized as nonfederal rural lands ('nonfederal' referring to all lands in private, municipal, state or tribal ownership). Land use on nonfederal lands in the state, which total 18,115,500 acres, is primarily forestland. South Carolina saw a twenty percent increase in developed lands between 1992 and 1997 (USDA 2000) and continues to see similar rates of conversion in land use.

As of 2002, there were approximately 4.85 million acres in agricultural production in South Carolina (USDA 2003). In 1982 there were approximately 5.5 million acres in agricultural production which amounts to a 12 percent drop in twenty years. The average farm in South Carolina was approximately 197 acres in size in 2002; up two percent from an average of 193 acres in 1997 (USDA 2003). The market value of agricultural products sold in 2003 totaled over \$1.6 billion with top outputs in poultry, tobacco and greenhouse/nursery production. Counties in South Carolina with the highest agricultural yields in 2002 were Lexington, Kershaw, York, Dillon and Orangeburg (USDA 2003).

South Carolina is rich in non-fuel raw minerals with a total of over \$506 million produced in 1997 (US Department of the Interior 1998). The most common minerals produced in South Carolina are: cement, clays, gemstones, peat, sand, gravel and crushed stone. In 1997, South Carolina was the top producer of vermiculite, ranked fourth in masonry cement, sixth in common clays, third in kaolin, and fifth in crude mica. Portland cement and crushed stone was estimated at \$193 and \$155 million respectively for 1997.

According to results of the US Forest Service Forest Inventory Analysis (FIA) published in 2000, 12.3 million acres of land in South Carolina is forested (Conner and Sheffield 2000)

(Figure 3-1). Nonindustrial private owners, including individual and corporate timberland owners not associated with the forest product industry, own 74 percent of these lands. Timberland ownership under corporate control has increased in recent years to 19 percent or 2.0 million acres. The percentage of forests managed by the forest products industry has decreased 14 percent, from 2.3 million to 2.0 million acres over the FIA study period. Public land ownership increased to 1.2 million acres. Total softwood production increased 14 percent to 9.2 billion cubic feet while hardwood production increase just over 4 percent to 10.2 billion cubic feet.

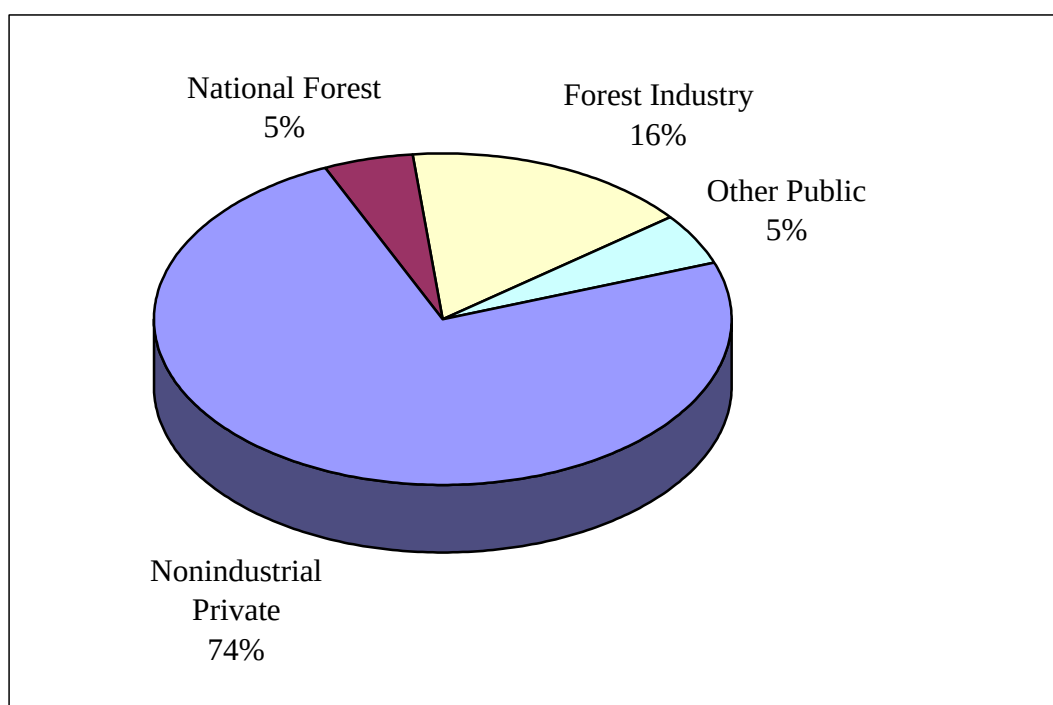


FIGURE 3-1: Distribution of forested land by ownership class in South Carolina (Conner and Sheffield 2000)

Climate

South Carolina has a humid subtropical climate. Average annual precipitation is about 49 inches per year with the coast receiving 48 to 50 inches while the Blue Ridge receives up to 80 inches per year. Average January temperatures range from 50 degrees near the coast to 38 degrees in the mountains; July temperatures average 81 near the coast and 71 in the mountains. The growing season ranges from 200 to 290 growing days. During the winter months, the state is typically under a continental air mass that is cold and dry, while during summer, the Bermuda high-pressure cell in the Atlantic drives much of the weather. Heat and humidity prevail when clockwise circulation around the Bermuda High brings a southerly flow of air from the Gulf of Mexico, a pattern that becomes rather stable as the mountains in the northwestern part of the state block any cool fronts which might arrive from the north.

The precipitation that falls in South Carolina is drained by four major river systems. All the streams and rivers that drain a region are collectively called a drainage basin. The drainage basins of South Carolina and the rivers involved are presented in Box 3-1.

BOX 3-1: MAJOR DRAINAGES OF SOUTH CAROLINA

- *Pee Dee River Basin* - Pee Dee, Lynches, Little Pee Dee, Black, Waccamaw and Sampit Rivers; drains 25 percent of South Carolina at the rate of 10.5 billion gallons per day.
- *Santee River Basin* - Santee, Congaree, Catawba-Wateree, Broad and Saluda Rivers; drains 34 percent of South Carolina at the rate of 7.5 billion gallons per day.
- *Ashley-Combahee-Edisto River Basin* - Ashley, Cooper, Edisto, Combahee, Coosawhatchie and New River; drains 26 percent of South Carolina at the rate of 5 billion gallons per day.
- *Savannah River Basin* - Savannah, Chattooga, Seneca, Little River, Stevens Creek, Rocky and Tugaloo Rivers; drains 15 percent of South Carolina at the rate of 8 billion gallons per day.

Introduction to South Carolina's Ecoregions

Many habitat types in South Carolina are strongly associated with certain geographic areas or physiographic regions within the state. Habitats in this strategy have been grouped according to five widely recognized regions, called "ecoregions" (Figure 3-1). The primary source of information on the ecoregions of South Carolina and surrounding states is the map and accompanying definitions from Griffith et al. (2002), with supplementary information for South Carolina taken from Myers et al. (1986). This chapter provides a summary of the general landscape and current condition of the five ecoregions of South Carolina. Further detailed descriptions of habitats, both terrestrial and aquatic, are provided in a separate volume, Supplement: Species and Habitat Accounts.

Habitat Classification

The principal source of information for terrestrial habitat definitions is Nelson's (1986) classification of South Carolina's natural communities. Since the viewpoint of Nelson's classification is primarily vegetation rather than wildlife, some exceptions are made. For instance, early successional upland habitat (grassland, shrubland, etc.) is extremely important to many species of wildlife. However, as a successional stage, it is not typically treated as a separate type of habitat as it is in the CWCS.

In addition, Nelson's treatment covers only terrestrial habitats, whereas many of the species covered in this plan occupy freshwater, estuarine or marine habitats. Techniques used to classify terrestrial habitats are often inadequate to describe aquatic or marine environments especially for habitats within the water column. For this strategy iteration, South Carolina habitats are divided into terrestrial, freshwater aquatic, and marine treatments. Terrestrial habitats include those found in the Blue Ridge, piedmont, sandhills and coastal plain ecoregions. Freshwater aquatics are classified by individual drainage basins and sub-basins, called ecobasins (see Table 3-1). Finally, all habitats influenced to any degree by saltwater are treated separately within marine descriptions.

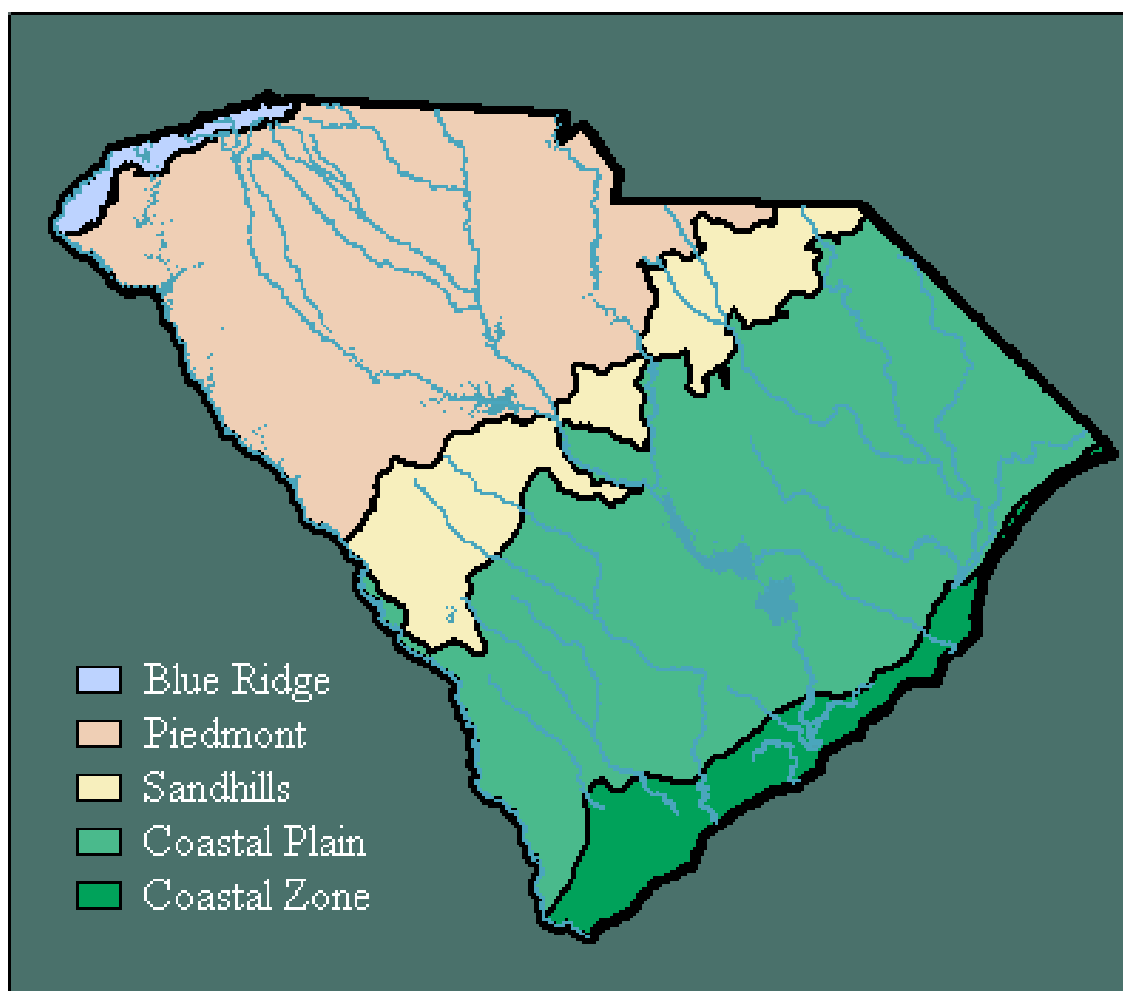


FIGURE 3-2: The five ecoregions of South Carolina. Source: Griffith et al. (2002). The Coastal Plain-Coastal Zone boundary is modified to conform to the legal delineation of the boundary between freshwater and saltwater zones for fisheries management purposes.

TABLE 3-1: Freshwater Aquatic Ecobasins by watersheds

Blue Ridge Watershed	Santee – Blue Ridge Ecobasin Savannah – Blue Ridge Ecobasin
Piedmont Watershed	Santee – Piedmont Ecobasin Savannah – Piedmont Ecobasin PeeDee – Piedmont Ecobasin
Southeastern Plains Watershed	Santee – Southeastern Plains Ecobasin Savannah – Southeastern Plains Ecobasin PeeDee – Southeastern Plains Ecobasin ACE – Southeastern Plains Ecobasin
Coastal Plain Watershed	Santee – Coastal Plain Ecobasin Savannah – Coastal Plain Ecobasin PeeDee – Coastal Plain Ecobasin ACE – Coastal Plain Ecobasin

Location Maps and Data

Ideally, information on the location and relative condition of the state's habitats would be available in the form of maps for all relevant habitats. Despite ongoing work by South Carolina's Gap Analysis Project to provide such a map from satellite-based vegetation data, the results available to date are not sufficiently accurate to provide the required information (Schmidt et al. 2001). Therefore, the descriptions of the locations and relative locations of habitats are mainly in narrative form, supported by maps and aerial photos of local areas where they are available and useful. These descriptions are included in the Supplemental Volume: Species and Habitat Accounts. An early implementation objective for the CWCS will be to make substantial improvements in the state's habitat mapping capabilities.

Blue Ridge Ecoregion

South Carolina's mountains are part of a multi-state region within the Southern Appalachians known as the Southern Blue Ridge Escarpment. The Escarpment forms an abrupt transition between higher mountains in adjoining states and the piedmont. High-gradient streams fed by high annual rainfalls carve the mountain landscape (Griffith et al. 2002). A portion of the region's northern boundary in South Carolina is formed by the Eastern Continental Divide, which provides resource managers with the rare opportunity of working with ecological and jurisdictional boundaries.

Beginning in the mid-twentieth century, a round of land consolidations began, which shifted ownership toward public and quasi-public purposes. In 1963, the Jocassee Gorges property was purchased by the Duke Power Company for hydropower development, a transfer that set the stage for the property's ultimate acquisition by the SCDNR in 1998. Other significant transfers in modern times include: Sumter National Forest, Pickens and Oconee Counties, Poinsett and Table Rock Reservoirs, Greenville County, Table Rock, Jones Gap and Caesars Head State Parks, and several acquisitions by the SCDNR. Comparison of public versus private ownership in the Blue Ridge is illustrated in Figure 3-3.

Although the Blue Ridge in South Carolina constitutes a small portion of the state's land area (328,500 acres or 1.69 percent of the total area), it supports the most extensive upland hardwood forest complex in the state. The region is rich in floral diversity, best expressed in the Mixed Mesophytic Forest vegetation community (Braun 1950), described as moist broadleaved forests that can harbor over 30 different tree species and many more types of fungi and ferns. Other biological resources unique to the region include a viable black bear (*Ursus americanus*) population extending across the North Carolina, Georgia and South Carolina state lines, sustained nesting of peregrine falcons (*Falco peregrinus*) following

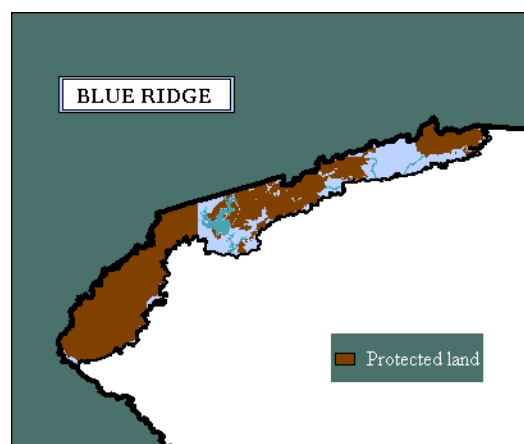


FIGURE 3-3. Major public and private lands in conservation status in the Blue Ridge. Management practices vary according to agency missions and goals. Inholdings are not shown

reintroduction in the 1980s and self-sustaining populations of native brook trout (*Salvelinus fontinalis*).

Overstory, understory, shrub and herbaceous plant communities of the Blue Ridge are generally related to topography, elevation, slope, soil type and other particular aspects of a site (Abella 2002). A few specialized habitat types, such as bogs or rock faces, are present due to unique geological formations. Habitat types in the region generally blend from one type to the next with the rare abrupt transition. Because of this integration of communities, very few animal species are strictly associated with any single habitat type. Species-habitat associations are presented in Appendix 7: Terrestrial Species Associations and described in more detail in the species and habitat accounts found in Supplemental Volume: Species and Habitat Accounts.

At higher elevations, the present Blue Ridge landscape consists of large tracts of unbroken forest. Overall condition of the forest trends toward mid-successional; both early- and late-successional ("old growth") stages tend to be lacking in the Blue Ridge. Major biological changes to forest community composition within historic times include removal of the American chestnut (*Castanea dentata*) as the dominant canopy tree species, removal of the Eastern cougar (*Felis concolor*) as the top predator and extinction of the Carolina parakeet (*Conuropsis carolinensis*).

Forest condition and age on public lands varies with ownership. Although the Sumter National Forest is managed under a multiple-use approach, recent legal challenges have significantly altered forestry operations. Current plant community composition on the National Forest is primarily a mixture of mid-successional pine-hardwood stands and managed pine-dominated stands of various ages. The SCDNR-owned Jocassee Gorges tract was heavily logged before acquisition by the SCDNR and US Forest Service was completed in 1998. Greenville Watershed and SC PRT lands have a long history of passive management.

Fire management practices also occur variably across the region, ranging from regular use of prescribed fire on the Sumter National Forest to total fire exclusion on Greenville Watershed and SC PRT lands. Current burning practices are contradictory to historic descriptions of widespread wildfires that created relatively open forest stands with sparse woody understory vegetation (Brose et al. 2001).

Habitats at lower elevations in the Blue Ridge are ecologically similar to those of the adjoining Piedmont Ecoregion. Settlement and land use patterns at these elevations are also similar to those of the piedmont; most land is in private ownership and, as such, land uses have become highly fragmented with agriculture, managed woodlands and residential uses separating tracts of natural forests. Further, many historic farming communities are undergoing rapid development as land values are increase rapidly. Amenities such as Highway 11, a scenic highway running along the base of the escarpment, SC PRT properties and Lakes Keowee and Jocassee contribute to the Blue Ridge region's popularity for recreation and development.

TABLE 3-2: Summary and brief description of habitat types found in the Blue Ridge Ecoregion

Habitat Type	General Description and Location
Appalachian Oak & Oak-Pine Forest.	Important to wildlife as the most extensive cover type in the region; vegetation composition and structure highly variable.
High-elevation Forest.	Limited in SC to the highest peaks; supports numerous species at their Southern range limits.
Moist or wet types due to unique landform	Wet places embedded within primary habitat types such as spray zones at the bases of waterfalls, waterslides, and bogs.
Vertical or Horizontal Rock Outcrop	Open rock faces ranging from nearly horizontal to nearly vertical, embedded within primary habitat types.
Riverbanks, Stream-banks, and Alder Zones	Restricted to scattered locations on relatively stable alluvium, generally along larger, lower-gradient streams; supports several riparian wildlife species.
Basic Mesic Forest	Well-developed hardwood forest on rich sites; limited in extent; important habitat for certain priority species. Equivalent to the Mixed Mesophytic Forest of Braun (1950).
Acidic Mesic Forest	Dominated by hemlock and rhododendron; common along streams and lower slopes; key habitat for wildlife species associated with riparian habitats.

Piedmont Ecoregion

The Piedmont Ecoregion occupies a hundred-mile-wide area between the Southern Blue Ridge Escarpment and the Sandhills Ecoregion. The northwestern boundary is generally considered to be the base of the Blue Ridge Escarpment; the division between the crystalline rocks of the piedmont and the sedimentary rocks of the sandhills represents the southeastern boundary of this ecoregion. The piedmont-sandhill contact zone is marked in many river channels by shoals and rock ledges that collectively form the “fall line.” Gently rolling hills with many stream-cut valleys characterize the region with only a few level floodplains. In the lower piedmont, there are relatively few sharp breaks in topography except along major river valleys.

A considerably smaller portion of forestland is in public ownership in the piedmont than in the Blue Ridge region. The U.S. Forest Service is the primary agent of land protection in the piedmont, with two large Ranger Districts of the Sumter National Forest, the Long Cane and the Enoree, located within the region. Most of the land in the piedmont is held by corporate or other private ownerships not associated with the forest product industry (Conner and Sheffield 2000).

To a greater degree than in other regions, the vegetation in the piedmont has been altered by human activity. Cotton agriculture changed much of the original hardwood and shortleaf pine (*Pinus echinata*) forests into fields. Subsequently, fields eroded due to poor agricultural practices, often losing all topsoil. By the 1930's, various factors including the Great Depression and boll weevil outbreaks as well as severe erosion led to widespread farmland abandonment. Although agricultural practices improved while farming declined during the 20th century, floodplain sediments persist, overlying former piedmont wetlands. These wetlands probably featured numerous depressions of swamp tupelo (*Nyssa biflora*) and Willow oak (*Quercus*

phellos) that served as natural 'green-tree reservoirs' for ducks and other wildlife (Ron Ahle, SCDNR, pers. comm.). Loblolly pine (*Pinus taeda*) was introduced to the piedmont during the nineteenth century as a cash lumber crop; this pine now dominates much of the region.

TABLE 3-3: Summary and brief description of habitat types found in the Piedmont Ecoregion

Habitat Type	General Description & Location
Upland Forest	Oak & hickory-dominated forest with dominant & associated tree species varying with position on slope and soil moisture. This is the primary potential vegetation type on the Piedmont. On a majority of sites it exists mostly in closed canopy pine-dominated stages that are not suitable habitat for many priority species.
Piedmont Small Stream Forest River Bottoms.(See Coastal Plain)	Hardwood-dominated forest occurring on narrow floodplains, includes elements of Coastal Plain River bottoms, although not as well developed as on the broader floodplains of the Coastal Plain. Included within the type are ponds immediately upland or within the floodplain that have some connectivity with the floodplain forest.
Cove Forest	Well-developed hardwood forests on scattered rich, generally small (<200 acre) sites, usually on protected bluffs in association with stream or river bottoms; important habitat for some priority species, notably amphibians.
Grassland & early Successional habitats (See Coastal Plain)	A variety of open-land habitats, including agricultural land, recently abandoned farmland, recently cleared land, and a matrix of managed open pine forest and grassland. Also included are golf courses and urban yards and open spaces. Generally occurs on upland sites, and the potential vegetation on most sites is Upland Forest.

Sandhills Ecoregion

The Sandhills Ecoregion is the inland portion of the coastal plain that borders the fall line. This ecoregion is frequently recognized as a physiographic province distinct from the coastal plain, although some researchers incorporate the sandhills within a broader area known as the "inner coastal plain." The sandhills form a discontinuous belt of varying width of deep sands across the middle of the state (Porcher and Rayner 2001).

Pliocene and Pleistocene sands deposited up to ten million years ago by strong southwest prevailing winds form the top layer of the sandhills (Murray 1995). These sands are a very pure and high quality source of silica; they are mined throughout the sandhills, especially in Lexington County (Murray 1995). These deep sands have created a xeric environment that supports a distinctive type of vegetation dominated by longleaf pines (*Pinus palustris*) and turkey oaks (*Quercus cerris*). This fire-adapted community burns with a frequency interval of 5 to 10 years and may be one of the oldest communities of this type in the southeast (Wharton 1978).

Major brownwater rivers that cut their way through the sandhills on their way from the mountains and piedmont to the sea include the Lynches, Wateree, Congaree and Savannah Rivers. The North and South Forks of the Edisto River are the only major rivers that originate in the sandhills.

Deep sand ridges ranging from 300 to over 600 feet above mean sea level are one of the most striking and dominant features of the Sandhills. Ridge tops of pure Lakeland and Kershaw Sands, some up to 30 feet deep (Wharton 1978), support the most extreme xeric scrub communities of longleaf pine and turkey oaks. The sandy soils on the ridges, excessively drained with low available water capacity, are low in fertility due to rapid leaching and possess little to no leaf litter (Lawrence 1976). The drier sand ridges are suitable for agriculture only when managed through fertilization and irrigation. These ridges can support timber production, particularly of longleaf pine, which is well adapted to deep, dry sandy soils.

Fire is a dominant factor in the ecology of this region. Sandhills pine forests are a fire climax community; as such, these forests are dependent on frequent ground fires to reduce hardwood competition and to perpetuate pines and grasses.

Sand ridges that have more clay and silt mixed with sand support subxeric sandhill scrub vegetation and mesic pine flatwoods. Increased plant diversity is a result of the more moderate growing conditions. Due to the increase in leaf litter, fire is an important factor in the maintenance of the subxeric scrub forest and woodlands. These subxeric to mesic communities can grade into oak-hickory forests or, in the absence of fire, they may succeed to oak-hickory forests.

Rainwater rapidly percolates through the sand ridges until it reaches hardpan, at which point it moves laterally until emerging at the surface on side slopes or near the base of sand ridges. These natural seepage areas result in distinctive wetland habitats embedded within the xeric forests and woodlands. The community type that develops is determined by the amount of water, the position on the slope and, especially, by fire. In the absence of fire, this wetland habitat can be forested with longleaf or pond pines (*Pinus serotina*) growing over a dense evergreen pocosin-like shrub layer or, with frequent fire, it can be an open hillside herb bog. Seepage accumulating at the base of the sand ridges results in a saturated zone that supports a streamside pocosin forest.

Compared to the adjoining Piedmont and Upper Coastal Plain Ecoregions, upland forest cover in the sandhills is relatively unbroken. However, numerous cycles of pine removals and exclusion of fire have left a vast, rather monotonous forest cover on much of the landscape, consisting of small longleaf pines, turkey oak and other oaks such as scrub oak (*Quercus berberidifolia*). Forests in this condition are not only unsuitable habitat for the priority species considered in this Strategy, the prevalence of forest in this condition is a primary source of concern for priority species.

Considerable effort is being made by the forestry community to encourage production of saw timber-size longleaf pines and more liberal application of fire. Encouraged by successful efforts to restore the red-cockaded woodpecker (RCW) (*Picoides borealis*) populations on public lands and extensive enrollment of private lands in the RCW Safe Harbor program, landowner interest in longleaf pine-wiregrass forest restoration seems to be increasing. Longleaf pine seedlings and technical guidance for establishing longleaf stands are also increasingly becoming more available.

Significant public land holdings in the sandhills include the US Army base Fort Jackson and the Army National Guard Leesburg Training Site; the Sandhills National Wildlife Refuge; Sandhills State Forest; major portions of the Savannah River Site; and Hitchcock Woods (operated by a private foundation). Although the impetus for conservation-oriented management on many of these facilities stems from the listing status of the RCW, the intended future condition of many forested tracts on these lands is a longleaf pine wiregrass community, with a significant portion of longleaf pine stands attaining older age classes.

TABLE 3-4: Summary and brief description of habitat types found in the Sandhills Ecoregion

Habitat Type	General Description & Location
Grassland and early successional habitats (See Coastal Plain)	Grasslands or early successional fields, with cover provided by grasses and/or weeds and with few, if any, trees. Also managed open areas such as meadows, pastures, golf courses, or expansive lawns with or without damp depressions.
Sandhills Pine Woodland	A complex of xeric pine and pine-hardwood forest types adapted to sandy soils. Principally in the Sandhills but also on fluvial sand ridges in the Coastal Plain. Absent frequent fire, a canopy of longleaf pine and a sub canopy of turkey oak prevails, interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to development of longleaf pine-wiregrass communities. On lower slopes sufficiently protected from fire, succession can proceed to oak-hickory forests similar to those of the Piedmont
Seepage Slopes	Steep slopes with a hard clay pan or fragipan below the sandy soil. Water percolating downhill is forced to the surface, which results in seasonally or permanently saturated soils. Vegetation is variable, depending on position on the slope, the amount of peat accumulation and fire history. Pond pine shrubland is representative, intergrading with fire-maintained hillside herb bogs on wetter seeps
Ponds and Depressions (See Coastal Plain)	A variety of permanently and semi-permanently flooded isolated freshwater wetlands, with open or closed canopy forest cover, including Depression Meadows, Pond Cypress Ponds, Swamp Tupelo Ponds, Pocosins, and Pond Pine Woodlands. Landforms include natural and artificial ponds dominated by cypress and/or swamp tupelo, and Carolina Bays.
Blackwater Stream Systems	Hardwood forests of narrow floodplains on tributary streams rising in the sandhills and coastal plain, supporting variants of bottomland hardwood and cypress-tupelo swamps. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets, or under suitable fire conditions, pure stands of Atlantic white cedar.
River Bottoms (See Coastal Plain)	Hardwood-dominated woodlands with moist soils that are usually associated with the floodplains of major rivers that dissect sandhills strata and form a floodplain on underlying sediments extending into the Coastal Plain. As in the coastal plain, characteristic trees include sweetgum, loblolly pine, water oak, willow oak, laurel oak, cherrybark oak, and American holly. The Cypress-tupelo swamp subtype occurs on lower elevation sites as seasonally flooded swamps. It is usually transected by tannic-acid rivers and creeks and contain oxbow lakes and pools. Dominant trees are bald cypress and water tupelo swamp gum, water elm and red maple .

Coastal Plain Ecoregion

The coastal plain is the largest ecoregion in South Carolina. Land elevation in this ecoregion begins at 270 to 300 feet at the inland boundary with the sandhills and reaches nearly to sea level at the coastal zone boundary. Although the Sandhills Ecoregion shares some of the geological history and physical features and is included in some definitions of the coastal plain, wildlife habitats in the two regions differ in some important respects. Therefore, the coastal plain and sandhills are treated as separate regions in the CWCS.

From a land use standpoint, the coastal plain consists of two significantly different landscapes. An inner belt is predominantly composed of cropland, with forest limited to small patches and hardwood “stringers” along creeks. An outer belt, sometimes called the “flatwoods” is primarily pine-dominated forest. Bisecting both belts are major floodplains, which are largely forested.

Eight major habitat types are defined for the coastal plain, of which six are either unique to the region or reach their greatest extent there. The predominant habitat types that most casual observers associate with the coastal plain are 1) grassland and early successional habitats, 2) pine woodland, and 3) river bottoms. Although the remaining types are less extensive, they provide habitat diversity that is important to a number of species, especially wetland species.

Grasslands or early successional fields include those with cover provided by grasses and/or weeds and with few, if any, trees. These sites also include managed open areas such as meadows, pastures, golf courses, or expansive lawns with or without damp depressions. These fields occur throughout the region; more extensively in the inner “agriculture belt.” Pine woodlands include all pine-dominated forests throughout the ecoregion. They include tracts that occupy a variety of soil moisture characteristics except floodplains. The canopy is dominated by one or several species of pine, generally loblolly (*Pinus taeda*), or longleaf (*Pinus palustris*), depending on elevation, soil type and silvicultural history. Dense shrub thickets of hollies (*Ilex* spp.) and wax myrtle (*Morella cerifera*) may be found throughout stands. Finally the river bottoms of the coastal plain include a variety of hardwood and hardwood-pine communities occupying the floodplains of small streams and infrequently flooded flats in association with streams or rivers. These flats are often characterized by the presence of American beech (*Fagus grandifolia*) and occur in scattered locations on sheltered sites with moist soils, particularly on north-facing river bluffs and on slopes of drains and creeks.

The coastal plain has been predominantly used for agricultural purposes since settlement by Europeans in the 18th century. Uplands and the better-drained terraces were cleared for fields at the same time that extensive longleaf pine and swamp hardwood forests on mesic and wet sites were cleared to supply timber, generally for export to the north. Several cycles of short-rotation pine forest were favored, along with agricultural practices that often provided substantial edge habitat for game species such as quail, but also deep woods or swamp habitat for deer, turkey, and waterfowl. By the late 20th century, economic conditions began to favor consolidation of land into larger holdings and the practice of clean field agriculture, along with shorter rotations of both upland and lowland timber. Extensive holdings in the flatwoods belt were also assembled as recreational hunting reserves and managed primarily for production of game species, with timber production to offset management expenses.

TABLE 3-5: Summary and brief description of habitat types found in the Coastal Plain Ecoregion

Habitat Type	General Description & Location
Grassland and early successional habitats	Grasslands or early successional fields, with cover provided by grasses and/or weeds and with few, if any, trees. Also managed open areas such as meadows, pastures, golf courses, or expansive lawns with or without damp depressions. Occurs throughout the region; more extensively in the inner "agriculture belt."
Pine Woodland	Includes all pine-dominated forests throughout the region, including those occupying a variety of soil moisture characteristics except floodplains. The canopy is dominated by one or several species of pine, generally loblolly (<i>Pinus taeda</i>), or longleaf (<i>Pinus palustris</i>), depending on elevation, soil type and silvicultural history. Dense shrub thickets of hollies (<i>Ilex</i> spp.) and wax myrtle (<i>Morella cerifera</i>) may be. Higher elevation Pine Woodlands have abundant grasses and herbs, particularly when burning is frequent.
Sandhill Pine Woodland (See Sandhills)	A complex of xeric pine and pine-hardwood forest types adapted to sandy soils. Occurs principally in the Sandhills but also on fluvial sand ridges in the Coastal Plain. Absent frequent fire, a canopy of longleaf pine and a subcanopy of turkey oak prevails, interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to development of longleaf pine-wiregrass communities.
Upland Forest (See Piedmont)	Forests dominated by hardwoods, primarily with oaks and hickories, and typically on fire-suppressed upland slopes near river floodplains or between rivers and tributaries. Vegetation composition is similar to oak-hickory forest in the Piedmont, where it is a major vegetation type. Upland forest is rare in the Coastal Plain. It Intergrades with River Slopes and is lumped with this type for species treatments (see below). Representative canopy trees are: white oak (<i>Quercus alba</i>), black oak (<i>Quercus velutina</i>), post oak (<i>Quercus stellata</i>), mockernut hickory (<i>Carya tomentosa</i>), pignut hickory (<i>Carya glabra</i>), loblolly pine (<i>Pinus taeda</i>), flowering dogwood (<i>Cornus florida</i>) and black gum (<i>Nyssa sylvatica</i>).
Ponds and Depressions	A variety of permanently and semi-permanently flooded isolated freshwater wetlands, with open or closed canopy forest cover, including Depression Meadows, Pond Cypress Ponds, Swamp Tupelo Ponds, Pocosins, Limestone Sinks and Pond Pine Woodlands. Landforms include natural and artificial ponds dominated by cypress and/or swamp tupelo, limestone sinks, and Carolina Bays. Occur extensively throughout the region, more extensively in the outer "Atlantic Coast Flatwoods" belt.
River Bottoms	Hardwood-dominated woodlands with moist soils that are usually associated with major river floodplains and creeks. May contain small creeks or pools and may be seasonally flooded. Characteristic trees include: sweetgum (<i>Liquidambar styraciflua</i>), loblolly pine (<i>Pinus taeda</i>), water oak (<i>Quercus nigra</i>), willow oak (<i>Quercus phellos</i>), laurel oak (<i>Quercus laurifolia</i>), cherrybark oak (<i>Quercus pagoda</i>) and American holly (<i>Ilex opaca</i>). In the Southern coastal counties on drier sites, spruce pine (<i>Pinus glabra</i>) may be an associate. The Cypress-tupelo swamp subtype occurs on lower elevation sites as seasonally flooded swamps. It is usually transected by tannic-acid rivers and creeks and contains oxbow lakes and pools. Dominant trees are bald cypress (<i>Taxodium distichum</i>) and water tupelo (<i>Nyssa aquatica</i>), swamp gum (<i>Nyssa biflora</i>), Carolina ash (<i>Fraxinus caroliniana</i>), water elm (<i>Planera aquatica</i>) and red maple (<i>Acer rubrum</i>).

Habitat Type	General Description & Location
River Slopes and Stream Bottoms	<p>A variety of hardwood and hardwood-pine communities occupying the floodplains of small streams and infrequently flooded flats in association with streams or rivers.</p> <p>Several mixed mesophytic subtype characterized by the presence of American beech occur in scattered locations on sheltered sites with moist soils, particularly on north-facing river bluffs and on slopes of drains and creeks.</p> <p>The calcareous cliff and marl forest subtype occurs on circumneutral soils derived from limestone or unconsolidated calcareous substrates such as marl.</p>

Coastal Zone and Marine Ecoregion

The coastal zone is that portion of the lower coastal plain that lies seaward of US Highway 17. This region includes a small portion of the mainland, but is primarily comprised of tidal marshlands and associated uplands that include large sea islands that are greater in size than 1,000 acres (404.69 hectares) and extends eastward to include barrier islands, Atlantic Ocean beaches and the Atlantic Ocean shallow continental shelf offshore to South Carolina's 4.8-kilometer (3-mile) jurisdictional boundary. The lower approximately 32 to 48 kilometers (20 to 30 miles) of all of the State's coastal rivers is included in the coastal zone.

The inland boundary of the coastal zone is somewhat arbitrary relative to mainland habitats, but is particularly relevant to riverine and alluvial habitats since Section 50-5-80 of the Code of Laws of South Carolina establishes boundaries for fresh and 'marine' waters that generally are associated with US Highway 17. These boundaries were established primarily for wildlife law enforcement concerns related to the enforcement of freshwater and marine fishery laws and regulations. The actual point at which riverine waters change from fresh (less than 0.5 parts per thousand salt) to brackish or 'marine' (greater than 0.5 parts per thousand salt) is highly variable, even daily, depending on the combined impacts of tides and river discharge as determined by rainfall or water releases from dams. During each approximately six-hour tide cycle from maximum ebb or low tide to maximum flood or high tide, the point of change from fresh to slightly brackish water may move several miles upriver, only to return downriver during the next ebb tide period.

The coastal zone contains the most diverse myriad of habitats of any of the ecoregions of the state and is treated somewhat separately from the other ecoregions because of this complexity. Many habitats within the region that are very important to wildlife species are completely dependent upon the influence of salt water and direct management action, such as coastal impoundments. In some cases it was inappropriate to classify the habitats solely based on vegetation. Further detail on habitats within the ecoregion are included in the Supplemental Volume: Species and Habitat Accounts.

Diverse forest types are distributed throughout the extreme eastern portion of the lower coastal plain mainland that is adjacent to estuaries and tidal river basins. Due to this proximity, large coastal zone islands, including barrier islands, sea islands and many hammock islands, also support forested habitats very similar to those found in the lower coastal plain. Forested habitats distributed within both the coastal zone and coastal plain include the following: bottomland hardwood, pine woodland, oak-hickory or hardwood dominated, mixed mesic hardwood and bald cypress-tupelo gum swamp. Larger landmasses within the coastal zone also contain

grassland and early successional habitats and wet flatwood. Ponds and depressions, or wetlands isolated from tidal waterways, occur in the coastal zone as well, including interdune ponds that are restricted to dune systems along the Atlantic Ocean beaches.

Much of the South Carolina coastal zone ecoregion has been affected by human population growth and associated development. By the early 1990's, about 50 percent of the total United States' human population lived in coastal areas (Moore et al. 1995); the trend of concentrated growth along coasts is expected to continue into the next century (Cullitan et al. 1990). About 88 miles (48.6 percent) of South Carolina's beachfront is currently developed (Kana 1988). The high concentration of human population growth and development in the coastal zone has fragmented forests and reduced other valuable habitats, such as shrub thickets and isolated wetlands.

TABLE 3-6: Summary and brief description of habitat types found in the Marine and Coastal Zone Ecoregion

Habitat Type	Habitat Definition
Forested Habitats of the Coastal Plain	Typical Coastal Plain pine and hardwood forests that extend into the Coastal Zone, sometimes with variations due to coastal influences or land management practices peculiar to the Coasts: Included Pine Woodland, Bottomland Hardwoods, Upland Oak-hickory forest, Southern Mixed Hardwood Forest, Marl Forest and Calcareous Cliff, and Cypress-tupelo swamp types. Cypress-tupelo swamps within the Coastal Zone may be influenced more by tidal activity than by river flows, but the water is typically fresh or nearly so. Cypress-Tupelo swamps may also be isolated from rivers and may be remnants of relict ricefield reserves.
Maritime Forest	Forests of the immediate Coastal Zone and typically occurring on barrier islands and immediately inland of dune systems and the Atlantic Ocean coast. Characteristic trees include live oak, laurel oak, cabbage palmetto, southern magnolia and southern red cedar. These evergreen-dominated forests are salt-tolerant and often support shrub thickets with yaupon holly, red bay and wax myrtle.
Early successional habitats of the Coastal Plain	Typical Coastal Plain upland grasslands or early successional fields extending into the Coastal Zone, with cover provided by grasses and/or weeds and with few, if any, trees. Also Meadows, pastures, golf courses, or expansive lawns with or without damp depressions.
Ponds & Depressions	Isolated wetlands including both natural and manmade ponds, pools, ditches and depressions. Some pools, called vernal pools, hold water only temporarily or seasonally vernal pools. Depression pools may occur in low areas or depressions. Interdune ponds are associated with Atlantic Coast beach dune systems. This is a highly variable habitat group in both water quality and vegetation. Such isolated wetlands may be imbedded within forest or other upland habitats.
Managed Impoundments	Impounded marshlands that are generally relict ricefields. Most of such impoundments are managed for waterfowl. Water quality, seasonality of water coverage and vegetation type are dependent upon management activity. Relict impoundments with breached or eroded, nonfunctional dikes are considered tidal marshlands.
Tidal Fresh and Brackish Systems	A complex of marshlands, sandbars, mud flats, sand flats, and waterways that are subject to mixing of salt and freshwater flows, usually in association with a freshwater source such as a river delta. Marsh vegetation is predominantly grasses, sedges and herbs with few trees; species makeup depends on salinity. Submerged vegetation may occur as well.

Habitat Type	Habitat Definition
Estuarine systems	A complex of marshlands, exposed flats of sand and/or mud, and tidal creeks that make up the coast's estuarine zone. Smooth cordgrass (<i>Spartina alterniflora</i>) is the dominant marsh plant, with black needlerush (<i>Juncus roemerianus</i>) and various shrub species occupying zones of slightly higher elevation and lower salinity. Salt flats vegetated with various salt-tolerant plant species are interspersed throughout the marsh. Oyster Bars or reefs composed primarily of live and dead eastern oysters occur throughout, usually in flats between tidal channels and salt marsh.
Isolated nonforested uplands	Generally small islands of mostly sand and isolated within sounds and bays or inlets. 'Inlet islands' usually have beaches and variably developed dune systems. 'Bay islands' are more protected from salt spray and wave action and may support silt-shrub plants. Can include manmade or man-altered islands with dikes to contain dredged material. Can also include sandbars and shell rakes that are at least partially exposed during all tide cycles and river stages, except under unusually high tides or flows. More stable sandbars may be partly colonized by grasses and shrubs.
Hammock Island	Vegetated islands within tidal marshlands that are <1000 acres in size. These islands, and particularly larger islands of higher elevation and variable topography, often support diverse habitat types, including isolated low-salinity wetlands.
Ocean beaches and transition zones	That portion of the Atlantic Ocean beach dune system vegetated by grasses and herbs or by a maritime shrub thicket. Dune habitat includes sand dunes and swales, flats and pools between dunes and between dunes and other features. Characteristic plants include sea oats, bitter panicgrass, seabeach evening primrose and dune waterpennywort. Seaward of the dune system, sandy flats may occur in areas where dunes have been eroded. These areas are influenced by windblown salt spray and sand and may be occasionally flooded, particularly during storms.
Marine Ecosystem	Habitats directly influenced by Atlantic Ocean seawater, including the intertidal beach, the surf zone, and the waters, sediments and structures of the Atlantic continental shelf extending offshore to the 3-mile State territorial limit. The surf zone, or submerged portion of the beach area is heavily influenced by turbulence from wave action. Seaward of the surf zone, the shallow shelf is composed of soft bottom, live (hard) bottom and pelagic (water column) habitats.
Man-made structures	Submerged structures including piles, jetties and artificial reefs. In estuarine and fresh and brackish systems, a broad variety of manmade items may occur in submerged or intertidal areas and/or extend above the water

CHAPTER 4: STATEWIDE CONSERVATION STRATEGIES

Having identified 1,240 priority species within South Carolina and, using currently available data, the current condition (including the condition of “unknown”) of these species and their habitats, as well as the challenges to those species and habitats, the focus now moves to conservation strategies to address those challenges. 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). These CAAs are presented in Box 4-1.

Because major challenges to species and habitats are similar across taxonomic groups and habitats, conservation strategies to address those challenges are also similar. In order to simplify the strategies South Carolina will employ to address threats, recommended species and habitat strategies are consolidated in this chapter by CAA. The specific conservation actions proposed for each species are presented in a separate volume, Supplemental Volume: Species and Habitat Accounts.

BOX 4-1: 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

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 CWCS; others may affect only a few species. In this chapter, the priority of each action is identified in brackets after each action. A brief discussion of conservation action prioritization is presented at the end of this chapter; a more complete discussion is presented in Chapter 7: Prioritization, Implementation and Adaptive Management.

Additionally, SCDNR recognized that there are overarching conservation strategies that are likely to assist in protecting wildlife and habitats statewide. Therefore, SCDNR determined that formation of Conservation Action Committees around each of the CAAs identified above 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 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 CWCS; the resulting conservation strategies are contained herein. Additional committee meetings will be held for the remaining CAAs as the CWCS is being implemented; resulting conservation strategies will be included in future revisions of the South Carolina CWCS.

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.

SCDNR currently has two education sections: one is based in Columbia and is managed by the Outreach and Support Services Division (OSS); the other is based in Charleston and is managed by the Marine Resources Division (MRD). Both sections are involved with formal education programs and public outreach programs. Many other sections throughout the SCDNR conduct outreach and education efforts specific to their program areas. Box 4-2 outlines current programs that are based in SCDNR and programs for which SCDNR is a major contributor or partner.

Box 4-2: SCDNR EDUCATION AND OUTREACH PROGRAMS

FORMAL EDUCATION PROGRAMS

- **Animal Program:** This program is designed to introduce students K-12 to the DNR and how the DNR protects and conserves our state natural resources. This program involves the use of live animals, mounts and “hands on” learning.
- **Aquatic Project WILD:** An interdisciplinary environmental and conservation education program of instructional workshops and supplementary curriculum materials for K-12 teachers emphasizing aquatic wildlife and ecosystems.
- **Boater Education Program:** This program teaches basic boating safety including proper safety equipment, navigation rules, boat trailering and preventive routine boat maintenance.
- **Becoming an Outdoors Woman:** This program exposes women over 18 years old to nature related outdoor activities such as hunting, fishing, bird watching, camping and more.
- **Camp Wildwood:** A week-long camp designed for high school students to increase their knowledge and experience with natural resources management.
- **Carolina Coastal Adventure:** A weekend workshop for high school students to study the coastal environment.
- **Coastal Discovery Cruise Program:** Cruise the coastal habitats on SCDNR’s educational vessel, *Discovery* and learn about immediate areas of concern within the coastal and inland regions of South Carolina, such as water quality, endangered species, and threatened habitats. Groups have the opportunity to discuss the biology of estuarine animals and plants with hands-on learning when the trawl drags in an array of marine species.
- **Earth Science Education Program:** Promotes the understanding of South Carolina’s geology, mineral resources and the principles of Earth Science.

Box 4-2: SCDNR EDUCATION AND OUTREACH PROGRAMS (CONTINUED)**FORMAL EDUCATION PROGRAMS (CONTINUED)**

- **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.
- **Graduate Student Guidance and Training:** This program provides logistical and staff support to state colleges and universities for graduate and undergraduate training of marine science 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.
- **Minorities in Marine and Environmental Science:** This program is a mentor-based summer program that provides college level minorities with training opportunities in marine and environmental science.
- **Project WET:** An interdisciplinary water education program of instructional workshops and supplementary curriculum materials for K-12 teachers emphasizing water related topics.
- **Project WILD:** An interdisciplinary environmental and conservation education program of instructional workshops and supplementary curriculum materials for K-12 teachers emphasizing terrestrial wildlife and ecosystems.
- **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.
- **Trapper Education Program:** This program includes discussions on furbearer biology, history of the fur trade, wildlife management principles, fur harvest regulations and ethical conduct.
- **Weather and Climate Science Education:** Resources are provided to teacher through access to real-time weather and climate data, student interactions, teacher workshops and more.

OUTREACH PROGRAMS

- **4-H FACE for Wildlife Contest:** FACE (Food and Cover Establishment) for Wildlife is an annual statewide contest for youth that consists of planting and establishing food plots.
- **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 cleanup of inland and coastal waterways.
- **Coastal Workshops:** These workshops are offered to teachers, students, lawmakers and business and community leaders to learn more about salt marsh ecology and estuarine animals.
- **Fishing Rodeos:** Youth fishing rodeos promote fishing as a positive alternative to the dangerous influences that abound in our society.
- **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.
- **Reel Art:** This contest enables students in grades K-12 to express their feelings of natural resources through their art and increases awareness of the aquatic environment in an artistic manner.
- **Reel Kids:** This program allows students to work toward goals like catching their first fish, learning about fish and improving their habitats.
- **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.

BOX 4-2: SCDNR EDUCATION AND OUTREACH PROGRAMS (CONTINUED)**OUTREACH PROGRAMS (CONTINUED)**

- **Young Outdoor Writers' Competition:** This is a natural resource magazine-article writing contest for students in grades 5 through 12.
- **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.

OUTREACH EVENTS

SCDNR participates in many events throughout the state that allow education and outreach about the agency's mission and it's programs including the following:

Legislative Outreach Expo	Palmetto Sportsmen's Classic
Shallow Water Expo	Festival Hispano
Myrtle Beach Show	Southeastern Wildlife Exposition
Charleston Boat Show	Charleston In-Water Boat Show
Greenville Boat Show	

PUBLICATIONS

SCDNR provides many publications around all programs including the following:

Brochures	In-depth Reports
Newsletters	Books
Websites	<i>South Carolina Wildlife Magazine</i>

Although education and outreach may not directly contribute to management of 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 public meetings 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.

Conservation Actions

- 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]
- 2) Develop and enhance education and outreach programs that encourage land stewardship values, particularly to private landowners in priority habitats. [Highest priority]
- 3) Develop and enhance education and outreach programs that inform the public about the importance of prescribed burning to benefit wildlife species. [Highest priority]
- 4) Ensure that accurate information about priority species and their habitats is made available, both within 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]

- 5) Promote partnerships, both in development and implementation of education and outreach programs. [High priority]
- 6) Promote volunteer participation, both in education and outreach programs as well as in data collection. [High priority]
- 7) Develop and enhance education and outreach programs that inform the public about the detrimental impacts of litter on priority species. [Moderate priority]
- 8) Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails. [Moderate priority]
- 9) Develop and enhance programs that educate fishermen about employing correct techniques for capture and release of marine mammals, fish and invertebrates and programs that educate fishermen about the importance of reporting ship strikes and entanglements to authorities. [Moderate priority]
- 10) Utilize a variety of methods for information dissemination including:
 - a. Printed materials
 - b. Websites
 - c. Formal education/outreach programs
 - d. Updates to existing education curricula
 - e. Demonstration sites
 - f. Landowner workshops
 - g. Media[Moderate priority]
- 11) Develop and enhance education and outreach programs that discourage stocking, release and transplanting nonnative animal and plant species throughout South Carolina. [Moderate priority]

Education and Outreach Conservation Action Committee

SCDNR recognized that there are many education/outreach programs being conducted throughout the state. Many public agencies, private organizations, educational institutions and industries provide such programs to the citizens of South Carolina. SCDNR further recognized that it would be impossible to achieve our goals without the valuable assistance offered by these entities and their programs. Therefore, partners were invited to participate in workshops to discuss natural resource education in South Carolina. Two Education and Outreach Committee workshops were held: one in Columbia and one in Charleston. Table 4-1 contains a list of participants and their affiliation.

At these meetings, partners were asked to identify major overarching education and outreach recommendations that would affect activities throughout the state of South Carolina. Both groups independently determined that in order to better insure consolidated and uniform messages are

being presented to the public, a catalogue of all natural resources programs offered in the state is badly needed. This catalogue should include contact persons for each program offered. The amount of information that this catalogue could contain is huge; further, programs are constantly being developed, contact people change routinely and information that needs to be included in individual programs constantly needs to be updated. Both groups also determined that partnerships between all natural resource education and outreach programs could be bolstered by development of South Carolina's CWCS.

TABLE 4-1: EDUCATION/OUTREACH CONSERVATION ACTION COMMITTEE ATTENDEES

Name	Affiliation
Wendy Allen	National Estuarine Research Reserve
Neil Bartley	South Carolina Department of Natural Resources
Steve Bates	South Carolina Department of Natural Resources
Dana Beach	South Carolina Coastal Conservation League
Devon Beaty	South Carolina Department of Health and Environmental Control
Melissa Bimbi	US Fish and Wildlife Service
Joy Boswell	South Carolina Department of Natural Resources
Warren Chavous	University of South Carolina - Salkehatchie
Jody Childs	University of South Carolina - Aiken
Janet Clark	South Carolina Department of Health and Environmental Control
Amy Curran	South Carolina Department of Health and Environmental Control
Larry DeLancey	South Carolina Department of Natural Resources
Caroline Foster	South Carolina Department of Natural Resources
Elaine Freeman	South Carolina State Park Service
Lex Glover	South Carolina Department of Natural Resources
Karen Hall	Clemson University
BeBe Harrison	South Carolina Department of Natural Resources
Sara Hartman	The Nature Conservancy
Will Haynie	Low Country Land Trust
Mischa Hey	The Nature Conservancy
Paula Keener-Chavis	National Oceanic and Atmospheric Administration
Susan Lovelace	National Oceanic and Atmospheric Administration
Whit McMillan	South Carolina Aquarium
Jennie Morris	South Carolina Forestry Commission
Lori Nowell	Sandhill Research Center
Michael Provost	The Nature Conservancy
Virginia Roberson	Centers for Ocean Sciences Education Excellence
Al Segars	South Carolina Department of Natural Resources
Lundie Spence	Centers for Ocean Sciences Education Excellence
Anna Toline	National Estuarine Research Reserve
Ernie Wiggers	Nemours Wildlife Foundation

As stated above, SCDNR is aware that information about our priority species is scarce and has currently not been provided to all partners throughout the state; SCDNR will strive to provide that information in the future. A suggestion was made to develop a map that would identify the locations of priority species and habitats to allow educators throughout the state to pick species and habitats for new program development. This map should be provided to all education and outreach entities in South Carolina.

Creation of a natural resource information database was also determined by the groups to be of major importance. As part of the CWCS process, SCDNR will be developing a department-wide database that will house all available data and information for the species on the priority list and their habitats. Although SCDNR cannot require all outside entities to submit data they collect on these species, all partners will be encouraged to submit data for inclusion in the SCDNR database. This database will allow anyone access to view this information. Quick and easy access to such data will enhance existing education and outreach programs throughout South Carolina.

Because there are 1,240 species on South Carolina's Priority Species List, it will be very difficult to develop separate education and outreach programs for each one. Therefore, it seems prudent to limit programs to a few "poster species" that will highlight conservation messages in each ecoregion of South Carolina. Further, existing programs should be enhanced to include priority species and their habitats into existing programs.

Education and Outreach Conservation Action Committee Recommendations

- 12) Ensure that all SCDNR employees are working to provide education and outreach information to partners and citizens of South Carolina by doing the following:
 - a. Dissemination of information to partners;
 - b. Cataloguing education and outreach programs in the state;
 - c. Updating the website catalogue annually; and
 - d. Coordination of priority species education and outreach efforts throughout the state.[Highest priority]
- 13) 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]
- 14) 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]
- 15) 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]
- 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]

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 6: Partnership Development). The importance that 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 SCDNR habitat protection programs and partnerships is presented in Box 4-3.

BOX 4-3: SCDNR HABITAT PROTECTION PROGRAMS

- **The Heritage Trust Program:** Established to preserve those natural features and cultural remains. The purpose of the program is to inventory, evaluate and protect the elements considered the most outstanding representatives of South Carolina's heritage.
- **Forest Legacy Program:** The purpose of the program is to identify and protect environmentally important forest land from conversion to non-forest uses, through the use of conservation easements and fee purchases.
- **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; 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 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 316,160 ha (128,000 ac) in the Basin have been protected through conservation easements, management agreements, and fee title purchases.
- **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.
- **Forest Stewardship Program:** In partnership with the South Carolina Forestry Commission, Clemson Extension Service and the Natural Resource Conservation Service, SCDNR provides a technical service program designed to encourage multiple resource management on private non-industrial forestlands.
- **The South Carolina Conservation Bank 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 will oversee the disbursement of grants to protect land. SCDNR acts as an advisor to this board.

BOX 4-3: SCDNR HABITAT PROTECTION PROGRAMS (CONTINUED)

- **National Estuarine Research Reserve System:** In partnership with the National Oceanic and Atmospheric Administration, SCDNR helps communities develop strategies to deal successfully with coastal resource issues including habitat restoration.
- **South Carolina Land Trust Network:** 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, SCDNR coordinates an annual, nationwide cleanup of inland and coastal waterways.

Historically, species conservation and management efforts have been employed to address single species to the exclusion of others occurring in the same habitat. However, SCDNR 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.

Loss and fragmentation of habitat have been identified as a major threat to many of the species included in South Carolina's Plan. 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. However, acquiring land 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 SCDNR partner with other agencies and organizations to acquire and manage lands that are available for conservation.

Even if SCDNR or partners do not own lands, there are ways of protecting habitats. Coordination of wildlife goals and strategies during land planning processes and 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 Strategy, education and outreach is imperative in the protection of the state's habitats.

Conservation Actions

- 1) Acquire property for protection of priority species and to ensure habitat linkage through fee simple acquisition and conservation easements in the following habitats:

Terrestrial Habitats

- a. Appalachian Oak and Oak-Pine Forest
- b. Basic Mesic Forest
- c. Acidic Mesic Forest
- d. High-elevation Forest
- e. Riverbanks, Streambanks and Alder Zones
- f. Moist or Wet Types
- g. Vertical or Horizontal Rock Outcrop
- h. Upland Forest
- i. Piedmont Small Stream Forest

- j. River Bottoms
- k. Cove Forest
- l. Grassland and Early Successional Habitats
- m. Sandhills Pine Woodland
- n. Seepage Slopes
- o. Ponds and Depressions
- p. Blackwater Stream Systems
- q. Pine woodland
- r. Upland Forest
- s. Wet Flatlands
- t. River Slopes and Stream Bottoms

Watersheds

- a. Santee River Watershed
- b. Savannah River Watershed
- c. Pee Dee River Watershed
- d. ACE Basin Watershed

Coastal and Marine Habitats

- a. Forested Habitats of the Coastal Plain
- b. Maritime Forest
- c. Early Successional Habitats of the Coastal Plain
- d. Managed Impoundments
- e. Tidal Fresh and Brackish Systems
- f. Isolated Nonforested Uplands
- g. Estuarine Systems
- h. Hammock Islands
- i. Ocean Beaches and Transition Zones
- j. Marine Ecosystem
- k. Man-made Structures

[Highest priority]

- 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]

- 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]

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

- 5) Partner with other state and federal agencies, to promote habitat protection and provide technical support to private landowners. [Highest priority]
- 6) Develop and implement protective Best Management Practices (BMPs) for habitats and land uses throughout South Carolina. [Highest priority]
- 7) Participate in development and review of environmental plans (including FERC relicensing projects) to ensure appropriate habitat protection. [Highest priority]
- 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]
- 9) Encourage city, county and state planning entities to consider habitat protection in all development projects. [Highest priority]
- 10) Where possible, manage wildlife species and promote habitat protection on an ecoregions-wide and/or watershed-wide scale. [High priority]
- 11) Continue to partner with private entities, private landowners and other state and federal agencies to protect riparian areas from degradation. [High priority]
- 12) Continue SCDNR participation in Emergency Response training programs to ensure that 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]

Invasive and Non-Native Species

There are an estimated 50,000 non-native species in the U.S., 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. Approximately 42 percent of the species listed as endangered or threatened under the federal Endangered Species Act are significantly impacted by invasive exotic species. On a national basis, the economic losses and environmental damage caused by exotic species total approximately \$120 billion per year (Pimentel et al. 2005). A recent survey of managers of 430 national wildlife refuges indicated that 80 percent of the refuges recognized problems with invasive exotic organisms. Refuge managers reported more than 790 invasive organisms, including 507 nonnative plants, 208 nonnative 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. A list of those known to be located in South Carolina is

presented in Box 4-4. Feral hogs, feral cats, blue catfish, flathead catfish, red crayfish and fire ants are examples of animals that can cause serious impacts to natural communities and native species. Additionally, invasive and non-native plants such as beach vitex, hydrilla, water hyacinth, and Chinese privet pose threats to South Carolina's species and habitats. Non-native disease organisms have also been shown to impact wildlife species.

Invasive and non-native species that do not directly harm wildlife species can harm animals 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 decline of hemlock populations; loss of streamside hemlocks can result in water temperature increases.

BOX 4-4: INVASIVE AND NON-NATIVE SPECIES KNOWN TO THREATEN SOUTH CAROLINA'S NATIVE WILDLIFE

ANIMALS

Feral Hogs
Feral Cats
Feral Dogs
Blue Catfish
Flathead Catfish
Grass Carp
Aquarium Fish
Ornamental Pond Fish
Red Crayfish
Asian Clams
Zebra Mussel
Rapana Whelk
Green Mussel
Fire Ants
Hemlock Wooly Adelgid
Gypsy Moth

DISEASES

Avian Vacuolar Myelinopathy (AVM)
West Nile Virus
Sudden Oak Death
Raccoon Roundworm
Fish, Shellfish and Shrimp Diseases

AQUATIC PLANTS

Hydrilla
Water Hyacinth
Water Lettuce
Giant Salvinia
Common Reed
Alligatorweed
Brazilian Elodea
Water Primrose

TERRESTRIAL PLANTS

Beach Vitex
Chinese Tallow Tree
Russian Olive
Thorny Olive
Autumn Olive
Japanese Privet
Chinese Privet
Multiflora Rose
Japanese Honeysuckle
Kudzu
Chinese Wisteria
Asian Wisteria
Japanese Stilt Grass
Wart Removing Herb

Impacts from invasive non-native species have been documented in South Carolina; control measures have been implemented to address these impacts. SCDNR is currently working to control aquatic invasive 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.

Conservation Actions

- 1) Prevent the spread of existing invasive and non-native species, eliminating them, where possible. [Highest priority]
- 2) Determine the impacts of invasive and non-native species on South Carolina's priority species and habitats used by those species. [Moderate priority]

- 3) Strive to prevent the import of additional invasive and non-native species to South Carolina. [Moderate priority]
- 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]
- 5) Develop partnerships with other entities in South Carolina to address impacts associated with invasive and non-native species. [Moderate priority]

Private Land Cooperation

Currently, 93 percent of the land in South Carolina is under private ownership. As such, SCDNR has little authority over habitat conservation and wildlife management on those lands. 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 to our quality of life. A number of programs are currently available to landowners through 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 4-5.

Box 4-5: 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.
- **Forest Stewardship Program:** In partnership with the South Carolina Forestry Commission, Clemson Extension Service and the Natural Resource Conservation Service, SCDNR provides a technical service program. SCDNR Wildlife Biologists conduct site visits and assist with management plan preparation and technical guidance for the wildlife component of forest management plans.
- **Conservation District Program:** SCDNR personnel provide technical assistance and cost-share for farmland improvements, including water quality and erosion management and wildlife habitat improvement.
- **Red-cockaded Woodpecker Safe Harbor Program:** Allows for 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 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; these are operated through the Atlantic Coast Joint Venture (example: ACE Basin Project).

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.

Conservation Actions

- 1) Develop or expand partnerships with other entities to provide landowner assistance programs that focus on conservation of priority species and their habitats. [Highest priority]
- 2) Conduct outreach efforts to private landowners to:
 - a. Explain the ecological importance of protecting natural resources on private lands and the benefits of protecting those resources to 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]
- 3) Develop or modify landowner education and outreach programs to include information about South Carolina's priority species and habitats. [High priority]

Public Land Management

Only seven percent of the land in South Carolina is in public ownership by federal, state and local governmental agencies. 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 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 protection of wildlife and their habitats.

The SCDNR has an excellent working relationship with other public land managers throughout the state. However, 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 SCDNR and other agencies.

Conservation Actions

- 1) Provide key information about management requirements for priority species and habitats in South Carolina to partners responsible for public land management. [Highest priority]
- 2) Continue to work with partners to manage and protect priority species and their habitats in South Carolina through other agency's funding programs. [Highest priority]

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

Regulatory Actions

Within South Carolina, there are several state and federal entities with regulatory authority governing certain aspects of wildlife and habitat conservation. State and federal regulations in South Carolina govern conservation of rare, threatened and endangered species; protection of natural areas and specific natural habitats; take of game and nongame wildlife species; 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.

Conservation Actions

- 1) Enhance SCDNR Law Enforcement capability to address priority wildlife species law enforcement needs. [Highest priority]
- 2) Develop Fisheries Management Plans 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]
- 3) Investigate the need to amend existing SCDNR regulations and/or develop additional SCDNR regulations to address conservation status of South Carolina's priority species. [High priority]
- 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]

Survey and Research Needs

When preparation of South Carolina's CWCS was initiated, it quickly became apparent that SCDNR and other entities in South Carolina are 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 by grants and private funds. In order to adequately manage for priority species in South Carolina, it is imperative that baseline research be conducted for these species.

Within this CWCS, Chapter 5: South Carolina Comprehensive Monitoring Program will specifically address 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.

Conservation Actions

- 1) Conduct surveys to determine the presence and extent of priority species populations and their habitat. [Highest priority]
- 2) Monitor the condition of priority species populations and their habitat, once discovered. [Highest priority]
- 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]
- 5) Determine genetic relationships of new species and those species with questionable taxonomic designations. [Moderate priority]
- 6) Determine the effects of plant and animal invasive and nonnative species (including diseases) on South Carolina's priority species and their habitats. [Moderate priority]
- 7) Determine the effects of hunting/fishing on South Carolina's priority species. [Moderate priority]

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 pristine 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 population increase was 5.3 percent while the percent of developed land was 30.2 for almost a six-fold increase. This 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.

As previously natural lands are converted to urban lands, wildlife and habitat are undoubtedly affected. Obviously, 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.

Conservation Actions

- 1) Encourage responsible land use planning throughout South Carolina that ensures protection of natural resources. [Highest priority]
- 2) Collaborate with city and county municipalities and communities to reduce the impacts of development through the following:
 - a. Implementation of Best Management Practices
 - b. Planned development communities
 - c. Low impact development[Highest priority]
- 3) Participate in the environmental review process for development projects throughout South Carolina. [High priority]
- 4) Collaborate with partners to establish appropriate recommendations for riparian buffer widths to assist in protection of coastal and inland water quality. [High priority]
- 5) Collaborate with the South Carolina Department of Transportation (SCDOT) to protect priority species and their habitats during and after road construction. [High priority]
- 6) 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]
- 7) Discourage development in habitats for South Carolina's priority species. [Moderate priority]

Urban and Developed Lands Conservation Action Committee

In April 2005, 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. Table 4-2 contains a list of all attendees and their affiliation.

**TABLE 4-2: URBAN AND DEVELOPED LANDS CONSERVATION ACTION COMMITTEE
ATTENDEES**

Name	Affiliation
John Cone	Home Builders Association of South Carolina
Mike Dawson	River Alliance
Paul Gettys	Katawba Valley Land Trust
John Hicks	Mayor, Town of Blythewood, South Carolina
Carolyn Jebailey	Sierra Club & Wildlife Action
Bill Molnar	Clemson University
Brad Wyche	Upstate Forever

The group identified five areas for conservation action opportunities. These areas are presented in Box 4-6.

BOX 4-4: 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, appointed and elected officials.

The group then developed strategies that would address the five identified areas for conservation action in the urban/wildlife interface.

Urban and Developed Lands Action Committee Recommendations

- 8) Develop wildlife/development win-win situations and disseminate information to local governments and the development community. [Highest priority]
- 9) Assist local governments in drafting meaningful comprehensive plans, as they relate to the Natural Resources section of local comprehensive plans. [Highest priority]
- 10) Act as a repository for best management practices relating to natural resources. [Highest priority]
- 11) 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]

12) 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]

Prioritized Conservation Actions and Measures of Success

As discussed at the beginning of this chapter, all the conservation actions presented herein were prioritized; a complete discussion of this process is presented in Chapter 7: Prioritization, Implementation and Adaptive Management. In very general terms, conservation action priorities were determined based on six criteria presented in Box 4-5.

BOX 4-5: 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.

Additionally, measures of success were developed for each of the conservation actions presented in South Carolina's CWCS. Conservation actions, a list of the highest priority species that area affected by implementation of the action, whether the action is proposed or ongoing (or both), the priority of the action and the measures of success that will be used to rate implementation of that action are all included in Table 4-3: Prioritized Conservation Actions and Measures of Success.

TABLE 4-3: Prioritized Conservation Actions and Measures of Success

Conservation Action Area	Conservation Action	Species/Habitat Affected¹	Ongoing/Proposed	Priority	Measures of Success
Education/ Outreach	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.	All Species	Ongoing	Highest	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Develop and enhance education and outreach programs that encourage land stewardship values, particularly to private landowners in priority habitats.	All Species and Habitats	Ongoing	Highest	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Develop and enhance education and outreach programs that inform the public about the importance of prescribed burning to benefit wildlife species.	American Kestrel, Northern Bobwhite, Red-cockaded woodpecker, Bachman's Sparrow, Brown-headed Nuthatch, Henslow's Sparrow, Gopher Tortoise, Pine Barrens Treefrog	Ongoing and Proposed	Highest	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given

¹ In consideration of space, not all species affected by the conservation action are listed. Selected highest priority species affected by each action will be presented in this table. The species and habitat accounts presented in their entirety in **Supplemental Volume: Species and Habitat Accounts** includes actions for all species in South Carolina's CWCS.

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Education/ Outreach (Continued)	Ensure that accurate information about priority species and their habitats is made available, both within 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.	All Species and Habitats	Ongoing	Highest	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Promote partnerships, both in development and implementation of education and outreach programs.	All Species and Habitats	Ongoing	High	# of partnerships created/supported; # of programs/products produced by partners; Feedback from partnerships
	Promote volunteer participation, both in education and outreach programs as well as in data collection.	Florida Manatee, Northern Bobwhite, Painted Bunting, American Kestrel, Loggerhead Shrike, Wood Thrush, Coral Snake, Loggerhead Turtle, Southern Hognose Snake	Ongoing	High	# of new volunteers; # of in-kind support hours; # of citizen supported programs
	Develop and enhance education and outreach programs that inform the public about the detrimental impacts of litter on priority species.	Leatherback Turtle, Little Blue Heron, Snowy Egret, White Ibis, Glossy Ibis, Tricolored Heron, Yellow-crowned Night Heron	Ongoing	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Education/ Outreach (Continued)	Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.	American Shad, Atlantic Sturgeon, Shortnose Sturgeon, American Eel, Blueback Herring, Hickory Shad, All Freshwater Fish, Mussels and Snails	Proposed	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Develop and enhance programs that educate fishermen about employing correct techniques for capture and release of marine mammals, fish and invertebrates and programs that educate fishermen about the importance of reporting ship strikes and entanglements to authorities.	Florida Manatee, Atlantic Sturgeon, Shortnose Sturgeon, Humpback Whale, Right Whale, Freshwater and Marine Fish and Invertebrates	Proposed	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Utilize a variety of methods for information dissemination including: printer materials, websites, formal education/outreach programs, updates to existing education curricula, demonstration sites, landowner workshops, media.	All Species and Habitats	Ongoing	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Education/ Outreach (Continued)	Develop and enhance education and outreach programs that discourage stocking, release and transplanting nonnative animal and plant species throughout South Carolina.	All Species and Habitats	Ongoing	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Ensure that all SCDNR employees are working to provide education and outreach information to partners and citizens of South Carolina.	All Species and Habitats	Ongoing	Highest	Management review of employee compliance; # of employee training seminars conducted; # of employees attending seminars
	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.	All Species and Habitats	Ongoing and Proposed	Highest	Completed review and update of existing SCDNR education programs; selection of “poster species” by ecoregions; # of programs/media created around those species; # of audiences reached; # of participants reached; # of programs/media given
	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.	All Species and Habitats	Proposed	High	Final map created and distributed to partners, public; feedback from partners/public collected and considered

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Education/ Outreach (Continued)	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.	All Species and Habitats	Proposed	High	Final database created and implemented; database access available on-line to partners and public; feedback from partners/public collected and considered
	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.	All Species and Habitats	Proposed	Moderate	Final catalog created and distributed to partners and public; feedback from partners/public collected and considered
Habitat Protection	Acquire property for protection of priority species and to ensure habitat linkage through fee simple acquisition and conservation easements all priority habitats.	All Species and Habitats	Ongoing	Highest	# of acres acquired or protected; # of long-term cooperative habitat protection projects; # of completed site inventories; # of acquisition processes that incorporate considerations/priorities identified in the CWCS
	Continue to partner with private entities and other state and federal agencies to acquire land for habitat protection. Develop additional partnerships for land acquisition.	All Species and Habitats	Ongoing	Highest	# of acres acquired or protected; # of long-term cooperative habitat protection projects; # of completed site inventories; # of acquisition processes that incorporate considerations/priorities identified in the CWCS

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Habitat Protection (Continued)	Restore and enhance impaired habitat, where feasible and cost-effective. Habitat enhancements include encouraging nest/roost site retention/restoration; employing prescribed burning; restoring natural stream courses and flows; eliminating or reducing invasive and non-native species from habitats; replanting native plants; and wetland restoration.	Northern Yellow Bat, Black Duck, Mallard, Northern Bobwhite, Eastern Meadowlark, Red-cockaded Woodpecker, American Kestrel, Northern Pintail, Bachman's Sparrow, Brown-headed Nuthatch, Pine Barrens Treefrog, Loggerhead Turtle, Hawksbill Turtle, Kemp's Ridley Turtle, Robust Redhorse, American Eel, American Shad, Atlantic Sturgeon, Shortnose Sturgeon, Savannah Lilliput	Proposed	Highest	# of acres/sites restored; species/population response to restoration; % improvement in measures of species diversity/composition; % increase in nesting and roosting activities; ; # of acres burned; # acres/miles of stream positively affected by management; measures of habitat quality/water quality improvements; % reduction of invasive/non-native species;
	Promote the importance of habitat protection and participation in conservation easement programs through education and outreach programs.	All Species and Habitats	Ongoing	Highest	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given
	Partner with other state and federal agencies to promote habitat protection and provide technical support to private landowners.	All Species and Habitats	Ongoing	Highest	# of technical guidance/support interactions
	Develop and implement protective Best Management Practices (BMPs) for habitats and land uses throughout South Carolina.	Florida Manatee, American Oystercatcher, Prairie Warbler, All Freshwater, Marine and Diadromous Fish, All Freshwater and Marine Invertebrates	Proposed	Highest	# of BMPs developed; # of BMP recommendations made; % of recommendations implemented; measures of degree of compliance; quality of compliance

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Habitat Protection (Continued)	Participate in development and review of environmental plans (including FERC relicensing projects) to ensure appropriate habitat protection.	All Species and Habitats	Ongoing	Highest	# of site visits; # of comments forwarded; # of plans/permits commented on; # of partnerships developed
	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.	Florida Manatee, Black-crowned Night Heron, Eastern Wood Peewee, Wood Thrush, Leatherback Turtle, Loggerhead Turtle, American Eel, American Shad, Atlantic Sturgeon, Shortnose Sturgeon	Ongoing and Proposed	Highest	# of species for which threats are identified and mitigated; # of threats mitigated; % increase in priority species numbers; % decrease in effects of threats on priority species
	Encourage city, county and state planning entities to consider habitat protection in all development projects.	All Species and Habitats	Proposed	Highest	# of entities participating; # of land use plans developed; # of technical guidance created; # of land owner agreements/participants in programs aimed at listed species recovery; # of data requests and exchanges; project-specific results of collaborative efforts
	Where possible, manage wildlife species and promote habitat protection on an ecoregions-wide and/or watershed-wide scale.	All Species and Habitats	Ongoing	High	Measures of degree of compliance; % ecoregions protected; % watersheds protected
	Continue to partner with private entities, private landowners and other state and federal agencies to protect riparian areas from degradation.	Florida Manatee; American Oystercatcher; Black-crowned Night Heron; Glossy Ibis; Little Blue Heron; Prairie Warbler; Bog Turtle; All Freshwater Fish, Crayfish, Mussels and Snails; All Marine Fish and Invertebrates; All Diadromous Fish	Ongoing	High	# of decision-making protocols adapting aquatic conservation priorities; # of acres of riparian habitat protected; # of acres/miles of stream/wetland positively affected; # of active partnerships; # of new partnerships developed; # of information exchanges

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Habitat Protection (Continued)	Continue SCDNR participation in Emergency Response training programs to ensure that 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.	Florida Manatee, Black Skimmer, Eastern Brown Pelican, Lesser Scaup, Wilson's Plover, Willet, All Marine Fish, All Marine Invertebrates	Ongoing	Moderate	# of trainings attended; # of individuals trained; # of programs developed
Invasive and Non-Native Species	Prevent the spread of existing invasive and non-native species, eliminating them, where possible.	Bald Eagle, Black Duck, Eastern Meadowlark, Wood Thrush, Florida Pine Snake, Loggerhead Turtle	Ongoing and Proposed	Highest	% of invasive/non-native species populations decreased; # of areas surveyed; # of species/populations located; # of individuals removed
	Determine the impacts of invasive and non-native species on South Carolina's priority species and habitats used by those species.	Black Duck, Bald Eagle, Northern Pintail, Eastern Wood Peewee, Gopher Tortoise, Loggerhead Turtle, Atlantic Sturgeon, Shortnose Sturgeon	Ongoing and Proposed	Moderate	# of areas surveyed; # of species/populations located; identification of causal factors in population change
	Strive to prevent the import of additional invasive and non-native species to South Carolina.	All Species and Habitats	Ongoing and Proposed	Moderate	# of species protocols established; # of areas surveyed; # of species/populations located; identification of causal factors in population change
	Develop and conduct an education and outreach campaign to raise awareness of the impacts of introducing non-native species into South Carolina.	All Species and Habitats	Ongoing and Proposed	Moderate	# of web-products developed/updated; # of media/outreach products developed/updated; # of reports/publications developed/distributed; # of audiences reached; # of participants/volunteers reached; # of programs given

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Invasive and Non-Native Species (Continued)	Develop partnerships with other entities in South Carolina to address impacts associated with invasive and non-native species.	All Species and Habitats	Ongoing and Proposed	Moderate	# of partnerships developed; # of information exchanges; # of Memoranda of Agreement/Understanding developed
Private Land Programs	Develop or expand partnerships with other entities to provide landowner assistance programs that focus on conservation of priority species and their habitats.	Black Bear, Swamp Rabbit, American Kestrel, Swallow-tailed Kite, Red-cockaded Woodpecker, Henslow's Sparrow, Northern Bobwhite, Bog Turtle	Ongoing	Highest	# of partnerships developed; # of information exchanges; # of Memoranda of Agreement/Understanding developed; # of programs implemented
	Conduct outreach efforts to private landowners to: explain the ecological importance of protecting natural resources on private lands and the benefits of protecting those resources to all citizens of South Carolina; encourage voluntary participation in natural resource conservation activities; encourage natural resource stewardship by utilizing Best Management Practices (BMPs) on private lands; and explain the mission of the SCDNR and the programs conducted by the department.	All Species and Habitats	Ongoing	High	# of audiences reached; # of participants in programs; # of volunteers recruited; # of positive/negative comments from public; # of public interactions/programs offered
	Develop or modify landowner education and outreach programs to include information about South Carolina's priority species and habitats.	All Species and Habitats	Ongoing	High	# of audiences reached; # of participants in programs; # of volunteers recruited; # of positive/negative comments from public; # of public interactions/programs offered
Public Land Management	Provide key information about management requirements for priority species and habitats in South Carolina to partners responsible for public land management.	All Species and Habitats	Proposed	Highest	# of information exchanges; database completed and published on the internet; # of educational efforts; # of CWCS recommendations implemented on public lands

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Public Land Management (Continued)	Continue to work with partners to manage and protect priority species and their habitats in South Carolina through other agency's funding programs.	All Species and Habitats	Ongoing and Proposed	Highest	# of partnerships formed; amount of money spent and in-kind services conducted by partners on public lands
	Ensure that priority species and their habitats on SCDNR lands are managed in accordance with the conservation actions provided in the CWCS.	All Species and Habitats	Ongoing	Highest	# of CWCS recommendation implemented on DNR lands; # of management plans influenced by CWCS research projects
Regulatory Actions	Enhance SCDNR Law Enforcement capability to address priority wildlife species law enforcement needs.	All Species and Habitats	Ongoing	Highest	Review law enforcement capabilities conducted; # of calls/responses to priority species concerns
	Develop Fisheries Management Plans 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.	Many Marine Fish and Invertebrates	Ongoing	Highest	# of plans developed; # of proposed recommendations implemented
	Investigate the need to amend existing SCDNR regulations and/or develop additional SCDNR regulations to address conservation status of South Carolina's priority species.	American Oystercatcher, Many Freshwater Mussels and Crayfish, Eastern Brook Trout	Ongoing	High	Adherence to schedules for rules review and updates; # of regulation change proposals; # of species protected from unregulated use or impact; # of regulation changes that enhance or protect wildlife or habitat; amount of habitat affected
	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.	Eastern Fox Squirrel, Eastern Spotted Skunk, Shovel-nosed Salamander, Atlantic Sturgeon, Shortnose Sturgeon	Ongoing	Moderate	Adherence to schedules for rules review and updates; # of regulation change proposals; # of species protected from unregulated use/impact; # of regulation changes that enhance or protect wildlife or habitat; amount of habitat affected

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Survey and Research Needs	Conduct surveys to determine the presence and extent of priority species populations and their habitat.	All Species and Habitats	Ongoing and Proposed	Highest	# of areas surveyed; # of new survey sites; # of species/populations located; compilation of new information on distribution and population size estimates
	Monitor the condition of priority species populations and their habitat, once discovered.	All Species and Habitats	Ongoing and Proposed	Highest	# of new monitoring sites or species protocols established; # of species for which trend information can be assessed; # of species for which population targets can be assigned; compilation of habitat trend information
	Determine the impacts of contaminants (including thermal discharges) on South Carolina's priority species.	All Species and Habitats	Ongoing and Proposed	Highest	# of areas surveyed; # of species/populations influenced located; compilation of new data collected on impacts and life history
	Conduct research to identify the habitat requirements for South Carolina's priority species and determine whether existing habitats meet those requirements.	All Species and Habitats	Ongoing and Proposed	High	# of areas surveyed; # of new survey sites; # of species/populations located; compilation of new data collected on life history requirements
	Determine genetic relationships of new species and those species with questionable taxonomic designations.	Northern Yellow Bat, Eastern Milk Snake, Atlantic Sturgeon, Carolina Pygmy Sunfish, "Broadtail" Madtom, Robust Redhorse, Highfin Carpsucker, Barrel Floater, Brother Spike,	Ongoing and Proposed	Moderate	# of species surveyed; # of genetic analyses conducted; # of taxonomic issues resolved; compilation of new data collected on genetic and taxonomic relationships

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Survey and Research Needs (Continued)	Determine the effects of plant and animal invasive and nonnative species (including diseases) on South Carolina's priority species and their habitats.	Bald Eagle, Black Duck, Eastern Wood Peewee, Mallard, Worm-eating Warbler, Northern Pintail, Loggerhead Turtle, Atlantic Sturgeon, Florida Softshell Turtle,	Ongoing and Proposed	Moderate	# of areas surveyed; # of new survey sites; # of species populations located; compilation of data collected on survival, competition, predation, response to management
	Determine the effects of hunting/fishing on South Carolina's priority species.	All Marine Fish and Invertebrates, All Diadromous Fish, Appalachian Cottontail, Swamp Rabbit, Eastern Fox Squirrel, Eastern Brook Trout	Ongoing and Proposed	Moderate	# of areas surveyed; # of new survey sites; # of species populations affected; compilation of data collected on survival, competition, predation, response to management
Urban and Developing Lands	Encourage responsible land use planning throughout South Carolina that ensures protection of natural resources.	All Species and Habitats	Ongoing and Proposed	Highest	# of cooperators; # of technical guidance interactions; # of land owner/agency contacts; % of recommendations implemented; # of instances of DNR participation in review processes
	Collaborate with city and county municipalities and communities to reduce the impacts of development through the following: implementation of Best Management Practices; planned development communities; and low impact development.	All Species and Habitats	Ongoing and Proposed	Highest	# of collaborators; # of BMPs developed; # of BMP recommendations made; % of recommendations implemented; measures of degree of compliance; quality of compliance
	Participate in the environmental review process for development projects throughout South Carolina.	All Species and Habitats	Ongoing	High	# of site visits; # of comments forwarded; # of plans/permits commented on; # of partnerships developed

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Urban and Developing Lands (Continued)	Collaborate with partners to establish appropriate recommendations for riparian buffer widths to assist in protection of coastal and inland water quality.	All Species and Habitats	Ongoing	High	# of decision-making protocols adapting aquatic conservation priorities; # of acres/miles of stream/wetland positively affected; # of active partnerships; # of new partnerships developed; # of information exchanges
	Collaborate with the South Carolina Department of Transportation (SCDOT) to protect priority species and their habitats during and after road construction.	Diamondback Terrapin, Rafinesque's Big-eared Bat, Coral Snake, Florida Pine Snake, Southern Hognose Snake, Mimic Glass Lizard, Slender Glass Lizard, Northern Pine Snake	Ongoing and Proposed	High	# of plans/permits commented on; # of site visits; # of collaborative efforts; # of project partnerships established; # of species protection measures implemented
	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.	All Species and Habitats	Ongoing and Proposed	Moderate	# of partnerships developed; # of information exchanges; # of sites protected; # of roosts/sites surveyed; project-specific results of collaborative efforts
	Discourage development in habitats for South Carolina's priority species.	All Species and Habitats	Ongoing and Proposed	Moderate	# of species for which threats are conclusively identified and abated; # of partnerships developed; # of information exchanges; # of sites protected; # of sites surveyed; project-specific results of collaborative efforts

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Urban and Developing Lands (Continued)	Develop wildlife/development win-win situations and disseminate information to local governments and the development community.	All Species and Habitats	Proposed	Highest	# of information requests received and responded to; % of recommendations implemented; # of mitigation scenarios developed; # of species/habitats affected; # of programs conducted
	Assist local governments in drafting meaningful comprehensive plans, as they relate to the Natural Resources section of local comprehensive plans.	All Species and Habitats	Ongoing and Proposed	Highest	# of partnerships developed; # of information exchanges; # of comprehensive plans prepared; % of recommendations implemented; # of comprehensive plans commented on
	Act as a repository for best management practices relating to natural resources.	All Species and Habitats	Proposed	Highest	Development of database and information infrastructure; # of information exchanges; # of partnerships formed; user evaluations and comments
	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: support the creation of local habitat protection capabilities; work with local land trusts on the location of priority habitats; promote and educate about transfer of development rights; and collaborate with local governments to develop best management practices for storm water run-off: education, incentives, and awards.	All Species and Habitats	Ongoing and Proposed	Highest	Management review of employee compliance; # of employee training seminars conducted; # of employees attending seminars; public surveys of outreach; # of partnerships developed; # of public/educational interactions

Conservation Action Area	Conservation Action	Species/Habitat Affected	Ongoing/Proposed	Priority	Indicators of Success
Urban and Developing Lands (Continued)	Provide wildlife/habitat research and demonstration projects. These could include: a buffer demonstration project that provides a win-win for both developers and the environment; research projects on the impact of buffers and corridors on wildlife and habitat; and a storm water demonstration project.	All Species and Habitats	Proposed	Moderate	# of projects/products developed; # of audiences reached; # of participants in programs; # of presentations/programs offered

CHAPTER 5: SOUTH CAROLINA COMPREHENSIVE MONITORING PROGRAM

Purpose and Justification for Monitoring

Throughout the history of natural resource conservation, managers and scientists have based most of their efforts on single species management. More recently, efforts have targeted threatened or endangered species management, drawing on much of the time and capital available to resource managers. Further, the literature of wildlife management provides testament to the effects of missed indices and unanticipated events on successful conservation.

Interestingly, in an effort to move to a more proactive framework for conservation, SCDNR is, in this CWCS planning process, tasked with streamlining management and stepping back to focus on a broader vision. 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 SCDNR has identified.

It seems apparent that this view of management will require constant and consistent adaptation to change. Single alterations in community function, from the loss of a species like white beach tiger beetles on a dune to the invasion of feral hogs in key sea turtle nesting areas can produce ripple effects that confound the most complete systems model. Without perfect knowledge, however, management must move forward if conservation is to succeed. And 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, implementation activities) and across multiple scales (local, statewide, regional, 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 must be inherent in simply understanding the effects, intended or otherwise, of any management approach.

Earlier this year, CWCS 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 CWCS and its subsequent implementation. South Carolina's team attended meetings to discuss collaborative efforts and structural design of CWCS monitoring programs. Paul Dressler, 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 SCDNR will employ through

implementation of the CWCS to create a more effective and efficient statewide monitoring program.

Monitoring Programs in South Carolina

An extensive list of monitoring efforts currently employed across the state and region is included in Appendix 4 of this Strategy. Cooperative efforts remain essential to accomplishing the goals of these programs. SCDNR will work first to ensure that existing programs remain effective where they meet the needs of conservation strategies within the CWCS. Monitoring continues to be a necessary component of most SCDNR efforts outside of the CWCS as well. The structure of the South Carolina Monitoring Program will build on existing SCDNR monitoring efforts and where appropriate those monitoring programs of partners. Additional partnerships and support will be researched during the development of the monitoring program.

Current Species Monitoring Programs

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 that map possible roads other taxa monitoring programs might use. 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 to conduct these assessments.

In South Carolina, current monitoring projects include the following:

- The U.S. Army Corps of Engineers and South Carolina Ocean and Coastal Resource Management (OCRM) have provided essential monitoring efforts for marine invertebrates.
- SCDHEC monitors water quality while surveying some freshwater invertebrate species.
- SCDNR assesses commercial fisheries and State Shellfish Grounds on an annual basis to evaluate shellfish population status.
- 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 abundance of fishes 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. Eleven surveys have been completed spanning 40

years. (1963–64; 1966–67; 1975–76; 1978–79; 1981–82; 1984–85; 1991–92; 1993–94; 1999–2000; 2002–03; 2004–05).

- The South Atlantic Fishery Management Council (SAFMC) monitors annual landings of many species.
- Reproductive effort and fledging success of South Carolina nesting bald eagles has been documented on an annual basis for 28 years.
- 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.

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 the most current programs completed.

- 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
- 2000 - Striped bass anglers' attitudes toward fisheries management on Lake Murray
- 2001 - South Carolina youth aquatic survey
- 2003 - South Carolina residents' attitudes and behaviors toward aquatic resources
- 2003 - South Carolina and Georgia anglers' 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
- 1991, 1996 and 2001 - The 2001 Economic Benefits of Freshwater Fishing in South Carolina

This list only briefly describes some of the monitoring efforts SCDNR undertakes in current management programs. A more complete list of monitoring efforts in South Carolina is provided in Appendix 4.

Monitoring Needs for Taxa Groups

Authors of the CWCS species accounts identified monitoring, survey and research needs for priority species. Recommendations for individual species can be located in a separate volume, Supplement: Species and Habitat Accounts. Some of the general needs for monitoring efforts are described here.

General Aquatic Monitoring Needs

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. Presently, SCDNR biologists are developing a system for stream habitat monitoring and assessment. 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.

General Terrestrial Monitoring Needs

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.

Mammals

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.

Birds

Continue ongoing monitoring coordination and support of recommendations of national and regional planning bodies such (PIF, SAMBI, NABCI, NAWMP and others). 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. Key habitats of concern include pine savannah and pine woodland, early successional and grasslands and forested wetlands. Efforts to continue monitoring of migratory and resident waterbirds and waterfowl are also recommended.

Amphibians and Reptiles

Development of monitoring protocols for amphibians and reptiles is of primary importance. SE PARC has already begun drafting such protocols and guidelines. SCDNR's continued involvement in this process is important for both development of reptile guidelines and continued refinement of existing amphibian guidelines.

Strategies for South Carolina's Comprehensive Monitoring Program

The following are specific strategies outlined for the development of the South Carolina Comprehensive Natural Resources Monitoring Program (South Carolina Monitoring Program).

Strategy 1: *Initiate a comprehensive monitoring program to coordinate monitoring efforts including establishment of a collaborative working group staffed with agents both from SCDNR and partner agencies.*

- 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 the next iteration of the CWCS.
- Build on existing state monitoring systems.
- Support local planning initiatives, regional planning teams and existing cooperative agreements where appropriate (Appendix 5: Existing SCDNR 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 CWCS planning efforts.

Strategy 2: *Create a South Carolina Comprehensive Natural Resources Data Initiative.*

- Develop a standard system to facilitate species, habitat and monitoring data collection for storage and dissemination across the agency and partnerships.
- Create a CWCS 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.
- 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.
- Track distribution and status of all priority species with intent to expand database for tracking non-priority species as well.
- Design the database with the intent to facilitate future reporting and revisions of the CWCS.

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

- Accomplish long-term objectives of monitoring key habitats using existing and new GIS programs.
- Update and analyze the existing GAP databases and crosswalk this information with a statewide habitat characterization as provided in the CWCS.
- 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 habitat scale.
- Evaluate the existing CWCS species goals for feasibility and applicability at broadening scales.
- Utilize landscape-level remote sensing and other mapping techniques, 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.*

- 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. The Breeding Bird Survey and Christmas Bird Counts are citizen initiatives; these programs provide some of the most complete data on bird distributions. 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 6: Partnership Development.

Monitoring Program Defined

As SCDNR proceeds with the development of the South Carolina Monitoring Program in support of the CWCS, several elements of design must be considered; these are outlined in Box 5-1 and adapted from guidance provided to the states by federal partners.

BOX 5-1: 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
 - How you assure and control 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 need and reflects best available science

Monitoring targets will be dictated during the program implementation and adaptive management process; this process is more thoroughly described in Chapter 7: Prioritization, 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 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 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. Selection of appropriate indicators is challenging. SCDNR will rely on the guidance provided by Schoonmaker and Luscombe (2005) (see Box 5-2 for additional definition and discussion 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 5-2: 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 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 in press) 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 revision of the CWCS. 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 and included in annual project reviews (see Chapter 7: Prioritization, 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 priority conservation concern.

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 CWCS.

Experimental Design for Monitoring Programs

As successful research is typically built on detailed experimental design, so shall design efforts benefit the CWCS 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 theoretic 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 closely tie with priorities for conservation actions as provided in Chapter 4: 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 6: PARTNERSHIP DEVELOPMENT

The Initial Stages: Drawing Plans

From the beginning of the CWCS effort, SCDNR and the planning team sought to realize successful partnerships and public involvement in the development of the strategy. 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 nongovernmental.

Early in the process, the team identified the issues of most prominent concern for wildlife conservation both from the perspective of agency staff and that of individuals and groups outside of SCDNR. First, focus groups were developed in order to determine the wildlife conservation priorities of SCDNR'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 throughout the state. 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 wildlife 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; investigate and verify the decline of species)
- Water quality - (better water quality management programs; wetland protection)
- Agency collaboration - (Inter- and intra-agency collaboration; public-private cooperation; collaborate with neighboring states; enforce existing regulations)
- Land owner incentives_- (land owner incentives; improved; ecological restoration on private lands; cost-sharing programs)

After the focus group meetings, 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. The information obtained through the focus groups allowed SCDNR to be better prepared to answer questions that might arise during public meetings. Public meetings were held at four locations around the state and were attended by representatives of groups similar to those present at that 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 planning process, including those identified through the initial public and partner involvement process, is included in Appendix 5: Nonexhaustive List of SCDNR Partnerships and Existing Collaborative Agreements.

Planning the Strategies: Building Bridges

Partnerships and collaborations were essential to the development of this plan. 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 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 seated 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 as well as outside. 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, as the coordination team worked to develop the South Carolina Comprehensive Natural Resources Data Initiative, 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 in 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). These CAAs are presented in Box 6-1.

Additionally, SCDNR recognized that there are overarching conservation strategies that are likely to assist in protecting wildlife and habitats statewide. Therefore, 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 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 CWCS; additional committee meetings will be held for the remaining CAAs as the CWCS is being implemented; resulting conservation strategies will be included in future revisions of the South Carolina CWCS.

BOX 6-1: 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

The two Conservation Action Committees that were convened 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 4: Statewide Conservation Strategies.

Late in the planning process, a representative of the Catawba Indian Nation was briefed on the CWCS to explore partnership opportunities. Potential actions identified for future discussion are based on four broad goals. 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 SCDNR. Similarly, SCDNR could help Reservation land managers develop biological resource inventories and site-specific management plans for priority species. The Catawba Nation could also support expanding outreach to other Native American bands and groups. In return, SCDNR could assist in developing new and existing cooperative conservation projects with neighboring landowners where objectives cross the Reservation boundaries.

Implementation: Shaking Hands and Cutting Ribbons

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 plan moves into implementation stages, 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 begins and planning for future revisions continues, the CWCS coordinating team will be tasked with maintaining the network of partnerships. The team plans to put in place streamlined measures including a Wildlife Initiative newsletter with listserve capabilities, continued use of web-based contacts and media, presentations and popular news media publications. *South Carolina Wildlife*, the SCDNR magazine publication, will release a supplemental issue concurrent with the submission of this plan to the USFWS. The supplement details the background and fundamentals of the development of the CWCS. The magazine has over 52,000 subscribers; SCDNR research indicates that each issue is read by three to four individuals, resulting in the supplement having an audience of well over 150,000 individuals. Additionally, 10,000 copies of the supplement will be available to serve as an informational tool as the team begins developing liaisons to coordinate partnerships throughout the state.

Finally, as the development of data tools to support the CWCS continues, the team will continue soliciting involvement and interest from partners throughout the state and region, in creating a dynamic user interface for collaborative input on projects, species and habitat information and demographics and, ultimately, future CWCS iterations. A novel approach to information collection, the collaborative interface 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 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 Strategy as the program strives to meet the needs of present and future interests.

CHAPTER 7: PRIORITIZATION, IMPLEMENTATION AND ADAPTIVE MANAGEMENT

Setting Priorities

In setting priorities for the plan, 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 and those species would need to be ranked based on existing data and expertise with those species. Additionally, the priority for implementation conservation actions to address challenges to priority species needed to be determined. The following identifies how SCDNR conducted prioritization of both species and conservation actions to address the needs of those species.

Species Prioritization

To accomplish priority species identification, each taxa leader worked with a committee to determine appropriate priority species. The methodologies used for this process differed by taxa and are presented in Chapter 2: South Carolina Priority Species.

Once the lists were complete, the taxa committees ranked the priority species into three categories: Highest Conservation Need, High Conservation Need and Moderate Conservation Need. The premise for these categories was to determine which species required immediate conservation action based solely on existing data and species expertise; this process was completed separately for each taxa. It is important to note that SCDNR did not develop a single priority species for the state; each taxa identified several species for each of the three categories.

Identification of priority rankings was accomplished by considering the data available for the criteria presented in Box 7-1.

BOX 7-1: EIGHT CRITERIA USED FOR DETERMINATION OF PRIORITY SPECIES

- 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 species prioritization process was not conducted for marine fish, marine invertebrates or insects because most of the species in those taxa are included on South Carolina's Priority Species List due to the knowledge gaps that exist. Because many of these species have not been investigated in the past, necessary data is lacking to allow for complete development of conservation actions. Until the SCDNR can determine the exact challenges that each of these species faces, it will be difficult to develop specific conservation strategies to meet those challenges. Therefore, general conservation actions that will address challenges that typically affect these species are included in this plan.

Prioritized species lists are presented in Appendix 1.

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 CWCS 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 implement all the conservation actions developed for inclusion in the CWCS immediately. Therefore, it was necessary to take a realistic approach to prioritizing conservation action implementation.

As discussed in detail in Chapter 4: Statewide Conservation Strategies, major challenges to species and habitats are similar across taxonomic groups. Therefore, conservation strategies to address those challenges are also similar. Consequently, conservation actions were consolidated.

A steering committee was formed in order to accomplish conservation action prioritization. This committee consisted of senior personnel within the SCDNR. Members of the steering committee are identified in Box 7-2.

Box 7-2: SC CWCS STEERING COMMITTEE

- John Frampton, Director
- Cary Chamblee, Assistant Director
- Robert Boyles, Deputy Director, Marine Resources Division
- Breck Carmichael, Deputy Director, Wildlife and Freshwater Fisheries Division
- Carole Collins, Deputy Director, Operations and Support Services Division
- Col. Alvin Taylor, Deputy Director, Law Enforcement Division
- Alfred Vang, Deputy Director, Land, Water and Conservation Division

As stated above, it was necessary to use a realistic approach to determine which 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 would be most likely to allow for conservation of priority species. The members of this committee were asked to consider the six criteria when ranking conservation actions, which are presented in Box 7-3.

Based on the prioritization process, SCDNR identified the manner in which conservation actions will be implemented for South Carolina's priority species over the next five years. Further, SCDNR decided to develop annual work plans that include these prioritized conservation actions. Ultimately, the CWCS will be updated to include these work plans.

BOX 7-3: 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.

Although the Strategy will be updated every five years, changing opportunities and challenges in the state lead SCDNR to the decision to prepare initial annual work plans for three years only (FY2006, FY2007 and FY2008). By providing annual work plans three years in advance, SCDNR can allow for public distribution of priorities, which will in turn allow for additional partnership development and funding opportunities.

Implementation of the CWCS

The primary focus of South Carolina's CWCS is continued, efficient and effective conservation and management of wildlife diversity. Through implementation of the Strategy, coordination of diverse conservation efforts and forging of effective partnerships, the CWCS will meet its mandate. Coordination efforts will bring together expertise and funding sources from various partners and apply them to needs identified in the CWCS. The initial congressional intent for the State Wildlife Grant Conservation Strategies 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 CWCS provides focus and guidance for SCDNR priorities when allocating personnel and financial resources for research and management.

First steps

As the SCDNR begins the process of putting the CWCS to the test, departmental decisions about funding, timing and cooperators will continue to be directed by the prioritization steering committee. Work plans will be developed annually based on the strategies defined by the CWCS and priorities identified by the steering committee as describe above. Funding will be allocated

according to budget cycles and request-for-proposal (RFP) processes associated with State Wildlife Grants and other funding sources.

Already, partnerships bolstered during the creation of the CWCS are offering potential resources for meeting the objectives and strategies described in this Strategy. Many potential CWCS partners have also identified the CWCS 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 will now be 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 can also serve as a framework for expanding partnerships and 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 CWCS information in a timely way.

Two main concerns have been identified in association with implementation planning. The first, identified in the public input process undertaken in the early stages of plan development, involves the need to communicate with constituents more effectively about the goals and vision of the SCDNR and the CWCS. Such communication would increase public support, ownership and partnership development. The second concern deals 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 include those associated with the development of the South Carolina Comprehensive Monitoring Program. 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.

Request for Proposals and Project Selection within the CWCS

Rigorous review and selection procedures will ensure that sponsored projects are effective and efficient in meeting the goals and objectives of the CWCS. There will be two levels of review. Initially, the CWCS planning team will review all proposals to determine if projects clearly focus on South Carolina priority species and their associated actions recommended within the CWCS. The steering committee will then be tasked with reviewing approved applications for inclusion in annual work plans.

The SCDNR will seek to fund innovative, interdisciplinary projects that attempt to address the needs of priority species and undertake practical application of CWCS goals. 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.

The urgent need to achieve environmental sustainability and protect South Carolina ecosystems challenges applicants to develop new ways to engage organizations in problem solving.

Adaptive Management, Maintenance and Communication Plan

Implementation will 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 5: South Carolina Comprehensive Monitoring Program, a major component of the CWCS 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 CWCS 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 Strategy. As an agency, SCDNR sets project objectives and identifies measures of success for management actions. As CWCS projects are evaluated, similar indicators of success will be defined at the strategy level.

With the information gathered in this program, project leaders will be required to produce annual progress reports for review by the steering committee and CWCS coordination team. These reports will be evaluated for insight into adaptive management needs and reassessments of the CWCS. These annual reviews of projects will be conducted electronically within the Natural Resources Database (see Chapter 5 for more information) infrastructure and will be collected for future revisions of the CWCS. Continued monitoring and evaluation of management actions will create an active implementation of the “living” CWCS document. Project leaders will also be involved in periodic communication efforts focused on increasing public awareness of CWCS implementation. Annual reports will be created for distribution to partners to supplement other coordination efforts. Maintaining these communication links with the public and broader conservation community will be critical to the success of the CWCS.

Review and Revision: Considering Lessons Learned

The CWCS program will be reviewed on a 5-year cycle to ensure the program and the CWCS remain relevant and current with evolving landscapes and developing conservation efforts. The 5-year 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 CWCS 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 identification and elimination of flaws in the program or CWCS implementation process, identification of more efficient or valid approaches to internal supporting processes such as species prioritization and threat assessment, and/or expansion of those taxa groups treated only cursorily in this initial CWCS development would be viewed as lessons learned contributing to the next iteration of the CWCS in 2010. For example, production

of the 2010 CWCS will be streamlined due to the development of CWCS reports from the planned Comprehensive Natural Resources Database (Chapter 5).

With the maiden voyage of the South Carolina CWCS 2005 occurring alongside the strategies of 55 other states and protectorates, it will also prove useful to maintain connections forged between states. Lessons learned will be many and varied for all states and the South Carolina CWCS coordination team can only reap benefits from remaining watchful in this inaugural implementation process.

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Glossary of Terms

A

accreted - To make larger or greater, as by increased growth.

acumen - A tapering point.

adipose fin - A soft boneless fin.

agouti (grizzled) - The alternation of light and dark bands of color in the fur of various animals, producing a grizzled appearance.

alates - Bearing wings.

allele - One member of a pair or series of genes that occupy a specific position on a specific chromosome.

allopatry - Occurring in separate, nonoverlapping geographic areas. Often used of populations of related organisms unable to crossbreed because of geographic separation.

allotypic - A biological specimen that is the opposite sex of a holotype.

amphidromous - Moving from fresh water to the sea, or vice versa, for nonreproductive purposes such as feeding.

amphipod - A small crustacean of the order Amphipoda, such as the beach flea, having laterally compressed body with no carapace.

anadromous - Migrating up rivers from the sea to breed in fresh water.

anal fin - An unpaired fin on the ventral surface of the fish, virtually always positioned after the vent.

angulate - Having angles or an angular shape.

anterior - Placed before or in front.

anthropogenic - Caused by humans.

apodeme - One of the processes of the shell which project inwards and unite with one another, in the thorax of many Crustacea.

appendage - A part or organ, such as an arm, leg, tail, or fin, that is joined to the axis or trunk of a body.

aquaculture - The science, art, and business of cultivating marine or freshwater food fish or shellfish, such as oysters, clams, salmon, and trout, under controlled conditions.

arboreal - Relating to or resembling a tree.

ascidian - Any of various sedentary tunicates of the class Ascidiacea, having a transparent sac-shaped body with two siphons.

auricular - Of or relating to the sense of hearing or the organs of hearing.

B

ballast - Heavy material that is placed in the hold of a ship or the gondola of a balloon to enhance stability.

barbel - One of the slender, whiskerlike tactile organs extending from the head of certain fishes, such as catfishes. Also called barb.

basal band - Of, relating to, located at, or forming a base.

basicaudal - On the base of the caudal fin (tail fin).

beak - The raised part of the dorsal margin of the shell; also called the umbo.

beak cavity - The depression or pocket on the inside of each valve leading into the beak.

benthic - Of or relating to or happening on the bottom under a body of water.

benthopelagic - Of or relating to or happening on the bottom under a body of water specifically open oceans or seas rather than waters adjacent to land or inland waters.

biangular - Having two angles or corners.

bib - A patch of colored feathers under the chin of a bird.

bioaccumulation - The accumulation of a substance (as a pesticide) in a living organism.

biomass - The total mass of all living things within a given area, biotic community, species population, or habitat; a measure of total biotic productivity.

biome - A major regional or global biotic community, such as a grassland or desert, characterized chiefly by the dominant forms of plant life and the prevailing climate.

bipectinate - Having two margins toothed like a comb.

biserrate - Serrated on both sides.

bivalve - A mollusk, such as an oyster or a clam, that has a shell consisting of two hinged valves.

book lung - A sacculate respiratory organ found in some arachnids, such as scorpions and spiders, consisting of several parallel membranous folds arranged like the pages in a book.

boreal - Of or relating to the forest areas of the northern North Temperate Zone, dominated by coniferous trees such as spruce, fir, and pine.

brackish - Having a somewhat salty taste, especially from containing a mixture of seawater and fresh water.

bromeliad - Any of various mostly epiphytic tropical American plants of the family Bromeliaceae, usually having long stiff leaves, colorful flowers, and showy bracts. Bromeliads include the pineapple, the Spanish moss, and numerous ornamentals.

brood parasitism - (Also called nest parasitism or breeding parasitism.) The laying of eggs by one bird species in the nest of another bird species and the subsequent brooding of the egg and raising of the young by the parasitized host, usually to the detriment of the host's young. Brood parasitism. (Also called nest parasitism or breeding parasitism.) The laying of eggs by one bird species in the nest of another bird species and the

- subsequent brooding of the egg and raising of the young by the parasitized host, usually to the detriment of the host's young.
- bryozoan - Any of various small aquatic animals of the phylum Bryozoa that reproduce by budding and form mosslike or branching colonies permanently attached to stones or seaweed.
- burrow - A hole or tunnel dug in the ground by a small animal for habitation or refuge.
- bycatch - The portion of a fishing catch that is discarded as unwanted or commercially unusable.
- byssal - A mass of strong, silky filaments by which certain bivalve mollusks, such as mussels, attach themselves to rocks and other fixed surfaces.
- C**
- calcareous - Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone; chalky.
- carapace - A hard bony or chitinous outer covering, such as the fused dorsal plates of a turtle or the portion of the exoskeleton covering the head and thorax of a crustacean.
- cardiform - Small, sharp, slender teeth; arranged like a series of combs.
- cardiomyopathy (enlargement of the heart muscle) - A disease or disorder of the heart muscle, especially of unknown or obscure cause.
- carnivore - Any animal that feeds on flesh.
- carpus - A joint in quadrupeds corresponding to the wrist.
- carrion - Dead and decaying flesh.
- catadromous - Living in fresh water but migrating to marine waters to breed.
- caudal - Of, at, or near the tail or hind parts; posterior
- caudal fin - The tail of fishes and some other aquatic vertebrates.
- caudal spot - A spot or blotch of color contrasting with the base color and located on or near the base of the caudal or tail fin of a fish.
- cercus - Either of a pair of terminal, dorsolateral sensory appendages of certain insects, such as the female mosquito.
- chela - A pincerlike claw of a crustacean or arachnid, such as a lobster, crab, or scorpion.
- chelate - Having chelae or resembling a chela.
- chelicerae - Either of the first pair of fanglike appendages near the mouth of an arachnid, such as a spider, often modified for grasping and piercing.
- cheliped - One or more pairs of thoracic legs of decapod crustaceans that terminate in a chela, or claw. The entire cheliped is often referred to as a claw.
- chlordan - A colorless, odorless, viscous liquid used as an insecticide. It may be toxic to humans and wildlife as a result of its effect on the nervous system.

- chlorosis - The yellowing or bleaching of plant tissues due to the loss of chlorophyll or failure of chlorophyll synthesis. It can be caused by insufficient light or nutrients, and also by certain diseases.
- cladoceran - Any of various small, mostly freshwater crustaceans of the order Cladocera, which includes the water fleas.
- cnidarians - Any of various invertebrate animals of the phylum Cnidaria, characterized by a radially symmetrical body with a saclike internal cavity, and including the jellyfishes, hydras, sea anemones, and corals. Also called coelenterate.
- concave - Curving inward.
- congener - An organism belonging to the same taxonomic genus as another organism.
- conspecific - Of or belonging to the same species.
- continental shelf - A submerged border of a continent that slopes gradually and extends to a point of steeper descent to the ocean bottom.
- copepod - Any of numerous minute marine and freshwater crustaceans of the subclass Copepoda, having an elongated body and a forked tail.
- costa - A rib or a riblike part, such as the midrib of a leaf or a thickened anterior vein or margin of an insect's wing.
- creel - A daily possession or bag limit for the recreational take of fishes.
- creel limit - Number and sizes of fish that can be legally harvested during a particular time period.
- crown - The top of the head.
- crustacean - Any of various predominantly aquatic arthropods of the class Crustacea, including lobsters, crabs, shrimps, and barnacles, characteristically having a segmented body, a chitinous exoskeleton, and paired, jointed limbs.
- ctenoid - Having marginal projections that resemble the teeth of a comb.
- cultch (material) - A natural bed for oysters, consisting of gravel or crushed shells to which the oyster spawn may adhere.
- cycloid scales - A fish scale which is thin and shows concentric lines of growth, without serrations on the margin.

D

- decapod - A crustacean of the order Decapoda, such as a crab, lobster, or shrimp, characteristically having ten legs, each joined to a segment of the thorax.
- demography - The study of the characteristics of populations, such as size, growth, density, distribution, and vital statistics.
- desiccation - To dry out thoroughly.
- detrital - Loose fragments or grains that have been worn away from rock.
- detritivore - An organism that feeds on dead organic and fecal matter.
- detritus - Loose matter resulting from the wearing away or disintegration of a tissue or substance.

- diapause - A period during which growth or development is suspended and physiological activity is diminished, as in certain insects in response to adverse environmental conditions.
- diatoms - Any of various microscopic one-celled or colonial algae of the class Bacillariophyceae, having cell walls of silica consisting of two interlocking symmetrical valves.
- diel - A 24-hour period, usually encompassing 1 day and 1 night.
- Dieldrin - A chlorinated hydrocarbon, C₁₂H₈Cl₆O, used as an insecticide.
- dimorphic - Existing or occurring in two distinct forms; exhibiting dimorphism.
- dioxin - Any of several carcinogenic or teratogenic heterocyclic hydrocarbons that occur as impurities in petroleum-derived herbicides.
- disking - A mechanical method of scarifying the soil to reduce competing vegetation and to prepare a site to be seeded or planted.
- distensible - That can be distended (To swell out or expand from or as if from internal pressure.)
- diurnal - Occurring or active during the daytime rather than at night.
- dorsal - Of, toward, on, in, or near the back or upper surface of an organ, part, or organism.
- dorsal fin - The main fin located on the back of fishes and certain marine mammals.
- drainage basin - The geographical area draining into a river or reservoir.

E

- echinoderm - Any of numerous radially symmetrical marine invertebrates of the phylum Echinodermata, which includes the starfishes, sea urchins, and sea cucumbers, having an internal calcareous skeleton and often covered with spines.
- ecoregion - An area defined by environmental conditions and natural features; a region defined by its ecology.
- ecotone - A transitional zone between two communities containing the characteristic species of each.
- ectocommensal - A commensal organism that lives on the outer body surface of another organism.
- eddy - A current, as of water or air, moving contrary to the direction of the main current, especially in a circular motion.
- effort - A record of effort in units of time (i.e. days or hours) for which a particular gear (i.e. hook and line or various nets) is used to capture fishes or other aquatic species.
- elongate - Long in proportion to width.
- elvers - An eel in its transparent, postlarval stage. Also called glass eels.
- elytra - Either of the leathery or chitinous forewings of a beetle or a related insect, serving to encase the thin, membranous hind wings used in flight. Also called wing case.
- endemic - Native to or confined to a certain region.

- endopod - The medial or interior ramus of a crustacean appendage. In the Isopoda, another name for a thoracic appendage (exclusive of the coxa and basis), although more typically applied to inner ramus of a pleopod or a uropod.
- epibenthic - Located at the surface of the sediments on the bay bottom, generally referring to algae.
- epifauna - Animals that live on the sediment but do not burrow into it.
- epimeron - In insects: The lateral piece behind the episternum.
- epiphytic - A plant, such as a tropical orchid or a staghorn fern, that grows on another plant upon which it depends for mechanical support but not for nutrients.
- epizootic - Affecting a large number of animals at the same time within a particular region or geographic area.
- estuary - The wide part of a river where it nears the sea; fresh and salt water mix.
- etiology - The study of causes or origins.
- euryhaline - Capable of tolerating a wide range of salt water concentrations.
- eurythermal - Adaptable to a wide range of temperatures.
- eutrophication - Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.
- exarate - To plow up; also, to engrave; to write.
- extirpate - To destroy totally; exterminate.
- exuviae - The cast-off skins or coverings of various organisms, such as the shells of crabs or the external coverings of the larvae and nymphs of insects.

E

- facet - One of the lenslike visual units of a compound eye, as of an insect.
- falcate - Curved and tapering to a point; sickle-shaped.
- fathom - A unit of length equal to 6 feet (1.83 meters), used principally in the measurement and specification of marine depths.
- flagella - A long, threadlike appendage, especially a whiplike extension of certain cells or unicellular organisms that functions as an organ of locomotion.
- flange - A protruding rim, edge, rib, or collar, as on a wheel or a pipe shaft, used to strengthen an object, hold it in place, or attach it to another object.
- flock - A collection of small, loosely held masses or aggregates of fine particles, resembling a tuft of wool and suspended in or precipitated from a solution.
- forbs - A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow.
- fratricide - The killing of one's brother or sister.
- frenum - A membranous fold of skin or mucous membrane that supports or restricts the movement of a part or organ.

freshet - A stream of fresh water that empties into a body of salt water.

frons - The anterior, uppermost part of the head of an insect.

fry - Small fish, especially young, recently hatched fish.

fusiform - Tapering at each end; spindle-shaped.

G

gaster - The portion of the abdomen behind the petiole in ants and other hymenopterous insects.

gastropods - Any of various mollusks of the class Gastropoda, such as the snail, slug, cowrie, or limpet, characteristically having a single, usually coiled shell or no shell at all, a ventral muscular foot for locomotion, and eyes and feelers located on a distinct head.

genotype - The genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms.

gill rakers - Generally stout projections extending from the gills (or better gill arches that support the gills) of fishes that are used to filter appropriate food items while allowing most inedible items to pass out of a fish's operculum or gill-cover.

glass eel - An eel in its transparent, postlarval stage. Also called an elver.

glochidia - The parasitic larva of certain freshwater mussels of the family Unionidae, having hooks for attaching to the gills or other external parts of a host fish.

gonopodium - A modified portion of the anal fin (fin on the lower abdomen posterior to the vent) in males of fishes in the live-bearer family (Poeciliidae) that functions as an organ that transports sperm during internal fertilization or copulation.

gorgonian - Any of various corals of the order Gorgonacea, having a flexible, often branching skeleton of horny material.

granivore - Feeding on grain and seeds.

granulation - 1. Small, fleshy, beadlike protuberances, consisting of outgrowths of new capillaries, on the surface of a wound that is healing. Also called granulation tissue.
2. The formation of these protuberances.

gular pouch - a pouch of bare skin between the lower mandibles (bottom bill parts), seen in such birds as the Brown Pelican. The word "gular" means "pertaining to the throat," and arises from the same Latin word as "gullet."

H

hammock island - Vegetated islands of 0.05 to 404.5 hectares (0.125 to 999.9 acres) in size that are surrounded by tidal wetlands and that are located inland of barrier islands. These uplands are generally not inundated by tide waters and frequently lie within large expanses of tidal-impacted marshland, called 'marsh islands,' that are bordered by tidal waterways.

hard bottom - Also called 'live bottom,' this includes areas of consolidated sediments, rock or other hard substrates that are usually quickly encrusted by living, stationary animals and algae. Such areas frequently have relief or vertical extension into the water

column greater than that of surrounding unconsolidated sand, shell, mud or mixed 'soft' bottoms.

heavy metal - A metal with a specific gravity greater than about 5.0, especially one that is poisonous, such as lead or mercury.

hemispherical - A half of a sphere bounded by a great circle.

hemolymph - The blood analogue used by all arthropods and most mollusks that have an open circulatory system. In these animals there is no distinction between blood and interstitial fluid. The liquid fills all of the interior (hemocoel) of the body and surrounds all cells.

hepatic - Of, relating to, or resembling the liver.

herbivore - An animal that feeds chiefly on plants.

hermaphroditic - Of animal or plant; having both male female reproductive organs

heterogeneity - The quality or state of being heterogeneous. (Consisting of dissimilar elements or parts; not homogeneous.)

holometabolous - Having complete metamorphosis.

holotype - The single specimen or illustration designated as the type for naming a species or subspecies or used as the basis for naming a species or subspecies when no type has been selected. Also called type.

hood (prothoracic covering of the head) - An expanded part, crest, or marking on or near the head of an animal.

hydroid - Any of numerous characteristically colonial hydrozoan coelenterates having a polyp rather than a medusoid form as the dominant stage of the life cycle.

I

imperilment - To put into peril.

impoundment - A body of water, such as a reservoir, made by impounding.

indicator species - An organism whose presence or state of health is used to identify a specific type of biotic community or as a measure of ecological conditions or changes occurring in the environment.

indigenous - Originating and living or occurring naturally in an area or environment.

infauna - Aquatic animals that live in the substrate of a body of water, especially in a soft sea bottom.

infaunal - Organisms that live within the sediment.

inflorescence - 1. A characteristic arrangement of flowers on a stem. 2. A flower cluster.

infraorder - Scientific classification or biological classification refers to how biologists group and categorize extinct and living species of organisms.

instar - A stage of an insect or other arthropod between molts.

interorbital - Situated or extending between the orbits of the eyes.

intertidal - Of or being the region between the high tide mark and the low tide mark.

introgression - Infiltration of the genes of one species into the gene pool of another through repeated backcrossing of an interspecific hybrid with one of its parents.

invertebrate - An animal, such as an insect or mollusk, that lacks a backbone or spinal column.

irruptive migrant - Migrations that are not seasonally or geographically predictable, irruptions may occur in one year but not again for many years. Distances and numbers of individuals involved are less predictable than for partial or complete migrants.

isochronal spawning - To release and fertilize eggs at the same time or interval.

isopod - Any of numerous crustaceans of the order Isopoda, characterized by a flattened body bearing seven pairs of legs and including the sow bugs and gribbles.

isotope - One of two or more atoms having the same atomic number but different mass numbers.

K

karyotypic - Studying the raw genetic information.

keel - A structure, such as the breastbone of a bird, that resembles a ship's keel in function or shape.

keystone species - A species that plays a pivotal role in an ecosystem and upon which a large part of the community depends.

kype - Hooked jaw acquired by trout and salmon, especially at spawning time; it is comprised of cartilage.

L

lacustrine - Living or growing in or along the edges of lakes.

larva - The newly hatched, earliest stage of any of various animals that undergo metamorphosis, differing markedly in form and appearance from the adult.

lentic - Of or relating to or living in still waters (as lakes or ponds).

leptocephalus - One of the small, flat, transparent larvae of eels and certain other fishes, characterized by a long, narrow head.

littoral - A coastal region; a shore.

littoral zone - The region of the shore of a lake or sea or ocean.

live bottom - See hard bottom.

longline - A heavy fishing line usually several miles long and having a series of baited hooks.

lore - The space between the eye and the base of the bill of a bird or between the eye and nostril of a snake.

lotic - Of or relating to or living in actively moving water.

lunule - A small crescent-shaped structure or marking.

M

malacological - The branch of zoology that deals with mollusks.

- malacology - The branch of zoology that deals with mollusks.
- malar stripe - Area at the sides of the chin. Synonym(s): whisker, mustache, malar streak.
- mangrove - A tropical tree or shrub bearing fruit that germinates while still on the tree and having numerous prop roots that eventually form an impenetrable mass and are important in land building.
- mast - The nuts of forest trees accumulated on the ground.
- maxilliped - One of the three pairs of crustacean head appendages located just posterior to the maxillae and used in feeding.
- medus - The tentacled, usually bell-shaped, free-swimming sexual stage in the life cycle of a coelenterate, such as a jellyfish.
- Megalops (megalopal stage) - A larva, in a stage following the zo["e]a, in the development of most crabs. In this stage the legs and abdominal appendages have appeared, the abdomen is relatively long, and the eyes are large.
- melanistic (black) - Dark coloration of the skin, hair, fur, or feathers because of a high concentration of melanin.
- melanophore - A pigment cell that contains melanin, especially as found in the skin of amphibians and reptiles.
- merus - The proximal segment of the hind limb; the thigh.
- mesial - Of, in, near, or toward the middle.
- mesic - Of, characterized by, or adapted to a moderately moist habitat.
- mesohaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 5 ‰ (or ppt = parts per thousand) to 18 ‰.
- mesonota - The upper surface covering the middle segment of the thorax of insects.
- mesoscutellum - The visible triangular piece of the mesonotum between the bases of the elytra.
- mesoscutum - The scutum or dorsal plate of the middle thoracic segment of an insect.
- mesotrophic - Refers to a region with moderate concentrations of nutrients and moderate biological productivity (compare eutrophic and oligotrophic).
- metamorphose - To change into a wholly different form or appearance; transform.
- metanota - The dorsal plate of the last (third) segment of the thorax.
- microhabitat - The microenvironment in which an organism lives.
- mollusk - Any of numerous chiefly marine invertebrates of the phylum Mollusca, typically having a soft unsegmented body, a mantle, and a protective calcareous shell and including the edible shellfish and the snails.
- molt - To shed periodically part or all of a coat or an outer covering, such as feathers, cuticle, or skin, which is then replaced by a new growth.
- montane - Of, growing in, or inhabiting mountain areas.
- morphology - The form and structure of an organism or one of its parts.

morphotype - Morphologically distinguishable portions of populations of a single taxon.

motile - Moving or having the power to move spontaneously.

mottled - To mark with spots or blotches of different shades or colors.

musk – 1. A greasy secretion with a powerful odor, produced in a glandular sac beneath the skin of the abdomen of the male musk deer and used in the manufacture of perfumes.
2. A similar secretion produced by certain other animals, such as the otter or civet.

N

nail - The button-like formation at the end of the mandibles is called the "nail" and is hard, much like a human fingernail.

nape - The back of the neck.

neap tides - The lowest tides of the lunar month, which occur in the second and fourth quarters of the moon.

nektonic - The collection of marine and freshwater organisms that can swim freely and are generally independent of currents, ranging in size from microscopic organisms to whales.

nest parasitism - See brood parasitism.

nocturnal - Most active at night.

nodus - A circumscribed mass of tissue; a node.

nonpoint - Not found or located at a single, definable point, as pollution whose source cannot be ascertained.

nonpoint source pollution - Pollutants detected in a concentrated water source such as a stream, river or lake, that come from a wide range of sources. These pollutants come from sources the common person has control over.

nota - The dorsal part of the thoracic segment of an insect.

nuptial - Of, relating to, or occurring during the mating season.

O

obligate - Able to exist or survive only in a particular environment or by assuming a particular role.

oblique - Having a slanting or sloping direction, course, or position; inclined.

oblong - Having a somewhat elongated form with approximately parallel sides.

obtuse - Not sharp, pointed, or acute in form; blunt.

ocellus (light sensing organ) - A small simple eye, found in many invertebrates, usually consisting of a few sensory cells and a single lens.

oligohaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 0.5 ‰ (or ppt = parts per thousand) to 5 ‰.

oligotrophic - Lacking in plant nutrients and having a large amount of dissolved oxygen throughout. Used of a pond or lake.

olivaceous - Olive-green.

- omnivore - An animal that feeds on both animal and vegetable substances.
- omnivorous - Eating both animal and vegetable foods.
- opercle - Any one of the bony plates which support the gill covers of fishes; an opercular bone.
- operculum - A lid or flap covering an aperture, such as the gill cover in some fishes or the horny shell cover in snails or other mollusks.
- opithosoma - The middle section of the carapace.
- organophosphates - Any of several organic compounds containing phosphorus, some of which are used as fertilizers and pesticides.
- ornithology - The branch of zoology that deals with the study of birds.
- osmoconformer - An invertebrate whose ion concentrations match those in the ocean.
- otolith - Any of numerous minute calcareous particles found in the inner ear of certain lower vertebrates and in the statocysts of many invertebrates.
- ovate - Shaped like an egg; oval.
- overstory - The uppermost layer of foliage that forms a forest canopy.
- oviparous - Producing eggs that hatch outside the body.
- ovipositor - A tubular structure, usually concealed but sometimes extending outside the abdomen, with which many female insects deposit eggs.

P

- palatine - Of or relating to the palate.
- palustrine - Of, pertaining to, or living in, a marsh or swamp; marshy.
- papillose - Having small nipplelike projections, such as a protuberance on the skin, at the root of a hair or feather, or at the base of a developing tooth.
- paramere - One of the symmetrical halves of any one of the radii, or spheromeres, of a radiate animal, as a starfish.
- paranota - Lateral expansions of pronotum.
- pathogen - An agent that causes disease, especially a living microorganism such as a bacterium or fungus.
- pectoral fin - Either of the anterior pair of fins attached to the pectoral girdle of fishes, corresponding to the forelimbs of higher vertebrates.
- peduncle - A stalklike structure in invertebrate animals, usually serving as an attachment for a larger part or structure. A stalklike bundle of nerve fibers connecting different parts of the brain.
- pelage - The coat of a mammal, consisting of hair, fur, wool, or other soft covering, as distinct from bare skin.
- pelagic - Of, relating to, or living in open oceans or seas rather than waters adjacent to land or inland waters.

- pelvic fin - Either of a pair of lateral hind fins of fishes, attached to the pelvic girdle and corresponding to the hind limbs of higher vertebrates.
- penaeid - A inclusive term referring to shrimps in the family Penaeidae, which includes the commercially and recreationally valuable marine and estuarine shrimps of South Carolina.
- peraeopod - One of the thoracic legs of a crustacean.
- perched water table - The water table of a relatively small groundwater body lying above the general groundwater body.
- phenotype - The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.
- photoreceptor - A nerve ending, cell, or group of cells specialized to sense or receive light.
- physiography - The study of physical features of the earth's surface.
- phytophagous - Feeding on plants, including shrubs and trees. Used especially of certain insects.
- phytoplankton - Minute, free-floating aquatic plants.
- pincers - The articulated prehensile claws of certain arthropods, such as the lobster.
- piscivorous - Habitually feeding on fish; fish-eating.
- plankton - The collection of small or microscopic organisms, including algae and protozoans, that float or drift in great numbers in fresh or salt water, especially at or near the surface, and serve as food for fish and other larger organisms.
- planktonic - Of or relating to plankton The collection of small or microscopic organisms, including algae and protozoans, that float or drift in great numbers in fresh or salt water, especially at or near the surface, and serve as food for fish and other larger organisms.
- plastron - The ventral part of the shell of a turtle or tortoise.
- pleopod - one of the paired abdominal appendages of certain aquatic crustaceans that function primarily for carrying the eggs in females and are usually adapted for swimming.
- polychaete worm - Chiefly marine annelids possessing both sexes and having paired appendages (parapodia) bearing bristles.
- polychlorinated biphenyl - Any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are toxic environmental pollutants which tend to accumulate in animal tissues called also PCB.
- polyhaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 18 ‰ (or ppt = parts per thousand) to 30 ‰.
- polyps - A coelenterate, such as a hydra or coral, having a cylindrical body and an oral opening usually surrounded by tentacles.
- polytene - Relating to or having large multistranded chromosomes whose corresponding chromomeres are in contact.

posterior - Located behind a part or toward the rear of a structure.

precocious - Characterized by or characteristic of exceptionally early development or maturity.

prehensile - Adapted for seizing, grasping, or holding, especially by wrapping around an object.

preopercular - Situated in front of the operculum, a lid or flap covering an aperture, such as the gill cover in some fishes or the horny shell cover in snails or other mollusks.

primary - One of the main flight feathers projecting along the outer edge of a bird's wing.

proboscis - The slender, tubular feeding and sucking organ of certain invertebrates, such as insects, worms, and mollusks.

pronotum - The dorsal plate of the prothorax in insects.

propodus - Second part from the distal end of a leg or maxilliped. In a cheliped the propodus consists of a palmar portion and a narrower, immovable finger

prosoma - The anterior or cephalic portion of the body of certain invertebrates, such as arachnids, in which segmentation is not evident.

protogyny - A state in hermaphroditic systems characterized by the development of female reproductive organs, or maturation of their gametes, before the appearance of the corresponding male product, thus insuring against self-fertilization.

pterostigma - A thickened opaque spot on the wings of certain insects.

punctate - Having tiny spots, points, or depressions.

pupae - The nonfeeding stage between the larva and adult in the metamorphosis of holometabolous insects, during which the larva typically undergoes complete transformation within a protective cocoon or hardened case.

R

raptorial - Subsisting by seizing prey; predatory.

recruitment - The influx of new members into a population by reproduction or immigration.

relict - 1. An organism or species of an earlier time surviving in an environment that has undergone considerable change. 2. Something that has survived; a remnant.

respiratory lamellae - A thin scale, plate, or layer of bone or tissue, as in the gills of a bivalve mollusk or around the minute vascular canals in bone.

rhizomes - A horizontal, usually underground stem that often sends out roots and shoots from its nodes.

rhomboid - A parallelogram with unequal adjacent sides.

riffle - A rocky shoal or sandbar lying just below the surface of a waterway.

riparian - Of, on, or relating to the banks of a natural course of water.

riverine - Located on or inhabiting the banks of a river; riparian.

rostrum - A rostrum (Latin beak) is an anatomical structure resembling a bird's beak, such as part of the carapace of a crustacean. Since the rostrum is typically located about the thorax of an arthropod, it is differentiated from the cauda or tail.

S

sabellid worms - Marine segmented worms (phylum Annelida) in the polychaete class and the family Sabellidae. Sabellid worms build membranous or sand tubes, are sedentary or stationary, and may be called fanworms, feather dusters or Christmas tree worms.

scapular - One of the feathers covering the shoulder of a bird.

scapulets - A secondary mouth fold developed at the base of each of the armlike lobes of the manubrium of many rhizostome medus[ae].

scavenger - An animal, such as a bird or insect, that feeds on dead or decaying matter.

sclerite - A chitinous or calcareous plate, spicule, or similar part of an invertebrate, especially one of the hard outer plates forming part of the exoskeleton of an arthropod.

sclerotized - Hardened by deposition of the protein sclerotin.

scyphomedusae - One of the two subdivisions of the Hydrozoa.

secondary - Of, relating to, or being the shorter flight feathers projecting along the inner edge of a bird's wing.

sessile - Permanently attached or fixed; not free-moving.

seta - A stiff hair, bristle, or bristlelike process or part on an organism.

sexually dimorphic – Physical features such as body size and color differs between the males and females of this species.

sinusoidal - Having a succession of waves or curves.

siphon - A tubular organ, especially of aquatic invertebrates such as squids or clams, by which water is taken in or expelled.

snag - A rough, sharp, or jagged protuberance, as a tree or a part of a tree that protrudes above the surface in a body of water. Also called sawyer.

spatulate - Shaped like a spatula.

spawn - To deposit eggs; produce spawn.

speculum - A bright, often iridescent patch of color on the wings of certain birds, especially ducks.

spermatheca - A receptacle in the reproductive tracts of certain female invertebrates, especially insects, in which spermatozoa are received and stored until needed to fertilize the ova.

spermathecae - A small sac connected with the female reproductive organs of insects and many other invertebrates, serving to receive and retain the spermatozoa.

spermatophore - A capsule or compact mass of spermatozoa extruded by the males of certain invertebrates and primitive vertebrates and directly transferred to the reproductive parts of the female.

spinous - Resembling a spine or thorn.

spinule - A small spine or thorn.

spumaline - A sticky, frothy substance used by adult moths as an adhesive to attach eggs to bark or twigs.

squamous - Covered with or formed of scales; scaly.

stemmata - A small, circular, simple eye present in various insect larvae.

subimago - A stage in the development of certain insects, such as the May flies, intermediate between the pupa and imago. In this stage, the insect is able to fly, but subsequently sheds a skin before becoming mature. Called also pseudimago.

subrhomboidal - Roughly resembling a rhomboid, a parallelogram with unequal adjacent sides (rectangle w/o right angles).

substrata - A layer of rock or soil beneath the surface of the earth; a sedimentary bed.

supercillium - The eyebrow.

supraloral - Situated above the lores; as, the supraloral feathers of a bird.

suture - A seamlike joint or line of articulation, such as the line of dehiscence in a dry fruit or the spiral seam marking the junction of whorls of a gastropod shell.

swash zone - The swash zone is the area of the nearshore that is intermittently covered and uncovered by wave run-up.

symbiotic - A close, prolonged association between two or more different organisms of different species that may, but does not necessarily, benefit each member.

sympatry - The occurrence of organisms in overlapping geographical areas, but without interbreeding.

T

tannic acid - Black or tannic acid rivers and streams have usually clear, tea-colored water that is stained by tannins or fulvic acids that are derived from decaying leaves and other vegetation. Tannic acid or black rivers are generally contained within the Coastal Plain and carry less silt than do the larger, longer rivers that originate in the Piedmont or Mountain ecoregions. Rivers that originate in the Piedmont or farther inland are often called red rivers because of the red or orange color of the water created by high silt loads during high flows.

tarsi - The distal part of the leg of an arthropod, usually divided into segments.

telemetry - The science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources, as from space vehicles, to receiving stations for recording and analysis.

telson - The “tail” of the carapace.

teneral - Of, pertaining to, or designating, a condition assumed by the imago of certain Neuroptera, after exclusion from the pupa. In this state the insect is soft, and has not fully attained its mature coloring.

- terga - The upper or dorsal surface, especially of a body segment of an insect or other arthropod.
- tergite - A sclerite forming one of the constituents of a tergum.
- terrestrial - Of or relating to the earth or its inhabitants.
- thorax - The second or middle region of the body of an arthropod, between the head and the abdomen, in insects bearing the true legs and wings.
- tibia - The fourth division of an insect's leg, between the femur and the tarsi.
- tidal bore - A high wave (often dangerous) caused by tidal flow (as by colliding tidal currents or in a narrow estuary).
- tide pool - A pool of water remaining after a tide has retreated.
- transverse - Lying across the long axis of the body or of a part.
- trapezoid - A quadrilateral having two parallel sides.
- trawl - A conical fishnet dragged through the water at great depths.
- tributary - A stream that flows into a larger stream or other body of water.
- trophic - Of or involving the feeding habits or food relationship of different organisms in a food chain.
- tubercle - A small rounded projecting part or outgrowth, such as a wartlike excrescence on the roots of some leguminous plants or a knoblike process in the skin or on a bone.
- tunicate - Any of various chordate marine animals of the subphylum Tunicata or Urochordata having a cylindrical or globular body enclosed in a tough outer covering and including the sea squirts and salps.

U

- ubiquitous - Being or seeming to be everywhere at the same time; omnipresent.
- umbo - A knoblike protuberance arising from a surface, as the prominence near the hinge of a bivalve shell or the projection at the scale tip of a seed-bearing cone.
- understory - An underlying layer of vegetation, especially the plants that grow beneath a forest's canopy.

V

- vent - The excretory opening of the digestive tract in animals such as birds, reptiles, amphibians and fish.
- ventral - Relating to or situated on or close to the abdomen; abdominal.
- vermiculate - Bearing wavy, wormlike lines.
- vertical niche partitioning - An evolved feeding or foraging strategy in whales by which they primarily feed at different depths or vertical distances above the ocean floor to limit competition between species.
- vestigial - Occurring or persisting as a rudimentary or degenerate structure.

W

watershed - The region draining into a river, river system, or other body of water.

X

xeric - Of, characterized by, or adapted to an extremely dry habitat.

Z

zooplankton - Animal constituent of plankton; mainly small crustaceans and fish larvae.

APPENDIX 1: PRIORITY CONSERVATION SPECIES OF SOUTH CAROLINA

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Mammals					
Black Bear	<i>Ursus americanus</i>	Highest	Of Concern, State	G5	S3?
Florida Manatee	<i>Trichechus manatus</i>	Highest	Federal and State Endangered	G2	S1S2
Northern Yellow Bat	<i>Lasiurus intermedius</i>	Highest	Of Concern, State	G4G5	S?
Appalachian Cottontail	<i>Sylvilagus obscurus</i>	High		G4	S3
Atlantic Right Whale	<i>Eubaleana glacialis</i>	High	Federal and State Endangered	G1	SA
Bottlenose Dolphin	<i>Tursiops truncatus</i>	High	Of Concern, State	G5	S4
Carolina Red-backed Vole	<i>Clethrionomys gapperi</i>	High	Of Concern, State	G5	S3
Dwarf Sperm Whale	<i>Kogia sima</i>	High	Of Concern, State	G4	S?
Eastern Small-footed Myotis	<i>Myotis leibii</i>	High	State Threatened	G3	S1
Hairy-tailed Mole	<i>Parascalops breweri</i>	High	Of Concern, State	G5	S?
Humpback Whale	<i>Megaptera novaeangliae</i>	High	Federal and State Endangered	G3	S1
Masked Shrew	<i>Sorex cinereus</i>	High	Of Concern, State	G5	S?
Meadow Vole	<i>Microtus pennsylvanicus</i>	High	Of Concern, State	G5	S?
Mink	<i>Mustela vison</i>	High		G5	S?
Pygmy Sperm Whale	<i>Kogia breviceps</i>	High	Of Concern, State	G4	SA
Rafinesque's Big-eared Bat	<i>Corynorhinus rafinesquii</i>	High	State Endangered	G3G4	S2?
Southeastern Bat	<i>Myotis austroriparius</i>	High	Of Concern, State	G3G4	S1
Star-nosed Mole	<i>Condylura cristata</i>	High	Of Concern, State	G5	S3?
Swamp Rabbit	<i>Sylvilagus aquaticus</i>	High	Of Concern, State	G5	S2S3
Eastern Fox Squirrel	<i>Sciurus niger</i>	Moderate	Of Concern, State	G5	S4
Eastern Spotted Skunk	<i>Spilogale putorius</i>	Moderate	Of Concern, State	G5	S4
Eastern Woodrat	<i>Neotoma floridana</i>	Moderate	Of Concern, State	G5	S3S4
Southern Pygmy Shrew	<i>Sorex hoyi</i>	Moderate		G5	S3
Woodland Jumping Mouse	<i>Napaeozapus insignis</i>	Moderate	Of Concern, State	G5	S4?

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Birds					
American Avocet	<i>Recurvirostra americana</i>	Highest		G5	S?
American Bittern	<i>Botaurus lentiginosus</i>	Highest	Of Concern, State	G4	S?
American Coot	<i>Fulica americana</i>	Highest		G5	SHB,SNRN
American Golden Plover	<i>Pluvialis dominica</i>	Highest		G5	SNA
American Kestrel	<i>Falco sparverius paulus</i>	Highest		G5	SNR
American Oystercatcher	<i>Haematopus palliates</i>	Highest	Of Concern, State	G5	S?
Bachman's Sparrow	<i>Aimophila aestivalis</i>	Highest	Of Concern, State	G3	S3
Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	Highest		G5	SNRB,SNRN
Black Duck	<i>Anas rubripes</i>	Highest		G5	SNRN
Black Rail	<i>Laterallus jamaicensis</i>	Highest	Of Concern, State	G4	S?
Black Skimmer	<i>Rynchops niger</i>	Highest	Of Concern, State	G5	S2
Black-throated Green Warbler	<i>Dendroica virens waynei</i>	Highest		G5	S4
Brown-headed Nuthatch	<i>Sitta pusilla</i>	Highest		G5	S4
Buff-breasted Sandpiper	<i>Tryngites subruficollis</i>	Highest		G4	SNA
Common Ground-dove	<i>Columbina passerine</i>	Highest	State Threatened	G5	S?
Common Tern	<i>Sterna hirundo</i>	Highest			
Dunlin	<i>Calidris alpina</i>	Highest		G5	SNR
Eastern Brown Pelican	<i>Pelicanus occidentalis carolinensis</i>	Highest		G4	SNR
Eastern Meadowlark	<i>Sturnella magna</i>	Highest		G5	SNR
Eastern Wood Peewee	<i>Contopus virens</i>	Highest		G5	S5B
Field Sparrow	<i>Spizella pusilla</i>	Highest		G5	S5?
Glossy Ibis	<i>Plegadis falcinellus</i>	Highest	Of Concern, State	G5	S?
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	Highest		G5	SNRB,SNRN
Gull-billed Tern	<i>Sterna nilotica</i>	Highest	Of Concern, State	G5	S?
Henslow's Sparrow	<i>Ammodramus henslowii</i>	Highest	Of Concern, State	G4	SZN
Kentucky Warbler	<i>Oporornis formosus</i>	Highest		G5	S4B
King Rail	<i>Rallus elegans</i>	Highest		G4	SNR
Least Bittern	<i>Ixobrychus exilis</i>	Highest		G5	SNRB,SNRN
Least Sandpiper	<i>Calidris minutilla</i>	Highest		G5	SNRN
Least Tern	<i>Sterna antillarum</i>	Highest	State Threatened	G4	S3
Lesser Scaup	<i>Aythya affinis</i>	Highest		G5	SNRN

AP 1: Priority Species List
SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Lesser Yellowlegs	<i>Tringa flavipes</i>	Highest		G5	SNRN
Little Blue Heron	<i>Egretta caerulea</i>	Highest	Of Concern, State	G5	S?
Loggerhead Shrike	<i>Lanius ludovicianus</i>	Highest	Of Concern, State	G4	S3
Long-billed Curlew	<i>Numenius americanus</i>	Highest		G5	SNA
Mallard	<i>Anas platyrhynchos</i>	Highest		G5	SNRB,SNRN
Marbled Godwit	<i>Limosa fedoa</i>	Highest		G5	SNRN
Northern Bobwhite	<i>Colinus virginianus</i>	Highest		G5	S4
Northern Pintail	<i>Anas acuta</i>	Highest		G5	SNRN
Painted Bunting	<i>Passerina ciris</i>	Highest		G5	SNRB
Pied-billed Grebe	<i>Podilymbus podiceps</i>	Highest		G5	SNRB,SNRN
Prairie Warbler	<i>Dendroica discolor</i>	Highest		G5	SRB
Purple Gallinule	<i>Porphyrio martinica</i>	Highest	Of Concern, State	G5	S4
Red-cockaded Woodpecker	<i>Picoides borealis</i>	Highest	Federal and State Endangerd	G3	S2
Red Knot	<i>Calidris canutus</i>	Highest		G5	SNRN
Royal Tern	<i>Sterna maxima</i>	Highest		G5	SNRB,SNRN
Rusty Blackbird	<i>Euphagus carolinus</i>	Highest		G4	SNRN
Sanderling	<i>Calidris alba</i>	Highest		G5	SNRN
Sandwich Tern	<i>Sterna sandvicensis</i>	Highest		G5	SNRB
Seaside Sparrow	<i>Amospiza maritima</i>	Highest			
Semipalmated Sandpiper	<i>Calidris pusilla</i>	Highest		G5	SNA
Short-billed Dowitcher	<i>Limnodromus griseus</i>	Highest		G5	SNRN
Snowy Egret	<i>Egretta thula</i>	Highest		G5	SNRB,SNRN
Solitary Sandpiper	<i>Tringa solitaria</i>	Highest		G5	SNA
Stilt Sandpiper	<i>Calidris himantopus</i>	Highest		G5	SNA
Swaison's Warbler	<i>Limnolophus swainsonii</i>	Highest	Of Concern, State	G4	S4
Swallow-tailed Kite	<i>Elanoides forficatus</i>	Highest		G5	S2
Tricolor Heron	<i>Egretta tricolor</i>	Highest		G5	SNRB,SNRN
Western Sandpiper	<i>Calidris mauri</i>	Highest		G5	SNRN
Whimbrel	<i>Numenius phaeopus</i>	Highest		G5	SNRN
White Ibis	<i>Eudocimus albus</i>	Highest		G5	
Willet	<i>Catoptrophorus semipalmatus</i>	Highest		G5	SNR
Wilson's Plover	<i>Charadrius wilsonia</i>	Highest	State Threatened	G5	S3?

AP 1: Priority Species List
SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Wilson's Snipe	<i>Gallinago gallinagodelicata</i>	Highest			
Wood Stork	<i>Mycteria americana</i>	Highest	Federal and State Endangerd	G4	S1S2
Wood Thrush	<i>Hylocichla mustelina</i>	Highest		G5	S3?B
Worm-eating Warbler	<i>Helmitheros vermivorus</i>	Highest		G5	S4B
Upland Sandpiper	<i>Bartramia longicauda</i>	Highest		G5	SNA
Yellow-crowned Night Heron	<i>Nyctanassa violacea</i>	Highest		G5	SNRB,SNRN
Yellow Rail	<i>Coturnicops noveboracensis</i>	Highest		G4	
Acadian Flycatcher	<i>Empidonax virescens</i>	High		G5	S4B
Bald Eagle	<i>Haliaeetus leucocephalus</i>	High	Federal Threatened/ State Endangered	G4	S2
Barn Owl	<i>Tyto alba</i>	High	Of Concern, State	G5	S4
Black-bellied Plover	<i>Pluvialis squatarola</i>	High		G5	SNRN
Black Scoter	<i>Melanitta nigra</i>	High		G5	SNRN
Black-throated Blue Warbler	<i>Dendroica caerulescens</i>	High		G5	S4B
Blue-winged Teal	<i>Anas discors</i>	High		G5	SNRB,SNRN
Canvasback	<i>Aythya valisineria</i>	High		G5	S4
Forster's Tern	<i>Sterna forsteri</i>	High		G5	SNRN
Peregrine Falcon	<i>Falco peregrinus</i>	High		G4	SHB,SNRN
Redhead	<i>Aythya Americana</i>	High		G5	SNRN
Semipalmated Plover	<i>Charadrius semipalmatus</i>	High		G5	SNRN
Spotted Sandpiper	<i>Actitis macularia</i>	High		G5	SNA
White-winged Scoter	<i>Melanitta deglandi</i>	High		G5	SNRN
American Woodcock	<i>Scolopax minor</i>	Moderate		G5	S4
Bewick's Wren	<i>Thryomanes bewickii</i>	Moderate	State Endangered	G5	S1?
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>	Moderate		G5	SNRB
Common Loon	<i>Gavia immer</i>	Moderate		G5	SNRN
Common Raven	<i>Corvus corax</i>	Moderate		G5	S4
Dark-eyed Junco	<i>Junco hyemalis</i>	Moderate		G5	SNRB,SNRN
Golden-crowned Kinglet	<i>Regulus satrapa</i>	Moderate		G5	S4
Gray Kingbird	<i>Tyrannus dominicensis</i>	Moderate		G5	SNRB,SNRN
Great Blue Heron	<i>Ardea herodias</i>	Moderate		G5	SNRB,SNRN
Great Egret	<i>Ardea alba</i>	Moderate		G5	SNRB,SNRN
Greater Scaup	<i>Aythya marila</i>	Moderate		G5	SNRN

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Greater Yellowlegs	<i>Tringa melanoleuca</i>	Moderate		G5	SNRN
Green Heron	<i>Butorides virescens</i>	Moderate		G5	SNRB,SNRN
Horned Grebe	<i>Podiceps auritus</i>	Moderate		G5	SNRN,SNRM
Long-billed Dowitcher	<i>Limnodromus scolopaceus</i>	Moderate		G5	SNRN
Louisiana Waterthrush	<i>Seiurus motacilla</i>	Moderate		G5	S4B
Mottled Duck	<i>Anas fulvigula</i>	Moderate		G4	S?
Pectoral Sandpiper	<i>Calidris melanotos</i>	Moderate		G5	SNA
Purple Sandpiper	<i>Calidris maritima</i>	Moderate		G5	
Red-breasted Nuthatch	<i>Sitta Canadensis</i>	Moderate		G5	S4B
Red Crossbill	<i>Loxia curvirostra</i>	Moderate		G5	S4
Ringneck	<i>Aythya collaris</i>	Moderate		G5	SNRN
Ruffed Grouse	<i>Bonasa umbellus</i>	Moderate		G5	S4
Scarlet Tanager	<i>Piranga olivacea</i>	Moderate		G5	SNRB
Tundra Swan	<i>Cygnus columbianus</i>	Moderate		G5	SNRN
White-rumped Sandpiper	<i>Calidris fuscicollis</i>	Moderate		G5	SNA
Wood Duck	<i>Aix sponsa</i>	Moderate		G5	SNRB,SNRN,SNRM
Herpetofauna					
Bog Turtle	<i>Glyptemys muhlenbergii</i>	Highest	Federal and State Threatened	G3	S1
Broad-striped Dwarf Siren	<i>Pseudobranchius striatus striatus</i>	Highest		G5	S2
Carolina Gopher Frog	<i>Rana capito capito</i>	Highest	Federal Threatened/ State Endangered	G3/G4	S1
Chamberlain's Dwarf Salamander	<i>Eurycea chamberlainii</i>	Highest			
Coal Skink	<i>Eumeces anthracinus</i>	Highest	State Threatened	G5	S1
Coral Snake	<i>Micrurus fulvius</i>	Highest	Of Concern, State	G5	S2
Eastern Milk Snake	<i>Lampropeltis triangulum</i>	Highest	Of Concern, State	G5	S2
Flatwoods Salamander	<i>Ambystoma cingulatum</i>	Highest	Federal Threatened/ State Endangered	G2G3	S1
Florida Green Watersnake	<i>Nerodia floridana</i>	Highest	Of Concern, State	G5	S2
Florida Pine Snake	<i>Pituophis melanoleucus mugitus</i>	Highest	Of Concern, State	G4T3?	S2
Green Salamander	<i>Aneides aeneus</i>	Highest	Of Concern, State	G3G4	S1
Green Sea Turtle	<i>Chelonia mydas</i>	Highest	Federal and State Endangered	G3	SNR
Gopher Tortoise	<i>Gopherus polyphemus</i>	Highest	State Endangered	G3	S1

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Hawksbill Sea Turtle	<i>Eretmochelys imbricata</i>	Highest	Federal and State Endangered	G3	SNR
Island Glass Lizard	<i>Ophisaurus compressus</i>	Highest	Of Concern, State	G3G4	S1S2
Leatherback Sea Turtle	<i>Demochelys coriacea</i>	Highest	Federal and State Endangered	G2	S?
Loggerhead Sea Turtle	<i>Caretta Caretta</i>	Highest	Federal and State Endangered	G3	S3
Kemp's Ridley Sea Turtle	<i>Lepidochelys kempii</i>	Highest	Federal and State Endangered	G1	S?
Pine Barrens Treefrog	<i>Hyla andersonii</i>	Highest	State Threatened	G4	S2S3
Shovel-nosed Salamander	<i>Desmognathus marmoratus</i>	Highest	Of Concern, State	G4	S2
Southern Hognose Snake	<i>Heterodon simus</i>	Highest	Of Concern, State	G2	S?
Tiger Salamander	<i>Ambystoma tigrinum</i>	Highest	Of Concern, State	G5	S?
Webster's Salamander	<i>Plethodon websteri</i>	Highest	State Endangered	G3	S2
Black Swamp Snake	<i>Seminatrix pygaea</i>	High	Of Concern, State	G5	S?
Chicken Turtle	<i>Deirochelys reticularia</i>	High		G5	SNR
Diamondback Terrapin	<i>Malaclemys terrapin</i>	High		G4	S?
Eastern Diamondback Rattlesnake	<i>Crotalus horridus</i>	High	Of Concern, State	G4	S?
Florida Cooter	<i>Pseudemys floridana</i>	High		G5	SNR
Florida Softshell Turtle	<i>Apalone ferox</i>	High	Of Concern, State	G5	S?
Four-toed Salamander	<i>Hemidactylium scutatum</i>	High	Of Concern, State	G5	S?
Gulf Coast Mud Salamander	<i>Pseudotriton montanus flavissimus</i>	High	Of Concern, State	G5T4	S3S4
Hellbender	<i>Cryptobranchus alleganiensis</i>	High	Of Concern, State	G3G4	S?
Mimic Glass Lizard	<i>Ophisaurus mimicus</i>	High	Of Concern, State	G3	S?
Pickerel Frog	<i>Rana palustris</i>	High	Of Concern, State	G5	S?
Pine Snake	<i>Pituophis melanoleucus</i>	High	Of Concern, State	G4	S3S4
Pine Woods Snake	<i>Rhadinea flavilata</i>	High	Of Concern, State	G4	S?
River Cooter	<i>Pseudemys concinna</i>	High		G5	SNR
Seepage Salamander	<i>Desmognathus aeneus</i>	High	Of Concern, State	G3G4	S?
Spiny Softshell Turtle	<i>Apalone spinifera</i>	High		G5	SNR
Striped Mud Turtle	<i>Kinosternon baurii</i>	High	Of Concern, State	G5	S?
Timber Rattlesnake	<i>Crotalus horridus</i>	High	Of Concern, State	G4	S?
Upland Chorus Frog	<i>Pseudacris triseriata</i>	High	Of Concern, State	G5	S3S4
Wood Frog	<i>Rana sylvatica</i>	High	Of Concern, State	G5	S3

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Yellowbelly Turtle	<i>Trachemys scripta</i>	High		G5	SNR
American Alligator	<i>Alligator mississippiensis</i>	Moderate	Federal Threatened	G5	S5
Bird-voiced Treefrog	<i>Hyla avivoca</i>	Moderate	Of Concern, State	G5	S5
Common Snapping Turtle	<i>Chelydra serpentina</i>	Moderate		G5	SNR
Northern Cricket Frog	<i>Acris crepitans</i>	Moderate	Of Concern, State	G5T5	S5
Slender Glass Lizard	<i>Ophisaurus attenuatus</i>	Moderate		G5	S4
Southern Dusky Salamander	<i>Desmognathus auriculatus</i>	Moderate		G5	SNR
Spotted Turtle	<i>Clemmys guttata</i>	Moderate	State Threatened	G5	S5
Freshwater Fish					
American Eel	<i>Anguilla rostrata</i>	Highest		G5	SNR
American Shad	<i>Alosa sapidissima</i>	Highest		G5	S5
Atlantic Sturgeon	<i>Acipenser oxyrinchus</i>	Highest	Of Concern, State	G3	S3
Blueback Herring	<i>Alosa aestivalis</i>	Highest	Of Concern, State	G3	S3
Bluebarred Pygmy Sunfish	<i>Elassoma okatie</i>	Highest	Of Concern, State	G2G3	S?
Bridle Shiner	<i>Notropis bifrenatus</i>	Highest	Of Concern, State	G5	S?
“Broadtail” Madtom	<i>Noturus</i> spp. [c.f. <i>insignis</i>]	Highest	State Threatened	G2	S1
Carolina Pygmy Sunfish	<i>Elassoma boehlkei</i>	Highest	State Threatened	G2	S1
Christmas Darter	<i>Etheostoma hopkinsi</i>	Highest	Of Concern, State	G4G5	S4
Hickory Shad	<i>Alosa mediocris</i>	Highest	Of Concern, State	G5	S4
Highfin Carpsucker	<i>Carpoides velifer</i>	Highest			
Redeye Bass	<i>Micropterus coosae</i>	Highest		G5	
Robust Redhorse	<i>Moxostoma robustum</i>	Highest		G1	SNR
Saluda Darter	<i>Etheostoma saludae</i>	Highest			
Sandhills Chub	<i>Semotilus lumbee</i>	Highest	Of Concern, State	G3	S2
Savannah Darter	<i>Etheostoma fricksium</i>	Highest		G4	SNR
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	Highest	Federal and State Endangerd	G3	S3
“Thinlip” Chub	<i>Cyprinella</i> spp. [c.f. <i>insignis</i>]	Highest			
Bannerfin Shiner	<i>Cyprinella leedsi</i>	High		G4	S2
Blackbanded Sunfish	<i>Enneacanthus chaetodon</i>	High		G4	S1
Carolina Darter	<i>Etheostoma collis</i>	High	Of Concern, State	G3	S?
Carolina Fantail Darter	<i>Etheostoma flabellare brevispina</i>	High		G5	S1

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
"Carolina" Redhorse	<i>Moxostoma</i> sp.	High		G1G2Q	SNR
Greenhead Shiner	<i>Notropis chlorocephalus</i>	High	Of Concern, State	G4	S?
Piedmont Darter	<i>Percina crassa</i>	High		G4	SNR
Pinewoods Darter	<i>Etheostoma mariae</i>	High	State Endangered	G3	S1
Quillback	<i>Carpionodes cyprinus</i>	High		G5	SNR
Santee Chub	<i>Cyprinella zanema</i>	High		G4	SNR
Seagreen Darter	<i>Etheostoma thalassinum</i>	High		G4	SNR
Smoky Sculpin	<i>Cottus bairdii</i>	High		G5	
Turquoise Darter	<i>Etheostoma inscriptum</i>	High		G4	SNR
Banded Darter	<i>Etheostoma zonale</i>	Moderate	Of Concern, State	G5	S1?
Banded Killifish	<i>Fundulus diaphanus</i>	Moderate	Of Concern, State	G5	S1
Blacknose Dace	<i>Rhinichthys atratulus</i>	Moderate	Of Concern, State	G5	S1
Bluefin Killifish	<i>Lucania goodei</i>	Moderate	Of Concern, State	G5	S1?
Central Stoneroller	<i>Camptostoma anomalum</i>	Moderate		G5	SNR
Comely Shiner	<i>Notropis amoenus</i>	Moderate		G5	S?
Eastern Brook Trout	<i>Salvelinus fontinalis</i>	Moderate	Of Concern, State	G5	S2
Fireyblack Shiner	<i>Cyprinella pyrrhomelas</i>	Moderate		G4	S4
Flat Bullhead	<i>Ameiurus platycephalus</i>	Moderate		G5	SNR
Florida Gar	<i>Lepisosteus platyrhincus</i>	Moderate		G5	S1
Greenfin Shiner	<i>Cyprinella chloristia</i>	Moderate		G4	S4
Highback Chub	<i>Hybopsis hypsinotus</i>	Moderate		G4	SNR
Longnose Dace	<i>Rhinichthys cataractae</i>	Moderate	Of Concern, State	G5	S?
Lowland Shiner	<i>Pteronotopis stonei</i>	Moderate			
Mirror Shiner	<i>Notropis spectrunculus</i>	Moderate	Of Concern, State	G4	S?
Mud Sunfish	<i>Acantharchus pomotis</i>	Moderate		G5	
Notchlip Redhorse	<i>Moxostoma collapsum</i>	Moderate			
Pugnose Minnow	<i>Opsopoeodus emiliae</i>	Moderate		G5	
Redlip Shiner	<i>Notropis chiliticus</i>	Moderate		G5	S1
River Chub	<i>Nocomis micropogon</i>	Moderate	Of Concern, State	G5	S?
Rosyface Chub	<i>Hybopsis rubrifrons</i>	Moderate		G4	SNR
Satinfin Shiner	<i>Cyprinella analostana</i>	Moderate		G5	SNR
Snail Bullhead	<i>Ameiurus brunneus</i>	Moderate		G4	SNR
Striped Bass	<i>Morone saxatilis</i>	Moderate		G5	SNR

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Tennessee Shiner	<i>Notropis leuciodus</i>	Moderate	Of Concern, State	G5	S?
Thicklip Chub	<i>Cyprinella labrosa</i>	Moderate		G4	SNR
V-lip Redhorse	<i>Moxostoma pappillosum</i>	Moderate	Of Concern, State	G4	S?
Warpaint Shiner	<i>Luxilus coccogenis</i>	Moderate	Of Concern, State	G5	S?
White Catfish	<i>Ameiurus catus</i>	Moderate		G5	SNR
Whitemouth Shiner	<i>Notropis alborus</i>	Moderate		G4	
Whitetail Shiner	<i>Cyprinella galactura</i>	Moderate		G5	SNR
Crayfish					
Mimic Crayfish	<i>Distocambarus carlsoni</i>	Highest		G3	SNR
Oconee Stream Crayfish	<i>Cambarus chauquaensis</i>	Highest		G2	S2S3
No Common Name	<i>Cambarus reflexus</i>	Highest		G4	S3
No Common Name	<i>Cambarus</i> sp. "B"	Highest			
No Common Name	<i>Distocambarus hunteri</i>	Highest		G1?	SNR
No Common Name	<i>Distocambarus youngineri</i>	Highest	Of Concern, State	G1	S1
No Common Name	<i>Procambarus echinatus</i>	Highest		G3	S3
Red Burrowing Crayfish	<i>Cambarus carolinus</i>	Highest		G4	S2?
Broad River Spiny Crayfish	<i>Cambarus spicatus</i>	High		G3	S3
No Common Name	<i>Distocambarus crockeri</i>	High		G3	S3
Pee Dee Lotic Crayfish	<i>Procambarus lepidodactylus</i>	High		G4	S4
Sandhills Crayfish	<i>Procambarus pearsei</i>	High		G4	S3
Waccamaw Crayfish	<i>Procambarus braswelli</i>	High		G2G3	SNR
Ditch Fencing Crayfish	<i>Faxonella clypeata</i>	Moderate		G5	S2?
Edisto Crayfish	<i>Procambarus ancylus</i>	Moderate		G4G5	S4S5
No Common Name	<i>Procambarus barbatus</i>	Moderate		G5	S4
No Common Name	<i>Procambarus chacei</i>	Moderate		G4	S4
No Common Name	<i>Procambarus enoplosternum</i>	Moderate		G4G5	SNR
No Common Name	<i>Procambarus hirsutus</i>	Moderate		G4	S4
No Common Name	<i>Procambarus lunzi</i>	Moderate		G4	S2S3
No Common Name	<i>Procambarus pubescens</i>	Moderate		G4G5	S3?
Rocky River Stream Crayfish	<i>Cambarus hobbsorum</i>	Moderate		G3G4	S3S4
Santee Crayfish	<i>Procambarus blandingii</i>	Moderate		G4	S4

AP 1: Priority Species List

SC CWCS

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Freshwater Mussels					
Atlantic Pigtoe	<i>Fusconaia masoni</i>	Highest	State Endangered	G2	S?
Barrel Floater	<i>Anodonta couperiana</i>	Highest	Of Concern, State	G4	S?
Brook Floater	<i>Alasmidonta varicosa</i>	Highest	Of Concern, State	G3	S?
Brother Spike	<i>Elliptio fraterna</i>	Highest	State Endangered	G1	S1
Carolina Creekshell	<i>Villosa vaugniana</i>	Highest		G2	
Carolina Heelsplitter	<i>Lasmigona decorata</i>	Highest	Federal and State Endangerd	G1	S1
Creeper	<i>Strophitus undulatus</i>	Highest	Of Concern, State	G5	S?
Notched Rainbow	<i>Villosa constricta</i>	Highest	Of Concern, State	G3	S?
Savannah Lilliput	<i>Toxolasma pullus</i>	Highest	Of Concern, State	G2	S1S3
Southern Rainbow	<i>Villosa vibex</i>	Highest	Of Concern, State	G4Q	S?
Triangle Floater	<i>Alasmidonta undulate</i>	Highest		G4	
Waccamaw Spike	<i>Elliptio waccamawensis</i>	Highest		G2	S1
Yellow Lampmussel	<i>Lampsilis cariosa</i>	Highest		G5	
Alewife Floater	<i>Anodonta implicate</i>	High			
Eastern Pondmussel	<i>Ligumia nasuta</i>	High		G4G5	
Northern Lance	<i>Elliptio fisheriana/nasutilus</i>	High		G4	
Pod Lance	<i>Elliptio folliculate</i>	High		G2G3	
Rayed Pink Fatmucket/Eastern Lampshell	<i>Lampsilis radiate/splendida</i>	High	Of Concern, State	G3	S?
Roanoke Slabshell	<i>Elliptio roanokensis</i>	High		G2G3	
Tidewater Mucket	<i>Leptodea ochracea</i>	High		G4	
Atlantic Spike	<i>Elliptio producta</i>	Moderate		G4	
Carolina Lance	<i>Elliptio angustata</i>	Moderate		G4	
Carolina Slabshell	<i>Elliptio congarea</i>	Moderate	Of Concern, State	G4	S?
Eastern Creekshell	<i>Villosa delumbis</i>	Moderate	Of Concern, State	G4	S?
Eastern Elliptio	<i>Elliptio complanata</i> complex	Moderate		G5	
Variable Spike	<i>Elliptio icterina</i> complex	Moderate		G4Q	

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Freshwater Snails					
Pebblesnail	<i>Somatogyrus</i> spp.	Highest			
Buffalo Pebblesnail	<i>Gillia altilis</i>	High		G5	SNR
Ridged Lioplax	<i>Lioplax subcarinata</i>	High		G5	S1
Snail	<i>Physa</i> sp. nov "A"	Moderate			
Marine Fish					
American Conger	<i>Conger oceanicus</i>				
Atlantic Bumper	<i>Chloroscombrus chrysurus</i>				
Atlantic Croaker	<i>Micropogonias undulatus</i>			G5	
Atlantic Cutlassfish	<i>Trichiurus lepturus</i>				
Atlantic Guitarfish	<i>Rhinobatos lentiginosus</i>				
Atlantic Menhaden	<i>Brevoortia tyrannus</i>				
Atlantic Moonfish	<i>Selene setapinnis</i>				
Atlantic Needlefish	<i>Strongylura marina</i>				
Atlantic Silverside	<i>Menidia menidia</i>				
Atlantic Spadefish	<i>Chaetodipterus faber</i>			G5	
Atlantic Stingray	<i>Dasyatis sabina</i>				
Atlantic Thread Herring	<i>Opisthonema oglinum</i>				
Atlantic Tripletail	<i>Lobotes surinamensis</i>				
Banded Drum	<i>Larimus fasciatus</i>				
Bank Cusk-eel	<i>Ophidion holbrooki</i>				
Bay Anchovy	<i>Anchoa mitchilli</i>			G5	
Bay Whiff	<i>Citharichthys spilopterus</i>				
Belted Sandfish	<i>Serranus subligarius</i>				
Bighead Searobin	<i>Prionotus tribulus</i>				
Black Drum	<i>Pogonias cromis</i>				
Black Grouper	<i>Mycteroperca bonaci</i>				
Black Sea Bass	<i>Centropristis striata</i>				
Blackcheek Tonguefish	<i>Symphurus plagiusa</i>				
Blacknose Shark	<i>Carcharhinus acronotus</i>				
Blacktip Shark	<i>Carcharhinus limbatus</i>				
Blotched Cusk-eel	<i>Ophidion grayi</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Blue Runner	<i>Caranx crysos</i>				
Bluefish	<i>Pomatomus saltatrix</i>				
Bluntnose Stingray	<i>Dasyatis say</i>				
Bonnethead	<i>Sphyrna tiburo</i>				
Broad Flounder	<i>Paralichthys squamilentus</i>				
Bull Pipefish	<i>Syngnathus springeri</i>				
Bull Shark	<i>Carcharhinus leucas</i>				
Bullnose Ray	<i>Myliobatis freminvillei</i>				
Butterfish	<i>Peprilus triacanthus</i>				
Carolina Hake	<i>Urophycis earllei</i>				
Chain Pipefish	<i>Syngnathus louisianae</i>				
Clearnose Skate	<i>Raja eglanteria</i>				
Cobia	<i>Rachycentron canadum</i>			GNR	
Cownose Ray	<i>Rhinoptera bonasus</i>				
Crested Blenny	<i>Hypleurochilus geminatus</i>				
Crevalle Jack	<i>Caranx hippos</i>			G5	
Darter Goby	<i>Ctenogobius boleosoma</i>				
Dotterel Filefish	<i>Aluterus heudelotii</i>				
Dusky Anchovy	<i>Anchoa lyolepis</i>				
Dusky Flounder	<i>Syacium papillosum</i>				
Dwarf Goatfish	<i>Upeneus parvus</i>				
Emerald Goby	<i>Ctenogobius smaragdus</i>				
Fat Sleeper	<i>Dormitator maculatus</i>				
Feather Blenny	<i>Hypsoblennius hentz</i>				
Finetooth Shark	<i>Carcharhinus isodon</i>			GNR	
Florida Pompano	<i>Trachinotus carolinus</i>				
Freckled Blenny	<i>Hypsoblennius ionthas</i>				
Freshwater Goby	<i>Ctenogobius shufeldti</i>				
Fringed Flounder	<i>Etropus crossotus</i>				
Gafftopsail Catfish	<i>Bagre marinus</i>				
Gag	<i>Mycteroperca microlepis</i>			GNR	
Goliath Grouper	<i>Epinephelus itajara</i>				
Gray Snapper	<i>Lutjanus griseus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Green Goby	<i>Microgobius thalassinus</i>				
Guaguanche	<i>Sphyræna guachancho</i>				
Gulf Flounder	<i>Paralichthys albigutta</i>				
Gulf Kingfish	<i>Menticirrhus littoralis</i>			GNR	
Gulf Pipefish	<i>Syngnathus scovelli</i>				
Hardhead Catfish	<i>Arius felis</i>			G5	
Harvestfish	<i>Peprilus paru</i>				
Highfin Goby	<i>Gobionellus oceanicus</i>				
Hogchoker	<i>Trinectes maculatus</i>				
Horse-eye Jack	<i>Caranx latus</i>				
Inland Silverside	<i>Menidia beryllina</i>				
Inshore Lizardfish	<i>Synodus foetens</i>				
King Mackerel	<i>Scomberomorus cavalla</i>				
Ladyfish	<i>Elops saurus</i>				
Lane Snapper	<i>Lutjanus synagris</i>				
Largescaled Spinycheek Sleeper	<i>Eleotris amblyopsis</i>				
Lemon Shark	<i>Negaprion brevirostris</i>				
Leopard Searobin	<i>Prionotus scitulus</i>				
Lesser Electric Ray	<i>Narcine bancroftii</i>				
Lined Seahorse	<i>Hippocampus erectus</i>		VULNERABLE	G5	
Lookdown	<i>Selene vomer</i>				
Lyre Goby	<i>Evorthodus lyricus</i>				
Marsh Killifish	<i>Fundulus confluentus</i>				
Mummichog	<i>Fundulus heteroclitus</i>			G5	
Mutton Snapper	<i>Lutjanus analis</i>				
Naked Goby	<i>Gobiosoma bosc</i>			G5	
Naked Sole	<i>Gymnachirus melas</i>				
Northern Kingfish	<i>Menticirrhus saxatilis</i>			GNR	
Northern Pipefish	<i>Syngnathus fuscus</i>				
Northern Puffer	<i>Sphoeroides maculatus</i>				
Northern Searobin	<i>Prionotus carolinus</i>				
Northern Stargazer	<i>Astroscopus guttatus</i>				
Nurse Shark	<i>Ginglymostoma cirratum</i>				

AP 1: Priority Species List

SC CWCS

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Ocellated Flounder	<i>Ancylosetta quadrocellata</i>				
Off-shore Tonguefish	<i>Symphurus civitatum</i>				
Opossum Pipefish	<i>Microphis brachyurus</i>				
Orange Filefish	<i>Aluterus schoepfii</i>				
Oyster Toadfish	<i>Opsanus tau</i>				
Palespotted Eel	<i>Ophichthus puncticeps</i>				
Permit	<i>Trachinotus falcatus</i>				
Pigfish	<i>Orthopristis chrysoptera</i>				
Pinfish	<i>Lagodon rhomboides</i>				
Planehead Filefish	<i>Stephanolepis hispidus</i>				
Rainwater Killifish	<i>Lucania parva</i>				
Red Drum	<i>Sciaenops ocellatus</i>				
Red Grouper	<i>Epinephelus morio</i>				
Red Snapper	<i>Lutjanus campechanus</i>				
Rock Sea Bass	<i>Centropristis philadelphica</i>				
Rough Silverside	<i>Membras martinica</i>				
Roughtail Stingray	<i>Dasyatis centroura</i>				
Round Herring	<i>Etrumeus teres</i>				
Sailfin Molly	<i>Poecilia latipinna</i>			G5	SNR
Sand Perch	<i>Diplectrum formosum</i>				
Sand Tiger Shark	<i>Carcharias taurus</i>				
Sandbar Shark	<i>Carcharhinus plumbeus</i>				
Scaled Sardine	<i>Harengula jaguana</i>				
Scalloped Hammerhead	<i>Sphyrna lewini</i>				
Scup	<i>Stenotomus chrysops</i>				
Sea Lamprey	<i>Petromyzon marinus</i>				
Seaboard Goby	<i>Gobiosoma ginsburgi</i>				
Sharksucker	<i>Echeneis naucrates</i>				
Sharpnose Atlantic Shark	<i>Rhizoprionodon terraenovae</i>				
Sheepshead	<i>Archosargus probatocephalus</i>			G5	
Sheepshead Minnow	<i>Cyprinodon variegatus</i>				
Shelf Flounder	<i>Etropus cyclosquamus</i>				
Shrimp Eel	<i>Ophichthus gomesii</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Silver Jenny	<i>Eucinostomus gula</i>				
Silver Perch	<i>Bairdiella chrysoura</i>				
Silver Seatrout	<i>Cynoscion nothus</i>				
Skilletfish	<i>Gobiesox strumosus</i>				
Smooth Butterfly Ray	<i>Gymnura micrura</i>				
Smooth Dogfish	<i>Mustelus canis</i>				
Smooth Puffer	<i>Lagocephalus laevigatus</i>				
Southern Flounder	<i>Paralichthys lethostigma</i>			G5	
Southern Hake	<i>Urophycis floridana</i>				
Southern Kingfish	<i>Menticirrhus americanus</i>			GNR	
Southern Stargazer	<i>Astroscopus y-graecum</i>				
Southern Stingray	<i>Dasyatis americana</i>				
Spanish Mackerel	<i>Scomberomorus maculatus</i>				
Spanish Sardine	<i>Sardinella aurita</i>				
Speckled Worm Eel	<i>Myrophis punctatus</i>				
Spinner Shark	<i>Carcharhinus brevipinna</i>				
Spiny Dogfish	<i>Squalus acanthias</i>				
Spot	<i>Leiostomus xanthurus</i>			G5	
Spotfin Killifish	<i>Fundulus luciae</i>				
Spotfin Mojarra	<i>Eucinostomus argenteus</i>				
Spotted Hake	<i>Urophycis regia</i>				
Spotted Seatrout	<i>Cynoscion nebulosus</i>				
Spotted Whiff	<i>Citharichthys macrops</i>				
Star Drum	<i>Stellifer lanceolatus</i>				
Striped Anchovy	<i>Anchoa hepsetus</i>				
Striped Blenny	<i>Chasmodes bosquianus</i>				
Striped Burrfish	<i>Chilomycterus schoepfi</i>				
Striped Cusk-eel	<i>Ophidion marginatum</i>				
Striped Killifish	<i>Fundulus majalis</i>			G5	
Striped Mullet	<i>Mugil cephalus</i>			G5	
Striped Searobin	<i>Prionotus evolans</i>				
Summer Flounder	<i>Paralichthys dentatus</i>				
Tarpon	<i>Megalops atlanticus</i>			G5	

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Tiger Shark	<i>Galeocерdo cuvieri</i>				
Tomtate	<i>Haemulon aurolineatum</i>				
Weakfish	<i>Cynoscion regalis</i>				
White Mullet	<i>Mugil curema</i>				
Windowpane	<i>Scophthalmus aquosus</i>				
Marine Invertebrates					
a bush coral	<i>Oculina arbuscula</i>				
Alternate tellin	<i>Tellina alternata</i>				
American grass shrimp	<i>Periclimenes americanus</i>				
Tulip mussel	<i>Modiolus americanus</i>				
American tellin	<i>Tellina americana</i>				
American tube-dwelling anemone	<i>Ceriantheopsis americanus</i>				
Amethyst gemclam	<i>Gemma gemma</i>				
Angelwing	<i>Cyrtopleura costata</i>				
Angular brittle star	<i>Ophiothrix angulata</i>				
Antillean fireclam	<i>Lima pellucida</i>				
Antillean sphenia	<i>Sphenia antillensis</i>				
Arrow shrimp	<i>Tozeuma carolinense</i>				
Atlantic abra	<i>Abra aequalis</i>				
Atlantic awningclam	<i>Solemya velum</i>				
Atlantic brief squid	<i>Lolliguncula brevis</i>				
Atlantic diplodon	<i>Diplodonta punctata</i>				
Atlantic ghost crab	<i>Ocypode quadrata</i>				
Atlantic giant cockle	<i>Dinocardium robustum</i>				
Atlantic jackknife clam	<i>Ensis directus</i>				
Atlantic mud crab	<i>Panopeus herbstii</i>				
Atlantic mud piddock	<i>Barnea truncata</i>				
Atlantic nutclam	<i>Nucula proxima</i>				
Atlantic oyster drill	<i>Urosalpinx cinerea</i>				
Wedge rangia	<i>Rangia cuneata</i>				
Atlantic rock crab	<i>Cancer irroratus</i>				
Atlantic rupellar	<i>Rupellaria typica</i>				
Atlantic sand crab	<i>Emerita talpoida</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Atlantic sand fiddler crab	<i>Uca pugilator</i>				
Atlantic seabob	<i>Xiphopenaeus kroyeri</i>				
Atlantic surf clam	<i>Spisula solidissima</i>				
Atlantic wing-oyster	<i>Pteria colymbus</i>				
Bamboo worm	<i>Clymenella torquata</i>				
Banded dwarf hermit crab	<i>Pagurus annulipes</i>				
Banded porcelain crab	<i>Petrolisthes galathinus</i>				
Banded snapping shrimp	<i>Alpheus armillatus</i>				
Banded tulip	<i>Fasciolaria hunteria</i>				
Bay barnacle	<i>Balanus improvisus</i>				
Beach sowbug	<i>Chiridotea caeca</i>				
Beautiful topsnail	<i>Calliostoma pulchrum</i>				
Bee spionid	<i>Spiophanes bombyx</i>				
Biform ghost shrimp	<i>Biffarius biformis</i>				
Bigclaw snapping shrimp	<i>Alpheus normanni</i>				
Blisterworm	<i>Polydora websteri</i>				
Blood ark	<i>Anadara ovalis</i>				
Bloodworm	<i>Glycera americana</i>				
Blotched swimming crab	<i>Portunus spinimanus</i>				
Blue crab	<i>Callinectes sapidus</i>				
Boa scaleworm	<i>Sthenelais boa</i>				
Brackish grass shrimp	<i>Palaemonetes intermedius</i>				
Brilliant sea fingers	<i>Titanideum frauenfeldii</i>				
Bristled river shrimp	<i>Macrobrachium olfersii</i>				
Mangrove mud crab	<i>Eurytium limosum</i>				
Brown fanworm	<i>Notaulax nudicollis</i>				
Brown glass shrimp	<i>Leander tenuicornis</i>				
Brown shrimp	<i>Farfantepenaeus aztecus</i>				
Mottled dog whelk	<i>Nassarius vibex</i>				
Bryozoan shrimp	<i>Thor floridanus</i>				
Burrowing brittle star	<i>Hemipholis elongata</i>				
Shame faced crab	<i>Hepatus epheliticus</i>				
Canonball jellyfish	<i>Stomolophus meleagris</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Capitellid threadworm	<i>Capitella capitata</i>				
Caribbean spiny lobster	<i>Panulirus argus</i>				
Carolina marshclam	<i>Polymesoda caroliniana</i>				
Carolinian ghost shrimp	<i>Callichirus major</i>				
Carolinian squareback crab	<i>Speocarcinus carolinensis</i>				
Cayenne keyhole limpet	<i>Diodora cayenensis</i>				
Channeled barrel-bubble	<i>Acteocina canaliculata</i>				
Channeled whelk	<i>Busycotypus canaliculatus</i>				
Christmas tree hydroid	<i>Halocordyle disticha</i>				
Cinnamon river shrimp	<i>Macrobrachium acanthurus</i>				
Coarsehand lady crab	<i>Ovalipes stephensoni</i>				
Coastal mud shrimp	<i>Upogebia affinis</i>				
Cock shrimp	<i>Exhippolysmata oplophoroides</i>				
Cockscomb hydrobe	<i>Littoridinops monroensis</i>				
Colorful sea whip	<i>Leptogorgia virgulata</i>				
Combclaw shrimp	<i>Leptochela serratorbita</i>				
Common Atlantic sandhopper	<i>Americorchestia longicornis</i>				
Common Atlantic slippersnail	<i>Crepidula fornicata</i>				
Common jingle	<i>Anomia simplex</i>				
Common mantis shrimp	<i>Squilla empusa</i>				
Common Atlantic octopus	<i>Octopus vulgaris</i>				
Common sea mat	<i>Membranipora tenuis</i>				
Common sea pansy	<i>Renilla reniformis</i>				
Common sheep's-wool bryozoan	<i>Amathia convoluta</i>				
Common southern clamworm	<i>Nereis succinea</i>				
Concentric ervilia	<i>Ervilia concentrica</i>				
Contracted corbula	<i>Corbula contracta</i>				
Coquina Clam	<i>Conax variabilis</i>				
Coral shrimp	<i>Sicyonia laevigata</i>				
Corrugate jewelbox	<i>Chama congregata</i>				
Crab barnacle	<i>Chelonibia patula</i>				
Crested oyster	<i>Ostrea equestris</i>				
Cristate pea crab	<i>Austinia cristata</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Cross-hatched lucine	<i>Divaricella quadrisulcata</i>				
Crumb-of-bread sponge	<i>Halichondria bowerbanki</i>				
Cryptic teardrop crab	<i>Pelia mutica</i>				
Culver's sandworm	<i>Laeonereis culveri</i>				
Cupped shipworm	<i>Bankia gouldii</i>				
Daggerblade shrimp	<i>Palaemonetes pugio</i>				
Decorator crab	<i>Cryptodromiopsis antillensis</i>				
Delicate sheep's-wool bryozoan	<i>Amathia distans</i>				
Disk clam	<i>Dosinia discus</i>				
Divided tunicate	<i>Styela partita</i>				
Dusky stiliger	<i>Ercolania fuscata</i>				
Dwarf sandworm	<i>Aglaophamus verrilli</i>				
Dwarf surfclam	<i>Mulinia lateralis</i>				
Eastern aligena	<i>Aligena elevata</i>				
Eastern auger	<i>Terebra dislocata</i>				
Eastern bearded chiton	<i>Chaetopleura apiculata</i>				
Duck snail	<i>Melampus bidentatus</i>				
Mud dog whelk	<i>Nassarius obsoletus</i>				
Eastern oyster	<i>Crassostrea virginica</i>				
Eastern tube crab	<i>Polyonyx gibbesi</i>				
Eastern white slippersnail	<i>Crepidula plana</i>				
Elongate narrowed macoma	<i>Macoma tenta</i>				
Emerson's cerith	<i>Cerithiopsis emersoni</i>				
Estuarine longeye shrimp	<i>Ogyrides alphaerostris</i>				
Estuarine mud crab	<i>Rhithropanopeus harrisi</i>				
Eteone worm	<i>Eteone heteropoda</i>				
False angelwing	<i>Petricola pholadiformis</i>				
False arrow crab	<i>Metoporphaphis calcarata</i>				
Fat dovesnail	<i>Parvanachis obesa</i>				
Fine-lined hydrobe	<i>Onobops jacksoni</i>				
Fiona	<i>Fiona pinnata</i>				
Depressed mud crab	<i>Eurypanopeus depressus</i>				
Flatclaw hermit crab	<i>Pagurus pollicaris</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Florida rocksnail	<i>Thais haemastoma floridana</i>				
Florida stone crab	<i>Menippe mercenaria</i>				
Foliaceous shipworm	<i>Nototeredo knoxi</i>				
Forbes' sea star	<i>Asterias forbesii</i>				
Forceps shrimp	<i>Leptalpheus forceps</i>				
Fragile star barnacle	<i>Chthamalus fragilis</i>				
Fringed scaleworm	<i>Lepidonotus variabilis</i>				
Fringe-gilled mudworm	<i>Paraprionospio pinnata</i>				
Garlic sponge	<i>Lissodendoryx isodictyalis</i>				
Giant hermit crab	<i>Petrochirus diogenes</i>				
Glassy lyonsia	<i>Lyonsia (Entodesma) hyalina</i>				
Golden acorn worm	<i>Balanoglossus aurantiacus</i>				
Granulate shellback crab	<i>Hypoconcha arcuata</i>				
Gravel scud	<i>Lysianopsis alba</i>				
Gray pygmy venus	<i>Chione grus</i>				
Greedy dovesnail	<i>Costoanachis avara</i>				
Green colonial tunicate	<i>Perophora viridis</i>				
Green jackknife clam	<i>Solen viridis</i>				
Green sea urchin	<i>Lytechinus variegatus</i>				
Green snapping shrimp	<i>Alpheus heterochaelis</i>				
Green's cerith	<i>Cerithiopsis greeni</i>				
Hairy sea cucumber	<i>Sclerodactyla briareus</i>				
Half-smooth odostome	<i>Boonea seminuda</i>				
Hard Clams	<i>Mercenaria mercenaria</i>				
Northern quahog	<i>Mercenaria campechiensis</i>				
Hauff's alcyonidium	<i>Alcyonidium hauffi</i>				
Mud urchin	<i>Moira atropos</i>				
Purple marsh crab	<i>Sesarma reticulatum</i>				
Snail fur	<i>Hydractinia echinata</i>				
Hidden sea cucumber	<i>Pseudothyone belli</i>				
Hitchhiking anemone	<i>Calliactis tricolor</i>				
Honeycomb tubeworm	<i>Sabellaria floridensis</i>				
Horseshoe Crab	<i>Limulus polyphemus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Horseshoe-crab flatworm	<i>Bdelloura candida</i>				
Ice cream cone worm	<i>Cistenides gouldii</i>				
Impressed odostome	<i>Boonea impressa</i>				
Incongruous ark	<i>Anadara brasiliana</i>				
Interrupted tunicate	<i>Ascidia interrupta</i>				
Iridescent shrimp	<i>Periclimenes iridescent</i>				
Iridescent swimming crab	<i>Portunus gibbesii</i>				
Ivory barnacle	<i>Balanus eburneus</i>				
Knobbed Whelk	<i>Busycon carica</i>			GNR	
Ocellate lady crab	<i>Ovalipes ocellatus</i>				
Lateral mussel	<i>Musculus lateralis</i>				
Lemon drop	<i>Doriopsilla pharpha</i>				
Lesser blue crab	<i>Callinectes similis</i>				
Lettered olive	<i>Oliva sayana</i>				
Lettuce bryozoan	<i>Thalamoporella floridana</i>				
Lightning whelk	<i>Busycon sinistrum</i>				
Crozier's flatworm	<i>Pseudoceros crozieri</i>				
Lined sea star	<i>Luidia clathrata</i>				
Lion's mane jellyfish	<i>Cyanea capillata</i>				
Long-armed hermit	<i>Pagurus longicarpus</i>				
Longnose spider crab	<i>Libinia dubia</i>				
Long-palped sandworm	<i>Ceratonereis irritabilis</i>				
Longtail grass shrimp	<i>Periclimenes longicaudatus</i>				
Loosanoff's haliclona	<i>Haliclona loosanoffi</i>				
Lunar dovesnail	<i>Astyris lunata</i>				
Lunz pea crab	<i>Pinnixa lunzi</i>				
Mahogany datemussel	<i>Lithophaga bisulcata</i>				
Mangrove tunicate	<i>Ecteinascidia turbinata</i>				
Many-lined lucine	<i>Parvilucina multilineata</i>				
Crowded wentletrap	<i>Epitonium multistriatum</i>				
Many-scaled worm	<i>Lepidometria commensalis</i>				
Marsh grass shrimp	<i>Palaemonetes vulgaris</i>				
Marsh periwinkle	<i>Littoraria irrorata</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Martinique crassinella	<i>Crassinella martinicensis</i>				
Masked swimming crab	<i>Callinectes larvatus</i>				
Medusa worm	<i>Loimia medusa</i>				
Milky ribbon worm	<i>Cerebratulus lacteus</i>				
Miniature moonshell	<i>Tectonatica pusilla</i>				
Moon jelly	<i>Aurelia aurita</i>				
Mottled encrusting tunicate	<i>Distaplia bermudensis</i>				
Mottled purse crab	<i>Persephona mediterranea</i>				
Sooty seahare	<i>Aplysia brasiliana</i>				
Mottled shore crab	<i>Pachygrapsus transversus</i>				
Mud brittle star	<i>Ophiophragmus wurdemanni</i>				
Mud fiddler crab	<i>Uca pugnax</i>				
Muddy-tuft bryozoan	<i>Anquinella palmata</i>				
Multi-tentacled sea wasp	<i>Chiropsalmus quadrimanus</i>				
Mushroom jelly	<i>Rhopilema verrilli</i>				
Neapolitan spurilla	<i>Spurilla neapolitana</i>				
Northern big-eyed sandhopper	<i>Americorchestia megalophthalma</i>				
Northern dwarf tellin	<i>Tellina agilis</i>				
Nut semele	<i>Semelina nuculoides</i>				
Oblong tunicate	<i>Clavelina oblonga</i>				
Obscure corambe	<i>Doridella obscura</i>				
Ohio river shrimp	<i>Macrobrachium ohione</i>				
Olivepit porcelain crab	<i>Eucramus praelongus</i>				
One-tooth simnia	<i>Simnialena uniplicata</i>				
Onion anemone	<i>Paranthus rapiformis</i>				
Opal worm	<i>Arabella iricolor</i>				
Orange telesto	<i>Telesto fruticulosa</i>				
Ornate worm	<i>Amphitrite ornata</i>				
Oyster flatworm	<i>Stylochus ellipticus</i>				
Oyster pea crab	<i>Zaops ostreum</i>				
Oyster piddock	<i>Diplothyra smithii</i>				
Pale anemone	<i>Aiptasia pallida</i>				
Parasitic scalesnail	<i>Cochliolepis parasitica</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Parchment worm	<i>Chaetopterus variopedatus</i>				
Pearly lyonsia	<i>Lyonsia (Entodesma) beana</i>				
Pentagonal porcelain crab	<i>Megalobrachium soriatum</i>				
Peppermint shrimp	<i>Lysmata wurdemanni</i>				
Pink hydroid	<i>Eudendrium carneum</i>				
Northern pink shrimp	<i>Farfantepenaeus duorarum</i>				
Leathery tunicate	<i>Styela plicata</i>				
Plicate mangelia	<i>Pyrgocythara plicosa</i>				
Periscope tubeworm	<i>Diopatra cuprea</i>				
Ponderous ark	<i>Noetia ponderosa</i>				
Portly spider crab	<i>Libinia emarginata</i>				
Punctate mangelia	<i>Kurtziella limonitella</i>				
Purple tuft bryozoan	<i>Bugula neritina</i>				
Purple-spined sea urchin	<i>Arbacia punctulata</i>				
Purplish tagelus	<i>Tagelus divisus</i>				
Radial-ridged corbula	<i>Corbula swiftiana</i>				
Rainbow tellin	<i>Tellina iris</i>				
Red beard sponge	<i>Microciona prolifera</i>				
Red nemertean worm	<i>Micrura leidyi</i>				
Red threadworm	<i>Scoloplos rubra</i>				
Red-jointed fiddler crab	<i>Uca minax</i>				
Ribbed mussel	<i>Geukensia demissa</i>				
Roofing worm	<i>Owenia fusiformis</i>				
Rough shellback crab	<i>Hypoconcha parasitica</i>				
Roughneck shrimp	<i>Rimapenaeus constrictus</i>				
Rugose swimming crab	<i>Callinectes exasperatus</i>				
Saltmarsh mud crab	<i>Panopeus obesus</i>				
Sand dollar	<i>Mellita isometra</i>				
Sand longeye shrimp	<i>Ogyrides hayi</i>				
Sand-dollar pea crab	<i>Dissodactylus mellitae</i>				
Sapelo okenia	<i>Okenia sapelona</i>				
Sargassum nudibranch	<i>Scyllaea pelagica</i>				
Sargassum shrimp	<i>Latreutes parvulus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Sargassum swimming crab	<i>Portunus sayi</i>				
Say mud crab	<i>Dyspanopeus sayi</i>				
Scorched mussel	<i>Brachidontes exustus</i>				
Florida top shell	<i>Calliostoma euglyptum</i>				
Sea grape	<i>Molgula manhattensis</i>				
Sea nettle	<i>Chrysaora quinquecirrha</i>				
Sea pork	<i>Aplidium stellatum</i>				
Sea wasp	<i>Tamoya haplonema</i>				
Seashore springtail	<i>Anurida maritima</i>				
Seaweed sowbug	<i>Erichsonella filiformis</i>				
Seawhip shrimp	<i>Neopontonides beaufortensis</i>				
Serpulid odostome	<i>Fargoa dianthophila</i>				
Shaggy parchment tubeworm	<i>Onuphis eremita</i>				
Shark eye	<i>Neverita duplicata</i>				
Short-armed brittle star	<i>Ophioderma brevispinum</i>				
Silkworm of the sea	<i>Polyodontes lupina</i>				
Slandered tellin	<i>Tellina probrina</i>				
Slender sargassum shrimp	<i>Latreutes fucorum</i>				
Smooth goose-neck barnacle	<i>Lepas anatifera</i>				
Smooth mud crab	<i>Hexapanopeus angustifrons</i>				
Southern lugworm	<i>Arenicola cristata</i>				
Southern quahog	<i>Mercenaria campechiensis</i>				
Speckled snapping shrimp	<i>Synalpheus fritzmuelleri</i>				
Speckled swimming crab	<i>Arenaeus cribrarius</i>				
Spineback hairy crab	<i>Pilumnus sayi</i>				
Sponge slug	<i>Doris verrucosa</i>				
Sponge threadworm	<i>Haplosyllis spongicola</i>				
Spotted porcelain crab	<i>Porcellana sayana</i>				
Squareback marsh crab	<i>Armases cinereum</i>				
Squatter pea shrimp	<i>Tumidotheres maculatus</i>				
Stout tagelus	<i>Tagelus plebeius</i>				
Striate tellin	<i>Tellina aequistriata</i>				
Striped sea cucumber	<i>Thyonella gemmata</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Subovate softshell clam	<i>Paramya subovata</i>				
Sunray venus	<i>Macrocallista nimbosa</i>				
Dall's dwarf tellin	<i>Tellina sybaritica</i>				
Tellin semele	<i>Cumingia tellinoides</i>				
Texas tellin	<i>Tellina texana</i>				
Thick-lip drill	<i>Eupleura caudata</i>				
Green-stripe hermit crab	<i>Clibanarius vittatus</i>				
New England dog whelk	<i>Nassarius trivittatus</i>				
Three-line pandora	<i>Pandora trilineata</i>				
Tiger armina	<i>Armina tigrina</i>				
Tinted cantharus	<i>Pisania tincta</i>				
Toothed crust bryozoan	<i>Parasmittina nitida</i>				
Tranverse ark	<i>Anadara transversa</i>				
Parchment-worm pea crab	<i>Pinnixa chaetoptera</i>				
Turtle barnacle	<i>Chelonibia testudinaria</i>				
Twelve-scaled worm	<i>Lepidonotus sublevis</i>				
Variable coquina (delete clam)	<i>Donax variabilis</i>				
Variable crust bryozoan	<i>Schizoporella errata</i>				
Variable dwarf olive	<i>Olivella mutica</i>				
American warty anemone	<i>Bunodosoma cavernata</i>				
Webster's mole crab	<i>Lepidopa websteri</i>				
Wedge piddock	<i>Martesia cuneiformis</i>				
Well-ribbed dovesnail	<i>Costoanachis lafresnayi</i>				
Western dondice	<i>Dondice occidentalis</i>				
Sandy sea squirt	<i>Molgula occidentalis</i>				
Northern white shrimp	<i>Litopenaeus setiferus</i>				
White strigilla	<i>Strigilla mirabilis</i>				
Worm reef hermit crab	<i>Pagurus carolinensis</i>				
Yellow boring sponge	<i>Cliona celata</i>				
Yellow pricklycockle	<i>Trachycardium muricatum</i>				
Zebra oyster flatworm	<i>Stylochus zebra</i>				
Zebra worm	<i>Trypanosyllis zebra</i>				
Eelgrass broken-back shrimp	<i>Hippolyte zostericola</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Acanthohaustorius intermedius</i>				
No common name	<i>Acanthohaustorius millsii</i>				
No common name	<i>Acartia tonsa</i>				
No common name	<i>Acetes americanus</i>				
No common name	<i>Achelia sawayai</i>				
No common name	<i>Acteocina candei</i>				
No common name	<i>Adocia tubifera</i>				
No common name	<i>Aegathoa oculata</i>				
No common name	<i>Aeverrillia armata</i>				
No common name	<i>Aeverrillia setigera</i>				
No common name	<i>Aiptasia eruptaurantia</i>				
No common name	<i>Albunea catherinae</i>				
No common name	<i>Amakusanthura magnifica</i>				
No common name	<i>Amathia vidovici</i>				
No common name	<i>Americamysis almyra</i>				
No common name	<i>Americamysis bahia</i>				
No common name	<i>Americamysis bigelowi</i>				
No common name	<i>Americhelidium americanum</i>				
No common name	<i>Americorophium aquafuscum</i>				
No common name	<i>Ameroculodes edwardsi</i>				
No common name	<i>Ampelisca abdita</i>				
No common name	<i>Ampelisca vadorum</i>				
No common name	<i>Ampelisca verrilli</i>				
No common name	<i>Amphinema dinema</i>				
No common name	<i>Amphinome rostrata</i>				
No common name	<i>Amphiodia atra</i>				
No common name	<i>Amphioplus abditus</i>				
No common name	<i>Amphipholis gracillima</i>				
No common name	<i>Amphiporeia virginiana</i>				
No common name	<i>Amphiporus cruentatus</i>				
No common name	<i>Amphiporus ochraceus</i>				
No common name	<i>Ampithoe valida</i>				
No common name	<i>Ancinus depressus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Ancistrostylis commensalis</i>				
No common name	<i>Ancistrostylis jonesi</i>				
No common name	<i>Ancula evelinae</i>				
No common name	<i>Anisodoris prea</i>				
No common name	<i>Anoplodactylus lentus</i>				
No common name	<i>Anoplodactylus petiolatus</i>				
No common name	<i>Anoplodactylus pygmaeus</i>				
No common name	<i>Aphelochaeta marioni</i>				
No common name	<i>Aphelochaeta sp.</i>				
No common name	<i>Aplidium constellatum</i>				
No common name	<i>Aplysilla sulphurea</i>				
No common name	<i>Apocorophium acutum</i>				
No common name	<i>Apocorophium lacustre</i>				
No common name	<i>Apocorophium simile</i>				
No common name	<i>Arabella mutans</i>				
No common name	<i>Archidistoma aggregatum</i>				
No common name	<i>Aricidea bryani</i>				
No common name	<i>Aricidea fragilis</i>				
No common name	<i>Aricidea wassi</i>				
No common name	<i>Armandia agilis</i>				
No common name	<i>Armandia maculata</i>				
No common name	<i>Asabellides sp. A</i>				
No common name	<i>Astrangia poculata</i>				
No common name	<i>Asychis elongata</i>				
No common name	<i>Atylus minikoi</i>				
No common name	<i>Autolytus dentalius</i>				
No common name	<i>Autolytus prolifera</i>				
No common name	<i>Axiognathus squamatus</i>				
No common name	<i>Axiothella mucosa</i>				
No common name	<i>Balanoglossus gigas</i>				
No common name	<i>Balanus subalbidus</i>				
No common name	<i>Balanus venustus</i>				
No common name	<i>Barentsia laxa</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Batea catharinensis</i>				
No common name	<i>Bathyporeia parkeri</i>				
No common name	<i>Bemlos unicornis</i>				
No common name	<i>Berghia benteva</i>				
No common name	<i>Berghia coerulescens</i>				
No common name	<i>Bhawania goodei</i>				
No common name	<i>Bhawania heteroseta</i>				
No common name	<i>Bimeria brevis</i>				
No common name	<i>Boccardiella hamata</i>				
No common name	<i>Bougainvillia rugosa</i>				
No common name	<i>Bowerbankia gracilis</i>				
No common name	<i>Bowerbankia imbricata</i>				
No common name	<i>Bowmaniella dissimilis</i>				
No common name	<i>Bowmaniella mexicana</i>				
No common name	<i>Branchioasychis americana</i>				
No common name	<i>Branchiostoma sp.</i>				
No common name	<i>Brania clavata</i>				
No common name	<i>Brasilomysis castroi</i>				
No common name	<i>Bugula fulva</i>				
No common name	<i>Bugula stolonifera</i>				
No common name	<i>Calcarea sp. A</i>				
No common name	<i>Calliobdella vivida</i>				
No common name	<i>Callipallene brevirostris</i>				
No common name	<i>Caprella equilibra</i>				
No common name	<i>Caprella penantis</i>				
No common name	<i>Carazziella hobsonae</i>				
No common name	<i>Carcinonemertes carcinophila</i>				
No common name	<i>Carinoma tremaphoros</i>				
No common name	<i>Carinomella lactea</i>				
No common name	<i>Cassidinidea ovalis</i>				
No common name	<i>Catriona perca</i>				
No common name	<i>Caulleriella killariensis</i>				
No common name	<i>Caulleriella sp.</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Cerapus tubularis</i>				
No common name	<i>Cerebratulus lineolatus</i>				
No common name	<i>Cerebratulus sp. A</i>				
No common name	<i>Chione elevata</i>				
No common name	<i>Chiridotea almyra</i>				
No common name	<i>Chiridotea arenicola</i>				
No common name	<i>Cirriformia filigera</i>				
No common name	<i>Cirriformia grandis</i>				
No common name	<i>Cirrophorus lyriformis</i>				
No common name	<i>Cirrophorus sp.</i>				
No common name	<i>Cleantoides planicauda</i>				
No common name	<i>Cliona lobata</i>				
No common name	<i>Cliona robusta</i>				
No common name	<i>Cliona spirilla</i>				
No common name	<i>Cliona vastifica</i>				
No common name	<i>Clytia coronata</i>				
No common name	<i>Clytia cylindrica</i>				
No common name	<i>Clytia hemispherica</i>				
No common name	<i>Clytia kincaidi</i>				
No common name	<i>Colomastix halichondriae</i>				
No common name	<i>Conjuguterus parvus</i>				
No common name	<i>Conopea galeata</i>				
No common name	<i>Conopeum seurati</i>				
No common name	<i>Conopeum tenuissimum</i>				
No common name	<i>Coronadena mutabilis</i>				
No common name	<i>Coronis excavatrix</i>				
No common name	<i>Craniella laminaris</i>				
No common name	<i>Cratena pilata</i>				
No common name	<i>Crisia eburnea</i>				
No common name	<i>Cryptosula pallasiana</i>				
No common name	<i>Ctenodrilus serratus</i>				
No common name	<i>Cupuladria doma</i>				
No common name	<i>Cyathura burbancki</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Cyathura polita</i>				
No common name	<i>Cyclaspis pustulata</i>				
No common name	<i>Cyclaspis unicornis</i>				
No common name	<i>Cyclaspis varians</i>				
No common name	<i>Cyclostremiscus pentagonus</i>				
No common name	<i>Cymadusa compta</i>				
No common name	<i>Dasybranchus lumbricoides</i>				
No common name	<i>Demonax microphthalmus</i>				
No common name	<i>Dentatisyllis carolinae</i>				
No common name	<i>Dexiospira corrugata</i>				
No common name	<i>Didemnum candidum</i>				
No common name	<i>Digynopora americana</i>				
No common name	<i>Diplosoma macdonaldi</i>				
No common name	<i>Discoporella umbellata</i>				
No common name	<i>Dispio uncinata</i>				
No common name	<i>Dodecaceria concharum</i>				
No common name	<i>Dorvillea sociabilis</i>				
No common name	<i>Doto sp. A</i>				
No common name	<i>Drilonereis magna</i>				
No common name	<i>Drilonereis monroi</i>				
No common name	<i>Dulichella appendiculata</i>				
No common name	<i>Dynamena cornicina</i>				
No common name	<i>Echinaster brasiliensis</i>				
No common name	<i>Ectopleura dumortieri</i>				
No common name	<i>Edotia triloba</i>				
No common name	<i>Edwardsia leidy</i>				
No common name	<i>Elasmopus levis</i>				
No common name	<i>Electra monostachys</i>				
No common name	<i>Enchytraeidae sp. A</i>				
No common name	<i>Enoplobranchus sanguineus</i>				
No common name	<i>Entovalva sp. A</i>				
No common name	<i>Entovalva sp. B</i>				
No common name	<i>Eobrolgus spinosus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Erichthonius brasiliensis</i>				
No common name	<i>Eteone lactea</i>				
No common name	<i>Eudendrium ramosum</i>				
No common name	<i>Eudendrium tenellum</i>				
No common name	<i>Eudevenopus honduranus</i>				
No common name	<i>Eudistoma carolinense</i>				
No common name	<i>Eudistoma hepaticum</i>				
No common name	<i>Eulalia sanguinea</i>				
No common name	<i>Eunice antennata</i>				
No common name	<i>Eusyllis lamelligera</i>				
No common name	<i>Euterpina acutifrons</i>				
No common name	<i>Exogone dispar</i>				
No common name	<i>Exogone verugera</i>				
No common name	<i>Exosphaeroma diminutum</i>				
No common name	<i>Fabricia sabella</i>				
No common name	<i>Fargoa bushiana</i>				
No common name	<i>Gammaropsis sutherlandi</i>				
No common name	<i>Gammarus daiberi</i>				
No common name	<i>Gammarus mucronatus</i>				
No common name	<i>Gammarus palustris</i>				
No common name	<i>Gammarus tigrinus</i>				
No common name	<i>Garveia franciscana</i>				
No common name	<i>Garveia humilis</i>				
No common name	<i>Gibbesia neglecta</i>				
No common name	<i>Gilvossius setimanus</i>				
No common name	<i>Gitanopsis tortugae</i>				
No common name	<i>Globosolembos smithi</i>				
No common name	<i>Glottidia pyramidata</i>				
No common name	<i>Glycera dibranchiata</i>				
No common name	<i>Glycera robusta</i>				
No common name	<i>Glycera sphyrabrancha</i>				
No common name	<i>Glycinde solitaria</i>				
No common name	<i>Goniada littorea</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Halecium gracile</i>				
No common name	<i>Halecium tenellum</i>				
No common name	<i>Haliclona permollis</i>				
No common name	<i>Halmyrapseudes bahamensis</i>				
No common name	<i>Haloclava producta</i>				
No common name	<i>Hargeria rapax</i>				
No common name	<i>Harmothoe aculeata</i>				
No common name	<i>Harmothoinae sp. A</i>				
No common name	<i>Haustorius canadensis</i>				
No common name	<i>Haustorius longirostris</i>				
No common name	<i>Hebella scandens</i>				
No common name	<i>Heteromastus filiformis</i>				
No common name	<i>Heteromysis formosa</i>				
No common name	<i>Hippoporida janthina</i>				
No common name	<i>Hippoporina verrilli</i>				
No common name	<i>Hyale plumulosa</i>				
No common name	<i>Hyalella azteca</i>				
No common name	<i>Hyboscolex longiseta</i>				
No common name	<i>Hydroides dianthus</i>				
No common name	<i>Hymeniacidon heliophila</i>				
No common name	<i>Idotea balthica</i>				
No common name	<i>Incisocalliope aestuarius</i>				
No common name	<i>Jaeropsis rathbunae</i>				
No common name	<i>Jassa marmorata</i>				
No common name	<i>Keratosa sp. A</i>				
No common name	<i>Kinbergonuphis jenneri</i>				
No common name	<i>Kupellonura formosa</i>				
No common name	<i>Learchis poica</i>				
No common name	<i>Leitoscoloplos fragilis</i>				
No common name	<i>Leitoscoloplos robustus</i>				
No common name	<i>Lembos hypacanthus</i>				
No common name	<i>Lepidactylus dytiscus</i>				
No common name	<i>Lepidasthenia varia</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Lepton sp. A</i>				
No common name	<i>Leptosynapta tenuis</i>				
No common name	<i>Leucon americanus</i>				
No common name	<i>Leucosolenia canariensis</i>				
No common name	<i>Leucothoe spinicarpa</i>				
No common name	<i>Lineus bicolor</i>				
No common name	<i>Lineus socialis</i>				
No common name	<i>Lineus sp. A</i>				
No common name	<i>Linvillea agassizi</i>				
No common name	<i>Listriella barnardi</i>				
No common name	<i>Listriella clymenellae</i>				
No common name	<i>Livoneca redmanii</i>				
No common name	<i>Livoneca reniformis</i>				
No common name	<i>Loimia viridis</i>				
No common name	<i>Lomanotus sp. A</i>				
No common name	<i>Lovenella gracilis</i>				
No common name	<i>Loxosomella cricketae</i>				
No common name	<i>Loxosomella tethyae</i>				
No common name	<i>Lucifer faxoni</i>				
No common name	<i>Lumbrineris coccinea</i>				
No common name	<i>Lysidice ninetta</i>				
No common name	<i>Lysilla alba</i>				
No common name	<i>Macroclymene zonalis</i>				
No common name	<i>Maera caroliniana</i>				
No common name	<i>Maera williamsi</i>				
No common name	<i>Magelona papillicornis</i>				
No common name	<i>Magelona phyllisae</i>				
No common name	<i>Magelona sp.</i>				
No common name	<i>Malmgrenia lunulata</i>				
No common name	<i>Manayunkia aestuarina</i>				
No common name	<i>Mancocuma altera</i>				
No common name	<i>Marphysa sanguinea</i>				
No common name	<i>Mediomastus ambiseta</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Mediomastus californiensis</i>				
No common name	<i>Megalomma lobiferum</i>				
No common name	<i>Melinna maculata</i>				
No common name	<i>Melita nitida</i>				
No common name	<i>Membranipora arborescens</i>				
No common name	<i>Mesochaetopterus taylori</i>				
No common name	<i>Metamysidopsis swifti</i>				
No common name	<i>Metharpinia floridana</i>				
No common name	<i>Microprotopus raneyi</i>				
No common name	<i>Microprotopus shoemakeri</i>				
No common name	<i>Miesea evelinae</i>				
No common name	<i>Mnemiopsis leidyi</i>				
No common name	<i>Monocorophium acherusicum</i>				
No common name	<i>Monocorophium tuberculatum</i>				
No common name	<i>Monopylephorus rubroniveus</i>				
No common name	<i>Montacutidae sp. A</i>				
No common name	<i>Montecellina sp.</i>				
No common name	<i>Mooreonuphis nebulosa</i>				
No common name	<i>Mycale cecilia</i>				
No common name	<i>Mycale sp. A</i>				
No common name	<i>Myrianida pachycera</i>				
No common name	<i>Myriochele oculata</i>				
No common name	<i>Mysella sp. B</i>				
No common name	<i>Mysella sp. C</i>				
No common name	<i>Mysidopsis furca</i>				
No common name	<i>Nemertopsis bivittata</i>				
No common name	<i>Neohaustorius biarticulatus</i>				
No common name	<i>Neohaustorius schmitzi</i>				
No common name	<i>Neomysis americana</i>				
No common name	<i>Nephtys bucera</i>				
No common name	<i>Nephtys picta</i>				
No common name	<i>Nereiphylla fragilis</i>				
No common name	<i>Nereis acuminata</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Nereis falsa</i>				
No common name	<i>Nolella stipata</i>				
No common name	<i>Notomastus hemipodus</i>				
No common name	<i>Notomastus latericeus</i>				
No common name	<i>Notomastus lobatus</i>				
No common name	<i>Nymphopsis duodorsospinosa</i>				
No common name	<i>Obelia bidentata</i>				
No common name	<i>Obelia dichotoma</i>				
No common name	<i>Obelia geniculata</i>				
No common name	<i>Octolasmis mulleri</i>				
No common name	<i>Odontosyllis fulgurans</i>				
No common name	<i>Oerstedia dorsalis</i>				
No common name	<i>Okenia impexa</i>				
No common name	<i>Okenia sp. A</i>				
No common name	<i>Okenia sp. B</i>				
No common name	<i>Oligoclado floridanus</i>				
No common name	<i>Ophryotrocha puerilis</i>				
No common name	<i>Ophryotrocha sp. A</i>				
No common name	<i>Orbinia ornata</i>				
No common name	<i>Orbinia riseri</i>				
No common name	<i>Orchestia grillus</i>				
No common name	<i>Oxyurostylis smithi</i>				
No common name	<i>Pantionemertes agricola</i>				
No common name	<i>Paracalanus crassirostris</i>				
No common name	<i>Paracaprella tenuis</i>				
No common name	<i>Paracerceis caudata</i>				
No common name	<i>Parahaustorius longimerus</i>				
No common name	<i>Parahesione luteola</i>				
No common name	<i>Paranaïs (frici?)</i>				
No common name	<i>Paranaitis gardineri</i>				
No common name	<i>Paranaitis speciosa</i>				
No common name	<i>Paranemertes biocellatus</i>				
No common name	<i>Paraonis fulgens</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Parapionosyllis longicirrata</i>				
No common name	<i>Parapionosyllis sp.</i>				
No common name	<i>Parhyale hawaiiensis</i>				
No common name	<i>Paysa quadridentata</i>				
No common name	<i>Pedicellina cernua</i>				
No common name	<i>Peloscolex sp. A</i>				
No common name	<i>Pentamera pulcherrima</i>				
No common name	<i>Persephona aquilonaris</i>				
No common name	<i>Phascolion strombus</i>				
No common name	<i>Phoronis architecta</i>				
No common name	<i>Phoronis ovalis</i>				
No common name	<i>Photis pugnator</i>				
No common name	<i>Phyllodoce arenae</i>				
No common name	<i>Pinnixa retinens</i>				
No common name	<i>Pinnixa sayana</i>				
No common name	<i>Piromis eruca</i>				
No common name	<i>Pista palmata</i>				
No common name	<i>Plagiostomum sp. A</i>				
No common name	<i>Platynereis dumerilii</i>				
No common name	<i>Plumularia floridana</i>				
No common name	<i>Podarke obscura</i>				
No common name	<i>Podarkeopsis levifuscina</i>				
No common name	<i>Poecilosclerida sp. A</i>				
No common name	<i>Polycera hummi</i>				
No common name	<i>Polycerella emertoni</i>				
No common name	<i>Polycirrus carolinensis</i>				
No common name	<i>Polycirrus eximius</i>				
No common name	<i>Polycirrus sp.</i>				
No common name	<i>Polydora colonia</i>				
No common name	<i>Polydora cornuta</i>				
No common name	<i>Polydora socialis</i>				
No common name	<i>Potamilla reniformis</i>				
No common name	<i>Potamilla torelli</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Prionospio cirrifera</i>				
No common name	<i>Prionospio cristata</i>				
No common name	<i>Prionospio dayi</i>				
No common name	<i>Probopyrinella latreuticola</i>				
No common name	<i>Proceraea fasciata</i>				
No common name	<i>Prosthiostomum pulchrum</i>				
No common name	<i>Prosuberites microsclerus</i>				
No common name	<i>Protohaustorius deichmannae</i>				
No common name	<i>Pseudeurythoe ambigua</i>				
No common name	<i>Pseudione upogebiae</i>				
No common name	<i>Pseudodiptomus coronatus</i>				
No common name	<i>Pseudohhaustorius caroliniensis</i>				
No common name	<i>Pycnogonum cessaci</i>				
No common name	<i>Rhepoxynius epistomus</i>				
No common name	<i>Rhepoxynius hudsoni</i>				
No common name	<i>Sabellaria vulgaris vulgaris</i>				
No common name	<i>Saccoglossus kowalevskii</i>				
No common name	<i>Schistomeringos rudolphi</i>				
No common name	<i>Schizocardium brasiliense</i>				
No common name	<i>Schizoporella unicornis</i>				
No common name	<i>Schizotricha tenella</i>				
No common name	<i>Scolecopides viridis</i>				
No common name	<i>Scolelepis squamata</i>				
No common name	<i>Scolelepis texana</i>				
No common name	<i>Scoletoma impatiens</i>				
No common name	<i>Scoletoma tenuis</i>				
No common name	<i>Scypha barbadensis</i>				
No common name	<i>Seila adamsi</i>				
No common name	<i>Sextonia sp. A</i>				
No common name	<i>Sphaeroma quadridentatum</i>				
No common name	<i>Sphaerosyllis longicauda</i>				
No common name	<i>Spilocuma watlingi</i>				
No common name	<i>Spio multioculata</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Spio setosa</i>				
No common name	<i>Spiochaetopterus costarum oculus</i>				
No common name	<i>Stenothoe georgiana</i>				
No common name	<i>Stenothoe minuta</i>				
No common name	<i>Stenothoe valida</i>				
No common name	<i>Streblospio benedicti</i>				
No common name	<i>Streptosyllis arenae</i>				
No common name	<i>Stylochus oculiferus</i>				
No common name	<i>Sundanella sibogae</i>				
No common name	<i>Syllis cornuta</i>				
No common name	<i>Syllis gracilis</i>				
No common name	<i>Syllis hyalina</i>				
No common name	<i>Synelmis ewingi</i>				
No common name	<i>Synnotum aegyptiacum</i>				
No common name	<i>Tanaissus psammophilus</i>				
No common name	<i>Tanystylum orbiculare</i>				
No common name	<i>Telmatogeton japonicus</i>				
No common name	<i>Tenaciella obliqua</i>				
No common name	<i>Tenellia pallida</i>				
No common name	<i>Terebella rubra</i>				
No common name	<i>Tetrastemma candidum</i>				
No common name	<i>Thalassema hartmani</i>				
No common name	<i>Tharyx acutus</i>				
No common name	<i>Tharyx setigera</i>				
No common name	<i>Thecacera pennigera</i>				
No common name	<i>Thelepus setosus</i>				
No common name	<i>Themiste alutacea</i>				
No common name	<i>Theristus polychaetophilus</i>				
No common name	<i>Thysanozoon brocchi</i>				
No common name	<i>Tortanus setacaudatus</i>				
No common name	<i>Trapania sp. A</i>				
No common name	<i>Travisia parva</i>				
No common name	<i>Tridentata distans</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
No common name	<i>Triticella elongata</i>				
No common name	<i>Tritonia bayeri</i>				
No common name	<i>Tubificoides brownae</i>				
No common name	<i>Tubificoides heterochaetus</i>				
No common name	<i>Tubificoides wasselli</i>				
No common name	<i>Tubulanus pellucidus</i>				
No common name	<i>Tubulanus rhabdotus</i>				
No common name	<i>Tubularia crocea</i>				
No common name	<i>Turbonilla acicula</i>				
No common name	<i>Turbonilla buteonis</i>				
No common name	<i>Turbonilla wrightsvillensis</i>				
No common name	<i>Turritopsis nutricula</i>				
No common name	<i>Uhlorchestia spartinophila</i>				
No common name	<i>Uhlorchestia uhleri</i>				
No common name	<i>Unciola dissimilis</i>				
No common name	<i>Unciola irrorata</i>				
No common name	<i>Unciola serrata</i>				
No common name	<i>Vitrinellidae sp. A</i>				
No common name	<i>Xestospongia halichondrioides</i>				
No common name	<i>Zoobotryon verticillatum</i>				
No common name	<i>Zygeupolia rubens</i>				
No common name	<i>Zygonemertes virescens</i>				
Insects					
American Sand Burrowing Mayfly	<i>Dolania Americana</i>			G4	S3
Black Fly	<i>Ectemnia invenusta</i>				
Calvert's Emerald	<i>Somatochlora calverti</i>			G3	SNR
Coyle's Purseweb Spider	<i>Sphodros coylei</i>		Of Concern, State	G4?	S?
Diana Fritillary	<i>Speyeria diana</i>			G3G4	S3?
Elephant (or Treehole) Predatory Mosquito	<i>Toxorhynchites rutilus rutilus/ T.r.septentrionalis</i>			GNR	
Forestiera Lace Bugs	<i>Leptoypha elliptica/L. ilicis</i>				
Moretti's Caddisfly	<i>Protophila moretti</i>			G1G2	SNR
Moth sp.	<i>Agnorisma bollii</i>			G4?	
Pointy-lobed Firefly	<i>Photinus acuminatus</i>				

AP 1: Priority Species List

SC CWCS

Common Name	Scientific Name	Priority	Legal Status	G Rank	S Rank
Pyramid Ants	<i>Dorymyrmex bureni/D. medeis</i>				
Sandhills Earth Boring Scarab Beetle	<i>Mycotrupes retusus</i>				
Smokies Needlefly	<i>Megaleuctra williamsae</i>			G2	
White Beach Tiger Beetle	<i>Cicindela dorsalis media</i>			G4T4	S4
Zigadenus Sawfly	<i>Rhadinoceraea zigadenusae</i>				

APPENDIX 2: SELECTED LIST OF EXISTING CONSERVATION PLANS

- USFWS Recovery Plans (West Indian manatee, bald eagle, pygmy sperm whale, dwarf sperm whale, humpback whale, bottlenose dolphin, Atlantic right whale, wood stork, shortnose sturgeon, Southern bog turtle, American alligator, Indiana bat, Carolina heelsplitter, piping plover, flatwoods salamander, peregrine falcon, red-cockaded woodpecker, green sea turtle, hawksbill sea turtle, leatherback sea turtle, loggerhead sea turtle)
- PIF North American Landbird Conservation Plan (March 2003—DRAFT)
- A Blueprint for the Future of Migratory Landbirds (Migratory Bird Program Strategic Plan 2004-2014)-- USFWS
- North American Waterfowl Management Plan (1998 Update, Expanding the Vision)-- USFWS
- Southeastern US Waterbird Conservation Plan (DRAFT?)
- PIF Bird Conservation Plan for the South Atlantic Coastal Plain (Physiographic Area 03)
- PIF Bird Conservation Plan for the Southern Piedmont (Physiographic Area 11)
- PIF Bird Conservation Plan for the Southern Blue Ridge (Physiographic Area 23)
- Waterbird Conservation for the Americas (North American Waterbird Conservation Plan, Version 1)-- NAWCP
- United States Shorebird Conservation Plan 2001-- Manomet
- The North American Bird Conservation Initiative in the United States (2000)
- Northern Atlantic Regional Shorebird Plan (June 2000)
- Atlantic Coast Joint Venture Plan (updated 2004)
- Southeastern Coastal Plain-Caribbean Shorebird Plan (revised July 2003)
- SAMBI Pelagic Conservation Plan (DRAFT)
- American Woodcock Management Plan (1990)—USFWS
- Appalachian Cooperative Grouse Project (October 1999)
- The Northern Bobwhite Conservation Initiative (2002)
- South Carolina Breeding Bird Atlas 1988-1995 (Cely 2003)
- SC Dept. of Natural Resources Wildlife Management Research and Survey Report (April 2004)
- Proceedings of the First South Carolina Endangered Species Symposium (MRD and the Citadel, 1976)
- A Process for Integrating Wildlife Population, Biodiversity, and Habitat Goals and Objectives on the National Wildlife Refuge System: Coordinating With Partners at all Landscape Scales (Final Report, January 2004)
- Priority Areas for Freshwater Conservation Action: A Biodiversity Assessment of the Southeastern United States (The Nature Conservancy, 2002)
- Aquatic Fauna In Peril: The Southeastern Perspective (book by Benz and Collins, 1997)
- Santee-Cooper Basin Diadromous Fish Passage Restoration Plan (SCDNR, 2001)
- A Strategic Plan for the Non-game and Heritage Trust Section (SCDNR, 1995)
- Amphibian Conservation (Semlitsch and Wake 2003) -- PARC
- Conserving Amphibians and Reptiles in the New Millennium (proceedings of PARC conference in 1999)
- Habitat Management Guideline for Reptiles and Amphibians of the Southeastern United States (due 2004)

- Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning (Volume I, Second Edition, 2000) / Appendices (Volume II)—TNC
- Natural Communities of South Carolina—SCDNR
- Integrating Land Use Planning and Biodiversity—Defenders of Wildlife
- North Carolina's Coastal Habitat Protection Plan (CHPP) – due out in 2004
- Mid/South Atlantic (Carolinian Province) Marine Ecoregional Assessment (TNC, April 2004)
- Workbook and Key to the Freshwater Bivalves of South Carolina (Bogan and Alderman - NC State Museum, USFWS, etc., 2004)
- Performance Measures For Ecosystem Management and Ecological Sustainability—TWS Technical Review 02-1, 2002
- South Carolina's Wetlands: Status and Trends 1982-1989 (USFWS)
- USFS plans for Sumter NF and Francis Marion NF
- Ecological Characterization of the Sea Island Coastal Region of SC and GA. (USFWS, 1980)
- http://www.sherpaguides.com/southeast/aquatic_fauna/chapter_3/
- Halting the Invasion: State Tools for Invasive Species Management (Environmental Law Institute 2002)

APPENDIX 3: BIRD PRIORITIZATION TABLES

Table AP3-1: Rankings, scores, tiers, and action levels representing global, regional, and state prioritization of landbirds selected for the SC CWCP

					SE Atlantic Coastal Plain BCR ⁴ 27			Appalachian Mountains BCR 28			Piedmont BCR 29			
Scientific Name	Common Name	Global Rank ¹	State Rank ²	Combined Score ³	CT ⁵	CA ⁶	RS ⁷	RS	CT	RS	CT	CA	RS	Residency by BCR ⁸
<i>Elanoides forficatus</i>	Swallow-tailed kite	G5	S2	16	Ia	MA	16	Ic	PR	16				B 27, 28, 29
<i>Haliaeetus leucocephalus</i>	Bald eagle	G4	S2	10	IIIa			IIIa			IIIa			B, N 27, 28, 29
<i>Falco peregrinus</i>	Peregrine falcon	G4	-	8	IIIb			Ib	IM	16				B 28
<i>Falco sparverius paulus</i>	American kestrel (Southeastern race)	G5T4	S4	7	Ib	MA	14				IVa			B 27, 29
<i>Bonasa umbellus</i>	Ruffed grouse	G5	S4					Ib	IM	16	IVb			B, N 28, 29
<i>Colinus virginianus</i>	Northern bobwhite	G5	S4		Ib	MA	16	Ib	IM	17	Ib	IM	16	B, N 27, 28, 29
<i>Columbina passerina</i>	Common ground-dove	G5	NR	11	Ib	IM	16							B, N 27
<i>Tyto alba</i>	Barn owl	G5	S4	9	IIIb						IVa			B, N 27, 28, 29
<i>Picoides borealis</i>	Red-cockaded woodpecker	G3	S2	18	Ia	IM	23	Ia	IM	21	Ia	IM	20	B, N 27, 28, 29
<i>Tyrannus dominicensis</i>	Gray kingbird	G5	NR	13	IVa									B 27
<i>Empidonax virens</i>	Acadian flycatcher	G5	S4	12	II	PR		Ib	MA	17	IVd			B 27, 28, 29
<i>Contopus virens</i>	Eastern wood-pewee	G5	S?	10	Ib	MA	14	Ib	MA	15	Ib	MA	15	B, N 27, 28, 29
<i>Corvus corax</i>	Common raven	G5	S4	6					IVc					B, N 28
<i>Sitta canadensis</i>	Red-breasted nuthatch	G5	S4	6					IVc					B, N 28
<i>Sitta pusilla</i>	Brown-headed nuthatch	G5	S4	14	Ic	MA	20	Ic	PR	16	Ic	PR	18	B, N 27, 28, 29
<i>Thryomanes bewickii</i>	Bewick's wren	G5	S1?	10				Ib	IM	17				B 28
<i>Hylocichla mustelina</i>	Wood thrush	G5	S3	14	Ia	MA	15	Ia	MA	16	Ia	MA	16	B, 27, 28, 29
<i>Regulus satrapa</i>	Golden-crowned kinglet	G5	S4	9	IVc									B, N 28; N 27, 29
<i>Lanius ludovicianus</i>	Loggerhead shrike	G4	S3	12	Ib	IM	16	Ib	IM	16	Ib	IM	16	B 28, 29; N 27, 29

					SE Atlantic Coastal Plain BCR ⁴ 27			Appalachian Mountains BCR 28			Piedmont BCR 29			
Scientific Name	Common Name	Global Rank ¹	State Rank ²	Combined Score ³	CT ⁵	CA ⁶	RS ⁷	RS	CT	RS	CT	CA	RS	Residency by BCR ⁸
<i>Limnothlypis swainsonii</i>	Swainson's warbler	G4	S4	14	Ic	MA	18	Ic	PR	16	Ia	MA	18	B 27, 28, 29
<i>Helmitheros vermivorus</i>	Worm-eating warbler	G5	S4	14	Ic	PR	15	Ia	MA	18	Ic	PR	13	B 27, 28, 29
<i>Dendroica caerulescens</i>	Black-throated blue warbler	G5	S?	12	II			IVc						B 28
<i>Dendroica virens waynei</i>	Black-throated green warbler (Wayne's race)	G5	S4	11	Ib	IM	16							B 27
<i>Dendroica pensylvanica</i>	Chestnut-sided warbler	G5	NR	13				IVc						B 28
<i>Dendroica discolor</i>	Prairie warbler	G5	S4	14	Ia	MA	18	Ia	MA	18	Ia	MA	18	B 27, 28, 29
<i>Seiurus motacilla</i>	Louisiana Waterthrush	G5	S4	13	IV			Ib	MA	18	IVd			B 27, 28, 29
<i>Oporornis formosus</i>	Kentucky Warbler	G5	S4	14	Ic	PR	16	Ia	MA	19	Ic	PR	15	B 27, 28, 29
<i>Sturnella magna</i>	Eastern meadowlark	G5	NR	11	Ib	MA	14	Ib	MA	14	Ib	MA	15	B, N 27, 28, 29
<i>Euphagus carolinus</i>	Rusty blackbird	G4	-	13	Ia	MA	18	Ia	MA	15	Ib	MA	18	B, N 27, 28, 29
<i>Piranga olivacea</i>	Scarlet tanager	G5	NR	12				IVc			IVc			B 28, 29
<i>Passerina ciris</i>	Painted bunting	G5	NR	16	Ib	IM	18				IVa			B 27
<i>Loxia curvirostra</i>	Red crossbill	G5	S4					Ib	IM	14	IVa			B 29, N 28
<i>Ammodramus savannarum</i>	Grasshopper sparrow	G5	NR	12	Ib	MA	15	Ib	IM	14	Ib	MA	14	B 28, 29 (27)
<i>Ammodramus henslowii</i>	Henslow's sparrow	G4	SZN	18	Ia	IM		Ia	IM	20	Ia	IM	19	N 27, B 29
<i>Ammospiza maritime</i>	Seaside sparrow	G4	NR	15	Ib	PR	22							B, N 27
<i>Aimophila aestivalis</i>	Bachman's sparrow	G3	S3	17	Ia	MA	21	Ia	IM	20	Ia	MA	18	B, N 27, 28, 29
<i>Junco hyemalis</i>	Dark-eyed junco	G5	NR	8	IVc			IVc			IVc			B, N 28, N 27, 29
<i>Spizella pusilla</i>	Field sparrow	G5	S5	12	Ib	MA	15	Ib	MA	16	Ib	MA	17	B, N 27, 28, 29
<i>Aix sponsa</i>	Wood duck	G5	S?		II	PR	18(b)							B, W 27

Table AP 3-2: Rankings, scores, tiers, and action levels representing global, regional, and state prioritization of shore and water birds selected for the plan. Sources: NatureServe 2005, Hunter and Demarest 2005, South Carolina Rare, Threatened and Endangered Species Inventory.

					SE Atlantic Coastal Plain BCR ⁴ 27			Appalachian Mountains BCR 28			Piedmont BCR 29			
Scientific Name	Common Name	Global Rank ¹	State Rank ²	Combined Score ³	CT ⁵	CA ⁶	RS ⁷	CT	CA	RS	CT	CA	RS	Residency by BCR ⁸
Colonial Nesting Seabirds and Shorebirds														
<i>Rynchops niger</i>	Black skimmer	G5	S2		Ib	MA	20							B, N 27
<i>Sterna sandvicensis</i>	Sandwich tern	G5	NR		I	MA	17							B 27
<i>Sterna maxima</i>	Royal tern	G5	NR		IIa	PR	20							B, T 27
<i>Sterna antillarum</i>	Least tern	G4	S3		I	MA	19							B 27
<i>Sterna hirundo</i>	Common tern	G5	-		I	IM	15							B, T 27
<i>Sterna nilotica</i>	Gull-billed tern	G5	S?		I	MA	18							B 27
<i>Sterna forsteri</i>	Forster's tern	G5	-		II	PR	19							B, T, N 27
<i>Charadrius wilsonia</i>	Wilson's plover	G5	S3?		I	MA	20							B 27
<i>Pelicanus occidentalis</i>	Eastern brown pelican	G4	S1S2		IIIa									B, N 27
<i>Haematopus palliatus</i>	American oystercatcher	G5	S?		I	MA	21							B, N 27
<i>Catoptrophorus semipalmatus</i>	Willet	G5	NR		I	PR	16							B, N 27
<i>Himantopus mexicanus</i>	Black-necked stilt	G5	-		IVa	PR								B 27
Colonial Nesting Wading Birds														
<i>Ardea herodias</i>	Great blue heron	G5	NR		IVe			IVe			IVe			B, N 27, 28, 29
<i>Egretta caerulea</i>	Little blue heron	G5	S?		I	MA	15							B, N 27
<i>Ardea alba</i>	Great Egret	G5	NR		IVe			IVe			IVe			B, N 27, 28, 29
<i>Bubulcus ibis</i>	Cattle Egret	G5	NR		IVf			IVf			IVf			B, N 27, 28, 29
<i>Egretta thula</i>	Snowy egret	G5	NR		I	MA	14							B, N 27
<i>Egretta tricolor</i>	Louisiana (Tri-colored) heron	G5	NR		I	MA	17							B, N 27
<i>Nycticorax nycticorax</i>	Black-crowned night heron	G5	NR		I	MA	15							B, N 27

					SE Atlantic Coastal Plain BCR ⁴ 27			Appalachian Mountains BCR 28			Piedmont BCR 29			
Scientific Name	Common Name	Global Rank ¹	State Rank ²	Combined Score ³	CT ⁵	CA ⁶	RS ⁷	CT	CA	RS	CT	CA	RS	Residency by BCR ⁸
Nyctanassa violacea	Yellow-crowned night heron	G5	NR		I	MA	14							B, N 27
Mycteria americana	Wood stork	G4	S1S2		I	IM	16							B 27
Plegadis falcinellus	Glossy ibis	G5	S?		I	MA	14							B, N 27
Eudocimus albus	White ibis	G5	-		I	MA	16							B, N 27
Butorides virescens	Green heron	G5	NR											B 27
Ixobrychus exilis	Least bittern	G5	NR		I	MA	14							B 27
Migratory Seabirds and Shorebirds														
Charadrius melodus	Piping plover	G3	S?		I	IM	22							N 27
Charadrius semipalmatus	Semipalmated plover	G5	-		II	PR								N 27
Pluvialis squatarola	Black-bellied plover	G5	-		II	PR	16							N 27
Pluvialis dominica	American golden plover	G5	-		I	MA	17							T 27
Actitis macularia	Spotted sandpiper	G5	-		II	PR								N 27
Tryngites subruficollis	Buff-breasted sandpiper	G4	-		I	IM	21							T 27
Bartramia longicauda	Upland sandpiper	G5	-		I	MA	18	I	MA	22				T 27, 28
Calidris fuscicollis	White-rumped sandpiper	G5	-											
Calidris pusilla	Semipalmated sandpiper	G5	-		I	MA	19							T 27
Calidris melanotos	Pectoral sandpiper	G5	-											
Calidris mauri	Western sandpiper	G5	-		I	MA	17							N 27
Calidris maritime	Purple sandpiper	G5	-		IV	PR								N 27
Calidris minutilla	Least sandpiper	G5	-		I	MA	18							N 27
Calidris himantopus	Stilt sandpiper	G5	-		I	MA	18							T 27
Calidris alba	Sanderling	G5	-		I	MA	17							N 27
Calidris canutus	Red knot	G5	-		I	MA	17							N 27
Tringa solitaria	Solitary sandpiper	G5	-		I	MA	18							T 27
Recurvirostra americana	American avocet	G5	-		I	MA	17							N 27
Tringa melanoleuca	Greater yellowlegs	G5	-											

					SE Atlantic Coastal Plain BCR ⁴ 27			Appalachian Mountains BCR 28			Piedmont BCR 29			
Scientific Name	Common Name	Global Rank ¹	State Rank ²	Combined Score ³	CT ⁵	CA ⁶	RS ⁷	CT	CA	RS	CT	CA	RS	Residency by BCR ⁸
<i>Tringa flavipes</i>	Lesser yellowlegs	G5	-		I	MA	17							N 27
<i>Calidris alpina</i>	Dunlin	G5	-		I	MA	16							N 27
<i>Limnodromus griseus</i>	Short-billed dowitcher	G5	-		I	MA	19							N 27
<i>Limnodromus scolopaceus</i>	Long-billed dowitcher	G5	-											
<i>Numenius phaeopus</i>	Whimbrel	G5	-		I	IM	19							B, N 27
<i>Numenius americanus</i>	Long-billed curlew	G5	-		I	IM	19							N 27
<i>Limosa fedoa</i>	Marbled godwit	G5	-		I	MA	18							N 27
Marsh Birds														
<i>Corturicops noveboracensis</i>	Yellow rail	G4	-		I	MA	21							N 27
<i>Laterallus jamaicensis</i>	Black rail	G4	NR		I	MA	22	I	MA	25	I	MA	26	B, N 27, 28, 29
<i>Rallus elegans</i>	King rail	G4	NR		I	IM	24	I	IM	21	I	IM		B, N 27, 28, 29
<i>Botaurus lentiginosus</i>	American bittern	G4	S?		I	MA	17							N 27
<i>Podilymbus podiceps</i>	Pied-billed grebe (breeding populations)	G5	NR		I	MA	14							N 27
<i>Fulica americana</i>	American coot (breeding populations)	G5	SH		IVb									N 27
<i>Gallinago gallinago delicata</i>	Common (Wilson's) snipe	G5	-		I	PR	19							B, N 27
<i>Scolopax minor</i>	American woodcock	G5	S4		IIIb			IIIb		IIIb				N 27, 28, 29
<i>Porphyryula martinica</i>	Purple gallinule	G5	S4		I	IM	17							B 27

Sources: NatureServe 2005, Hunter and Demarest 2005.

¹Global rank is the Nature Conservancy rating of degree of endangerment world-wide

(For further detail see NatureServe 2005): G1 - Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction

G2 - Imperiled globally because of rarity or factor(s) making it vulnerable

G3 - Either very rare throughout its range or found locally in a restricted range, or having factors making it vulnerable

G4 - Apparently secure globally, though it may be rare in parts of its range

G5 - Demonstrably secure globally, though it may be rare in parts of its range

²State rank is the Nature Conservancy rating of degree of endangerment in South Carolina (for further explanation see NatureServe 2005):

S1 - Critically imperiled state-wide because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation

S2 - Imperiled state-wide because of rarity or factor(s) making it vulnerable

S3 - Rare or uncommon in state

S4 - Apparently secure in state

S5 - Demonstrably secure in state

S? – Status unknown

³Combined scores global scores calculated at the continental level as population size + [highest of breeding distribution or non-breeding distribution] + [highest of threats breeding or threats non-breeding] + population trend. Higher values indicate higher vulnerability and a maximum of 30 points can be calculated (for further detail see Rich et al. 2004 Appendix A).

⁴Bird Conservation Region (BCR) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (For further detail and maps see NABCI 2005): 27 – Southeastern Coastal Plain, 28 – Appalachian Mountains, and 29 – Piedmont.

⁵CT, Conservation Tier, PIF Tier, Partners In Flight ranking based six assessment factors (for further explanation see Rich et al. 2004). New tier system combines both continental and regional concern species in Tier I:

Tier I, Species of High Continental and/or Regional Concern in need of both management and monitoring Importance, (a) continental concern and regional concern, (b) regional concern only, (c) continental concern only.

Tier II, Species not otherwise of continental nor regional concern where monitoring attention is needed to ensure population security;

Tier III, Species where at least monitoring attention is needed to ensure population persistence, but management attention may or may not be necessary based on legal requirements and political boundaries, (a) additional federally listed, (b) additional state listed, and (c) additional politically recognized species (e.g., nature reserve s1, s2).

Tier IV, Other species of conservation or management interest not otherwise listed above, (a) locally rare or peripheral species of interest, (b) game species of particular local or state management or economic interest, (c) nongame species or particular local or state management or economic interest, (d) species frequently occurring as a regional concern species in other BCRs just not in this one with regional density >2.

⁶CA, Conservation Action level based on combinations of assessment scores to indicate relative level and immediacy of conservation action needed. A critical measure of conservation need.

Immediate management (IM) needed to reverse or stabilize significant, long-term population declines in species with small populations, or to protect species with the smallest populations for which trends are poorly known. Lack of action may lead to extirpations or extinction. Generally species with a TB/TN=5 or a TB/TN=4+PT=5 fall under this action level.

Management or other on-the-ground conservation actions (MA) needed to reverse or stabilize significant, long-term population declines in species that are still relatively abundant. All other Regional Concern species that are not IM, fall under this action level. Some Federally or State/Provincial listed species not otherwise meeting either Continental or Regional Concern criteria may fall under this action level.

Long-term Planning and Responsibility (PR) needed for species to ensure that sustainable populations are maintained for species for which a region has

high responsibility for that species. All Continental Concern species that are not also Regional Concern species fall under this action level, as well as any additional Regional Stewardship and Continental Stewardship species and any additional local or regional interest species identified.

⁷Regional scores (combined score with population trend, threat breeding and threat non-breeding based on local data; and a score for relative density examined independently). Higher values indicate higher vulnerability and a maximum of 35 points can be calculated. Scores are calculated for breeding, non-breeding permanent residents, and non-breeding seasonal residents.

⁸ Residency status, B, breeding; N, non-breeding or wintering; and T, transient, usually migrating.

APPENDIX 4: EXISTING MONITORING PROGRAMS THAT INCLUDE SOUTH CAROLINA COVERAGE

Name of Program	Coordinating Agency	Contact	Participating Partners	Extent of Coverage	Affected Species
<i>SCDNR Programs</i>					
Wading Bird Surveys	SCDNR	Tom Murphy		Annual Aerial estimates	Hérons, egrets, ibis, anhinga, DOCC
Bald Eagle Survey (breeding season)	SCDNR	Tom Murphy	FWS	Statewide during breeding season	Bald Eagle
Bald Eagle Survey (mid-winter)	SCDNR coordinates SC survey	Charlotte Hope	USGS coordinates U.S. surveys	Coordinate and conduct statewide during winter	Bald Eagle
Seabird Nesting Colony Surveys	SCDNR	Tom Murphy or Felicia Sanders	Cape Romain NWR, COE and Clemson COOP	Complete ground counts	Pelicans, gulls, terns, skimmers
American Oystercatcher	SCDNR	Felicia Sanders	Clemson COOP	Periodic statewide surveys of nesting and wintering populations	AMOY
American Oystercatcher	SCDNR	Felicia Sanders	AMOY regional working group	Annual monitoring of color banded birds	AMOY
Wood Stork	SCDNR	Tom Murphy	Wood Stork Working Group, FWS	Annual statewide nest counts and productivity estimates	WOST
Bluebird Monitoring Project	SCDNR	Lex Glover	Volunteers and DNR staff.	Conducted during the nesting season.	Eastern bluebirds and various cavity nesting species.
In-water Turtle Survey	SCDNR	Al Sanders, SCDNR, MRD	NMFS/NOAA	Charleston shipping channel (ongoing)	Loggerhead sea turtle (<i>Caretta caretta</i>), green sea turtle (<i>Chelonia mydas</i>), Kemp's Ridley sea turtle (<i>Lepidochelys kempii</i>)
Artificial Reef Monitoring Survey	SCDNR	Bob Martore, SCDNR, MRD	USFWS (Dingle-Johnson)	Continental shelf and estuarine (ongoing)	Habitat for myriad marine invertebrates and vertebrates

AP 4: Existing Monitoring Programs
SC CWCP

Cobia Tagging	SCDNR	Don Hammond, SCDNR, MRD	Cooperative Fisheries Research Program (federal), Hilton Head Sport-fishing Club, Port Royal Conservancy	Port Royal Sound, Beaufort County (Jan 2005 – March 2006)	Cobia (<i>Rachycentron canadum</i>)
Dolphin Tagging	SCDNR	Don Hammond, SCDNR, MRD	NMFS/NOAA, Cooperative Fisheries Research Program (federal), private sport- fishers	Offshore of South Carolina, U.S. territorial Atlantic Ocean (Jan 2005 – March 2006)	Dolphinfish (<i>Coryphaena hippurus</i>)
Bill-fishing Survey	SCDNR	Tom DuPre, SCDNR, MRD	Govenor's Cup Bill-fishing Series participants	Offshore of South Carolina, U.S. territorial Atlantic Ocean (summer – fall, annual)	Billfishes (marlins, swordfish, sailfish), tunas, dolphinfish, wahoo
State Finfish Survey (recreational fishery creel survey at public access)	SCDNR	Bryan Stone, SCDNR, MRD	USFWS (Dingle-Johnson)	South Carolina Coastal Zone (annual)	Red drum (<i>Sciaenops ocellatus</i>), spotted seatrout (<i>Cynoscion nebulosus</i>), sheepshead (<i>Archosargus probatocephalus</i>), flounders (<i>Paralichthys</i> sps.)
Fisheries Statistics Survey	SCDNR	Nan Jenkins, SCDNR, MRD	NMFS/NOAA, Atlantic Coastal Cooperative Statistics Program (federal)	South Carolina Coastal Zone and U.S. territorial Atlantic Ocean (annual)	All commercial marine fishes and American shad (<i>Alosa sapidissima</i>), hickory shad (<i>Alosa mediocris</i>) and blueback herring (<i>Alosa aestivalis</i>)
Remote-sensing Oyster Mapping	SCDNR	Bob Van Dolah, SCDNR, MRD	NMFS/NOAA	South Carolina Coastal Zone (ongoing)	Eastern oyster (<i>Crassostrea virginica</i>)
State Shellfish Ground Assessment	SCDNR	Bill Anderson, SCDNR, MRD		South Carolina Coastal Zone (annual, spring & summer)	Eastern oyster (<i>Crassostrea virginica</i>), northern quahog (<i>Mercenaria mercenaria</i>), southern quahog (<i>Mercenaria campechiensis</i>)
Shellfish Culture Permit Monitoring	SCDNR	Bill Anderson, SCDNR, MRD	Shellfish culture/harvest permit holders	South Carolina Coastal Zone (annual)	Eastern oyster (<i>Crassostrea virginica</i>), northern quahog (<i>Mercenaria mercenaria</i>), southern quahog (<i>Mercenaria campechiensis</i>)

AP 4: Existing Monitoring Programs
SC CWCP

Shellfish Mariculture Permit Management	SCDNR	Bill Anderson, SCDNR, MRD	Shellfish mariculture permit holders	South Carolina Coastal Zone (annual)	Eastern oyster (<i>Crassostrea virginica</i>), northern quahog (<i>Mercenaria mercenaria</i>), southern quahog (<i>Mercenaria campechiensis</i>)
Public Shellfish Ground Planting and Restoration	SCDNR	Bill Anderson, SCDNR, MRD		South Carolina Coastal Zone (annual)	Eastern oyster (<i>Crassostrea virginica</i>), northern quahog (<i>Mercenaria mercenaria</i>), southern quahog (<i>Mercenaria campechiensis</i>)
Whelk Fishery Monitoring and Management	SCDNR	Bill Anderson, SCDNR, MRD	Whelk trawl fishery permit holders	South Carolina shallow Atlantic shelf (winter – spring, annual)	Knobbed whelk (<i>Busycon carica</i>), channeled whelk (<i>Busycotypus canaliculatus</i>)
Juvenile American Eel Survey	SCDNR	Mark Collins, SCDNR, MRD	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	Upper Goose Creek below Goose Creek Reservoir (late winter – early spring, annual)	American eel (<i>Anguilla rostrata</i>)
Shad Tagging	SCDNR	Mark Collins, SCDNR, MRD	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	Edisto, Santee and Waccamaw-Pee Dee Rivers (annual with three-year cycle per river)	American shad, hickory shad
Commercial Shad Fishery Monitoring	SCDNR	Mark Collins, SCDNR, MRD	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	All State waters (annual)	American shad, (<i>Alosa sapidissima</i>), hickory shad (<i>Alosa mediocris</i>)
Sturgeon Surveys	SCDNR	Mark Collins, SCDNR, MRD	NMFS/NOAA	Edisto and Savannah Rivers, Lake Marion (ongoing)	Shortnose sturgeon (<i>Acipenser brevirostrum</i>), Atlantic sturgeon (<i>Acipenser oxyrinchus</i>)
Marine Resources Monitoring, Assessment and Prediction (MARMAP) Program	SCDNR	Patrick Harris, SCDNR, MRD	NMFS/NOAA	Atlantic Ocean shelf and slope (high salinity estuaries for juvenile gag grouper recruitment study) (ongoing)	Benthic or bottom-dwelling marine fishes, primarily snappers and groupers, specifically gag (<i>Mycteroperca microlepis</i>)

AP 4: Existing Monitoring Programs
SC CWCP

South Carolina Estuarine and Coastal Assessment Program (SCECAP)	SCDNR	Bob Van Dolah, SCDNR, MRD	SCDHEC, USEPA, NOAA, USFWS	Coastal Zone estuaries Annual since 1999 through at least 2006	Measurement of water and sediment quality and related presence and diversity of marine invertebrates and fishes
Oceans and Human Health Initiative	SCDNR	Bob Van Dolah, SCDNR, MRD	NOAA, SCDHEC, MUSC, College of Charleston	Tidal creek habitats representing various levels of urban development. Semi annual to annual through 2007	Measurement of water and sediment quality, benthic and demersal invertebrate and fish communities, testing of new bioindicators of biota health using oysters.
SECOOS Fish Watch	SCDNR	Charlie Barans, SCDNR, MRD	NOAA, UNC-W, Univ. of Ga.	NC, SC, GA coastal waters. Ongoing	Underwater camera systems to document fish movements.
Southeast Area Monitoring and Assessment Program (SEAMAP)	SCDNR	Betty Wenner, SCDNR,MRD	NOAA, ASFMC,	NC,SC,GA coastal waters. Ongoing	Demersal finfish and invertebrate stock assessment and water quality measures
Inshore Recreational Finfish Surveys	SCDNR	Charlie Wenner, SCDNR, MRD	NOAA,	SC estuaries, ongoing	Monitoring the status of inshore recreational finfish species such as red drum (<i>Sciaenops ocellatus</i>), spotted seatrout, flounder, and other species.
Electrofishing finfish surveys	SCDNR	Betty Wenner, Charlie Wenner, SCDNR, MRD	ACE Basin, NOAA	SC tidal freshwater and oligohaline areas. Ongoing	Fish community sampling
Crustacean Monitoring Program	SCDNR	Betty Wenner, Larry DeLancey, SCDNR, MRD		SC estuaries and some nearshore sampling. Ongoing	Shrimp and crab population monitoring using fishery independent methods.
Monitoring of Shrimp Viral Disease	SCDNR	Craig Browdy, SCDNR, MRD	NOAA	Coastal waters, Beaufort, NC to Jacksonville, FL; through 2005	White shrimp (<i>Litopenaeus setiferus</i>)
Red Drum Stocking Assessment Program	SCDNR	Ted Smith, SCDNR, MRD	NOAA, SeaGrant	SC estuaries where red drum have been stocked	Monitoring the effectiveness of red drum (<i>Sciaenops ocellatus</i>) stocking approaches
Cooperative Atlantic States Shark Pupping and Nursery Survey	SCDNR	Glenn Ulrich, SCDNR,MRD	NMFS	SC coastal waters and estuaries, ongoing	Monitoring various shark species abundance and distribution.

AP 4: Existing Monitoring Programs
SC CWCP

Adult Red Drum Monitoring Program	SCDNR	Glenn Ulrich, SCDNR-MRD		SC coastal waters, ongoing	Monitoring adult red drum (<i>Sciaenops ocellatus</i>) populations in nearshore coastal ocean waters.
Harmful Algal Bloom Monitoring Program	SCDNR	Alan Lewitus, SCDNR, MRD and USC	Sea Grant, NOAA, CEC, SCDHEC, USC	SC estuarine and coastal waters including retention pond systems, ongoing	Monitoring of the distribution and abundance of phytoplankton, including harmful algal species, assessing effect on marine biota, assessing pathways of toxin transfer to eagles.
Folly Beach Renourishment Study	SCDNR	Bob Van Dolah, Martin Levisen, SCDNR-MRD	US Army Corps of Engineers	Folly Beach and nearshore waters, ongoing	Monitoring the impact of dredging and beach nourishment on invertebrate populations on beach and in nearshore zone.
Ocean Dredged Material Disposal Areas	SCDNR	Stacie Crowe, Bob Van Dolah SCDNR-MRD	US Army Corps of Engineers	Hard Bottom Reef Habitats adjacent to Charleston Ocean Disposal Area	Assessment of impacts of sediment movements on hard bottom reef habitats
<i>Federal Programs</i>					
Midwinter Waterfowl Survey	U.S. Fish & Wildlife Service	Carl Ferguson (USFWS); Walt Rhodes (SCDNR)	SCDNR	Coastal Counties, incl. Atl. Ocean & Santee Cooper Lakes	All waterfowl species/eagles
Breeding Bird Survey	USGS	Keith Pardieck	Surveys conducted by volunteers including DNR staff. Laurel Barnhill is the SC Statewide Coordinator.	U.S. and Canada total number of routes 4461. SC has 28 routes. Conducted during the breeding season.	All Birds
R8 Bird Point Counts	USFS	Gary Peters	Surveys conducted by USFS biologists	Francis-Marion Sumter National Forest Conducted during the breeding season	Landbirds

AP 4: Existing Monitoring Programs
SC CWCP

Red-cockaded Woodpecker Monitoring	USFWS	Ralph Costa	All agencies with Red-cockaded woodpeckers present on their lands. Nicole Chadwick coordinates monitoring efforts on state owned and private lands within SC.	Extent of red-cockaded range in accordance with recovery plan guidelines. SC program is statewide. Conducted throughout the year.	Red-cockaded Woodpecker
Flatwoods salamander	USFS	Robin Mackie	DNR	FMNF	
Webster's salamander	USFS	Robin Mackie	DNR	Sumter NF	
Isolated wetlands(Carolina Bays) and herps	DOE/ SREL	Whit Gibbons	DNR	SRS	
Marine Recreational Fisheries Statistical Survey	NMFS/NOAA			U.S. Coastwide, all estuarine and marine waters (annual)	All recreational species, including species taken from charter boats, head boats, piers and from shore
Charleston Dolphin Abundance and Distribution (CDAD) Survey	NOS/NOAA	Eric Zolman, NOS	NMFS/NOAA	Charleston Harbor, Cooper River, Wando River and Stono River (annual)	Bottlenose dolphin (Tursiops truncatus)
Health and Environmental Risk Assessment (HERA) Project	NOS/NOAA	Pat Fair, NOS	NMFS/NOAA, Harbor Branch Oceanographic Institute, SCDNR, Medical University of Couth Carolina, University of Miami, Mote Marine Laboratory, Mystic Aquariums, Cornell University	Charleston area, estuarine (annual)	Bottlenose dolphin (Tursiops truncatus)
Marine Mammal Stranding Survey	NOS/NOAA	Wayne McFee, NOS	NMFS/NOAA, SCDNR	Coastal Zone (annual)	All marine mammals

AP 4: Existing Monitoring Programs
SC CWCP

NMFS, Beaufort Laboratory, Cetacean and Sea Turtle (CAST) Survey	NMFS/NOAA	Aleta Hohn, NMFS	NOS/NOAA	Coastal Zone and Atlantic Ocean shelf (annual) - Southeast USA	Bottlenose dolphin (<i>Tursiops truncatus</i>) (stock structure and genetics)
Non-Federal Programs					
Monitoring Avian Productivity and Survivorship	Institute for Bird Populations	David DeSante	Volunteers including DNR staff. Lex Glover contact for SCDNR stations.	International (Canada, U.S. and Mexico). Conducted during the breeding season. Two DNR stations, Congaree NPS and McCrady. Other SC Stations: 1 operated by USFS.	Landbirds
Christmas Bird Count	Audubon	Local Audubon Chapters. Lex Glover coordinates Santee NWR and Winyah Bay counts.	Volunteers including DNR staff.	U.S. and Canada. Survey conducted in December.	All birds
Coastal Carolina Dolphin Abundance and Distribution Survey	Coastal Carolina University	Rob Young, CCU	NMFS/NOAA, NOS/NOAA	North Inlet and Winyah Bay, Georgetown County (estuarine) (annual)	Bottlenose dolphin (<i>Tursiops truncatus</i>)
UNC-W Dolphin Abundance and Distribution Survey	University of North Carolina - Wilmington	Peggy Sloan, UNC-W	NMFS/NOAA, NOS/NOAA	Bulls Bay and McClellanville (estuarine) (through September 2005)	Bottlenose dolphin (<i>Tursiops truncatus</i>)
Carolinas Coastal Ocean Observing and Prediction System (CaroCOOPS)	University of South Carolina, North Carolina State University	Madilyn Fletcher, USC	NOAA	North and South Carolina from beach to shelf break	Oceanographic data, some buoy arrays to have plankton and camera systems installed.

APPENDIX 5: NONEXHAUSTIVE LIST OF SCDNR PARTNERSHIPS AND EXISTING COLLABORATIVE AGREEMENTS

CWCS Development Participants

- Audubon Society
- Centers for Ocean Sciences Education Excellence
- Clemson University (and Clemson Extension)
- Coastal Conservation Association of South Carolina
- Congaree Land Trust
- Defenders of Wildlife
- Department of Health and Environmental Control
- Ducks Unlimited
- Eastern Carolina CDC of Florence, SC
- Edisto Island Open Land Trust
- Environmental Protection Agency
- Friends of Congaree Swamp
- Friends of the Edisto
- Friends of the Reedy River
- Historic Ricefield Association
- Home Builders Association of SC
- International Association of Fish and Wildlife Agencies
- Katawba Valley Land Trust
- Lowcountry Open Land Trust
- National Wild Turkey Federation
- Nation Ford Land Trust
- Natural Resource Conservation Service
- NatureServe
- National Oceanic and Atmospheric Administration
- National Estuarine Research Reserve
- Nemours Wildlife Foundation
- North American Waterfowl Conservation Act -- Committee (NAWCA)
- Organization of Wildlife Planners
- Palmetto Conservation Foundation
- Partners In Flight (Joint Ventures and Bird Conservation Regions)
- Pee Dee Land Trust
- Quality Deer Management Association
- Quail Unlimited
- River Alliance
- SC Aquarium
- SC Coastal Conservation League
- SC Conservation Association
- SC Conservation Land Bank
- SC Department of Health and Environmental Control

- SC Department of Transportation
- SC Environmental Economic Justice Development Network
- SC Environmental Law Project
- SC Environmental Watch
- SC Farm Bureau
- SC Forestry Commission
- SC Forest Watch
- SC Native Plant Society
- SC United Action
- SC Waterfowl Association
- SC Wildlife Federation
- Sierra Club (Wildlife and Endangered Species Committee, state chapter)
- Southern Environmental Law Center
- The Conservation Fund
- The Land Trust Alliance
- The Nature Conservancy
- The Wildlife Society
- Town of Blythewood, SC
- Trout Unlimited
- Trust for Public Land
- University of South Carolina – Aiken
- University of South Carolina – Baruch Laboratory
- University of South Carolina – Saulkehatchie
- Upper Savannah Land Trust
- Upstate Forever Land Trust
- USC Environmental Clinic
- US Forest Service
- US Public Interest Research Group
- Wildlife Action
- World Wildlife Fund
- State Environmental Resource Center

Nonexhaustive list of SCDNR Program Partnerships

- Atlantic Large Whale Take Reduction Team
- BASF Corporation
- Bottlenose Dolphin Take Reduction Team
- Catawba Indian Reservation
- Center for Coastal Environmental Health and Biomolecular Research
- Charleston Math and Science Hub
- Coastal Carolina University
- College of Charleston
- Crescent Resources
- Duke Power
- Georgia-Pacific

- Home Builders Association
- International Paper
- Mead-Westvaco
- Monsanto
- NOAA Fisheries
- Palmetto Agrobusiness Council
- Robust Redhorse Conservation Committee
- SC Air National Guard
- SC Association of Realtors
- SC Department of Education
- SC Poultry Association
- SC Realtors Land Institute
- SC Sporting Protection League
- SC Tourism Council
- Sea Turtle Stranding and Salvage Network
- South Atlantic Fishery Management Council
- South Carolina Aquarium
- South Carolina Sea Grant Consortium
- Southeastern Fisheries Science Center
- Southeastern Right Whale Recovery Plan Implementation Team
- U.S. Army Corps of Engineers
- University of Georgia

Land Trusts

- Aiken County Land Trust
- Beaufort County Open Land Trust
- Black Creek Land Trust
- Congaree Land Trust
- Edisto Island Open Land Trust
- Hilton Head Island Land Trust
- Katawba Valley Land Trust
- Kiawah Island Natural Habitat Conservancy
- Lord Berkeley Conservation Trust
- Lowcountry Open Land Trust
- Nation Ford Land Trust
- Naturaland Trust
- Pacolet Area Conservancy
- South Carolina Battleground Preservation Trust
- Spartanburg Conservation Endowment
- The Nature Conservancy
- Wetlands America Trust

Conservation and Reinvestment Act Supporters in South Carolina

- Aiken Audubon Society

- Aiken County Open Land Trust
- Airport Hunt Club
- Andrew Jackson State Park
- Artemis Hunt Club
- Augusta-Aiken Audubon Society
- BCSO Hunt Club
- Beaufort County Open Land Trust
- Beaufort County Parks & Leisure Services
- Berkeley Soil and Water Conservation District
- Beverly Quarles
- Black Oak Hunt Club
- Black River Chapter of the National Wild Turkey Fed.
- Broken Lake Club
- Buck Down Hunt Club
- Buck Head Hunt Club
- Buck Ridge Plantation
- Catawba Regional Planning Council
- Cedar Hill Hunt Club
- Cedar Ridge Farm
- Central Recreation Department
- Chapin Recreation Commission
- Cheraw Visitors Bureau
- Cherry Park Advisory Committee
- City of Anderson Parks and Recreation Department
- City of Isle of Palms
- City of North Augusta Parks & Recreation
- City of North Charleston
- City of Rock Hill
- City of Rock Hill Parks, Recreation & Tourism Dept.
- Columbia Audubon Society
- Congaree Land Trust
- Cornelia Carrier Gibbs
- Coum Creek Hunt Club
- County Council of Beaufort County
- Cox Hunt Club
- D. Lindsay Pettus Real Estate
- Davis Hunt Club
- Diachronic Research Foundation
- Discover Upcountry Carolina Association
- Ducks Unlimited-South Carolina Chapter
- Edisto Hunt Club
- Florence County Council
- Florence County Parks and Recreation
- Francis Beidler Forest, Audubon Center & Sanctuary
- Frank Brafman, Beaufort County Council
- Freshwater Fisheries Coalition

- Furtick Hunt Club
- Generation Green
- Glen Bishop
- Goose Creek Recreation Commission
- Gosnell Hunt Club
- Governor Jim Hodges
- Great Branch Hunt Club
- Green Gardeners
- Greenhouse Hunt Club
- Harold Prince
- Hayden Hunt Club
- Hood Creek Hunt Club
- Houser Farm Dove Club
- International Primate Protection League
- Iron Station Bow Hunters
- Isle of Palms/Sullivan's Island Loggerhead Sea Turtle Volunteers
- J & J Hunt Club
- Joint Recreation Commission for Lancaster County
- Kirkland/Carey
- Kirkland/Carey Hunt Club
- Lancaster Council on Garden Clubs
- Lancaster Garden Club
- Laurens County Parks, Recreation and Tourism Department
- Leaf and Petal Garden Club
- Leroy Springs & Company, Inc.
- Leysath Hunt Club
- Lowcountry & Resort Islands Tourism Commission
- Mayor of Edisto Beach
- Mayor of Hilton Head Island
- Mayor of Isle of Palms
- Mayor of Mount Pleasant
- Mayor of North Charleston
- Midlands Striped Bass Club
- Moore Hunt Club
- Morris Hunt Club
- Myrtle Beach Planning Commission
- Nation Ford Land Trust
- National Audubon Society-Columbia Audubon Society
- National Society of Park Resources
- North Edisto Hunt Club
- Old 96 District Tourism Commission
- Olde English District
- Other Club
- Palmetto Trails
- Paulling & James
- Pawley's Island Civic Association

- Pendleton District Commission
- Piedmont Hunt Club
- Pinewood Buck Masters
- Pocotaliga Hunt Club
- Port-Tronics
- Power Bay
- Quail Unlimited (Midlands Chapter)
- Rabun Creek Hunt Club
- Raines Hunt Club
- Ram Boy Hunt Club
- REAL TUF Sports of Swansea Mfg. Co., Inc.
- Red Oak Hunt Club
- Renegade Hunt Club
- Riverside Hunt Club
- Rock Hill Adult Softball Advisory Committee
- Rock Hill Area YMCA
- Rock Hill Youth Baseball Advisory Committee
- Rock Hill Youth Football Advisory Committee
- Rock Hill Youth Girls Softball Advisory Committee
- Rock Hill Youth Soccer Advisory Committee
- SanBar Forestry & Wildlife Services
- Santee Cooper Country Promotion Commission
- SC Chapter of The Wildlife Society
- SC Senior Sports Classic
- Shady Pine Rod & Game
- Shandon Hunt Club
- Smoak's
- South Carolina Coastal Conservation League
- South Carolina Coastal Zone Management Appellate Panel
- South Carolina Department of Natural Resources
- South Carolina Open Shooting Dog Championship
- South Carolina Sportsmen's Coalition
- South Carolina Wildlife Federation
- Southeastern Section of The Wildlife Society
- Stone Property Hunt Club
- Strauss Moore Shiple
- Summerton Gun Club
- Sumter & Lee Hunt Club
- Sumter County Fish & Game
- Talbert Hunt Club
- The Catawba Naturalist Association
- The Hitchcock Foundation
- The Wildlife Society-Clemson University Student Chapter
- The Wildlife Society-South Carolina Chapter
- Tindall Hunt Club
- Town of Cheraw

- Town of Edisto Beach
- Town of Hilton Head Island
- Town of Mount Pleasant
- Town of Prosperity
- Town of Summerville
- Trophy Management Hunt Club
- Trout Unlimited
- Turtle Rock Hunt Club
- Vercon Construction, Inc.
- W W Hunt Club
- Wade's Repair Service
- Walterboro-Colleton County Recreation Commission
- Wanda's Repair Service
- Wateree Dive Center
- Whipper Will Hunt Club
- White Feather Hunt Club
- White Rock Homeowners Association
- Whitmire Recreation Department
- Wild Birds Unlimited-N. Charleston
- Wildlife Action
- Wildlife Action, Inc. Cross Chapter
- Wildlife Action, Inc. Lowcountry Chapter
- Williams Farm Hunt Club
- Williams Sporting Goods

Reinvestment Act National Supporting Organizations

- 20/20 Vision
- American Bass Association, Inc.
- American Bird Conservancy
- American Birding Association
- American Coastal Coalition
- American Conservation Assoc., Inc.
- American Farmland Trust
- American Fisheries Society
- American Hiking Society
- American Lands
- American Ornithologists Union
- American Planning Association
- American Recreation Coalition
- American Rivers
- American Society of Ichthyologists
- American Wildlands
- American Wildlife Research Foundation
- American Zoo and Aquarium Assoc.
- Americans for Our Heritage & Recreation
- Americans for the Environment

- Archery Manufacturers and Merchants Org.
- Association for Biodiversity Information
- Association for Conservation Information
- Association of Field Ornithologists
- Association of Midwest Fish & Game Law Enforcement Officers
- B.A.S.S. Inc.
- Bat Conservation International
- Bluebird Recovery Committee
- Boone and Crockett Club
- Building Owners and Management Association (BOMA) International
- Businesses for the Northern Forest
- Center for the Study of Tropical Birds, Inc.
- Coast Alliance
- Coastal Conservation Society
- Coastal States Organization
- Conservation Opportunities Institute
- Cooper Ornithological Society
- Cornell Laboratory of Ornithology
- Delta Waterfowl Foundation
- Desert Fishes Council
- Ducks Unlimited, Inc.
- Endangered Species Coalition
- Environmental & Energy Study Institute
- Environmental Council of the States
- Federation of Western Outdoor Clubs
- Foundation for North American Wild Sheep
- Friends of the Earth
- Game Conservation International
- Greater Ecosystem Alliance
- Hawkwatch International
- Horned Lizard Conservation Society
- International Mountain Bicycling Association
- International Sonoran Antelope Foundation
- International Association for Bear Research & Management
- International Association of Fish and Wildlife Agencies
- International Society of Tropical Foresters, Inc.
- Izaak Walton League of America
- Keeping Track, Inc.
- Land Trust Alliance
- Lutheran Office for Governmental Affairs, Evangelical Lutheran Church in America
- Management Recruiters of Anderson
- Manomet Observatory
- Maryland Ornithological Society, Inc
- Midwest Raptor Research Fund
- Mississippi Interstate Cooperative Resource Association
- National Alliance of Gateway Communities

- National Assoc. of Conservation Districts
- National Assoc. of Police Athletic Leagues
- National Association of Counties
- National Association of Realtors
- National Association of State Foresters
- National Association of State Park Directors
- National Audubon Society
- National Council of Youth Sports
- National ECO Institute
- National Environmental Trust
- National Fish and Wildlife Foundation
- National League of Cities
- National Military Fish and Wildlife Association
- National Multi-Housing Council and National Apartment Association
- National Museum of Natural History/Smithsonian
- National Outdoor Leadership School
- National Park Trust
- National Parks Conservation Association
- National Recreation and Park Association
- National Rifle Association
- National Shooting Sports Foundation
- National Soccer Coaches Assoc. of America
- National Society of Park Resources
- National Trust for Historic Preservation
- National Wild Turkey Federation
- National Wildflower Research Center
- National Wildlife Federation
- National Wildlife Rehabilitators Association
- Native Fish Society
- National Association of State Outdoor Recreation Liaison Officers
- National Conference of State Historic Preservation Officers
- Natural Areas Association
- New England Governors' Association
- New England LWCF Coalition
- North American Association for Environmental Education
- North American Bluebird Society
- North American Country Trail Association
- North American Falconers' Association
- North American Fishing Club
- North American Hunting Club
- North American Loon Fund
- North American Wolf Society
- Organization for Fish and Wildlife Information Managers
- Outdoor Heritage Education Center, Inc.
- Outdoor Recreation Coalition of America
- Outside Magazine

- Pacific Seabird Group
- Partnership for the National Trails System
- Pennypack Ecological Restoration Trust
- Pheasants Forever, Inc.
- Physicians for Social Responsibility
- Pop Warner Little Scholars, Inc.
- Predator Defense Institute
- Preservation Action
- Public Lands Foundation
- Purple Martin Conservation Association
- Quail Unlimited
- Rainforest Alliance
- Raptor Research Foundation
- Republican Governors Association
- Rob & Bessie Welder Wildlife Foundation
- Rocky Mountain Elk Foundation
- Ruffed Grouse Society
- Saskatchewan Wetlands Conservation
- Society for the Study of Amphibians and Reptiles
- Soccer America
- Soccer in the Streets
- Soccer Industry Council of America
- Societas Biophilia
- Society for American Archaeology
- Society for Conservation Biology
- Society for Ecological Restoration
- Society of American Foresters
- Soil and Water Conservation Society
- Southeastern Fishes Council
- Southern Governors' Association
- Sporting Goods Manufacturers Association
- States Organization for Boating Access
- The Camp Fire Club of America
- The Chewonki Foundation
- The Conservation Fund
- The Ecological Society of America
- The Evangelical Environmental Network
- The General Federation of Women's Clubs
- The Humane Society of the United States
- The Institute for Bird Populations
- The Nature Conservancy
- The Ornithological Council
- The Prairie Enthusiasts
- The Raptor Center at the University
- The Ruffed Grouse Society
- The Trumpeter Swan Society

- The Trust for Public Land
- The Western States Land Commissioners Association
- The Wilderness Society
- The Wildfowl Trust of North America
- The Wildlife Legislative Fund of America
- The Wildlife Society
- Trout Unlimited
- U.S. Conference of Mayors
- U.S. Prairie Pothole Joint Venture
- Unitarian Universalist Association of Congregations
- United Hebrew Congregations of America
- United Methodist Church -- General Board of Church and Society
- Urban Wildlife Resources
- US Soccer Federation
- Watchable Wildlife, Inc.
- Western Hemisphere Shorebird Reserve Network
- Western Governors' Association
- Western Regional Environmental Education Council
- Wetlands for the Americas
- Whitetails Unlimited, Inc.
- Whooping Crane Conservation Association
- Wild Canid Survival & Research Center
- Wildlife Action, Inc.
- Wildlife Conservation Society
- Wildlife Forever
- Wildlife Habitat Council
- Wildlife Legislative Fund of America
- Wildlife Management Institute
- Wildlife Preservation Trust International
- Wilson Ornithological Society

APPENDIX 6: LIST OF ACRONYMS AND ABBREVIATIONS

ACE Basin	Ashepoo, Combahee and Edisto Rivers
ACGRP	Appalachian Cooperative Grouse Research Project
ACOE	Army Corps of Engineers
ALWTRT	Atlantic Large Whale Take Reduction Team
APHA	American Public Health Association
ASMFC	Atlantic States Marine Fisheries Commission
AVM	Avian Vacuolar Myelinopathy
BBS	Breeding Bird Survey
BCR	Bird Conservation Region
BDTRP	Bottlenose Dolphin Take Reduction Plan
BDTRT	Bottlenose Dolphin Take Reduction Team
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BRD	Bycatch Reduction Device
CCEHBR	Center for Coastal Environmental Health and Biomolecular Research
CITES	Convention on International Trade in Endangered Species (of Wild Fauna & Flora)
COASTSPAN	Cooperative Atlantic States Shark Pupping and Nursery Survey
CPUE	Catch Per Unit of Effort
CRBO	Cape Romain Bird Observatory
CRNWR	Cape Romain National Wildlife Refuge
CWS	Canadian Wildlife Service
DBH	Diameter Breast Height
DHEC	Department of Health and Environmental Control
DOE	Department of Energy
DPS	Distinct Population Segment
DTWG	Diamondback Terrapin Working Group
EDC	Endocrine Disrupting Chemical
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
EPT	Ephemeroptera, the mayflies; Plecoptera, the stoneflies; and Trichoptera, the caddis flies
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FLMNH	Florida Museum of Natural History
FMNF	Francis Marion National Forest
FMP	Fishery Management Plan
FSA	Farm Service Agency
GADNR	Georgia Department of Natural Resources
GIS	Geographic Information System
HABs	Harmful Algal Blooms

HAPC	Habitat Areas of Particular Concern
HIP	Harvest Information Program
IFMP	Interstate Fisheries Management Plan
ISS	International Shorebird Surveys
ITIS	Integrated Taxonomic Information System
IUCN	International Union for the Conservation of Nature and Natural Resources
LAL	Limulus Amoebocyte Lysate
LIP	Landowner Incentive Program
MARMAP	Marine Resources Monitoring, Assessment and Prediction
MARPOL	International Convention for the Prevention of Pollution from Ships
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MRFSS	Marine Recreational Fisheries Statistics Survey
MRRI	Marine Resources Research Institute
mtDNA	mitochondrial Deoxyribonucleic acid
MWS	Midwinter Waterfowl Survey
NABCI	North American Bird Conservation Initiative
NAWCA	North American Wetland Conservation Act (of 1989)
NAWMP	North American Waterfowl Management Plan
NCDENR	North Carolina Department of Environment and Natural Resources
NCSU	North Carolina State University
NCWRC	North Carolina Wildlife Resources Commission
NGO	Non-Governmental Organization
NGS	National Geographic Society
NMFS	National Marine Fisheries Service
NMFS FRP	National Marine Fisheries Service, Final Recovery Plan
NMP	Nutrient Management Plan
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Services
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
NWCO's	Pest Control and Wildlife Control Operators
NWR	National Wildlife Refuge
OCP	Outer Coastal Plain
OCRM	Ocean and Coastal Resource Management
ODMDS	Ocean Dredged Material Disposal Site
OFM	Office of Fisheries Management
OSP	Optimum Sustainable Population
PAH	Polycyclic Aromatic Hydrocarbon
PARC SE HMG	Partners in Amphibians and Reptile Conservation South Eastern Habitat Management Guidelines
PBR	Potential Biological Removal
PCB	Polychlorinated Biphenyl
PHEREC	Public Health Entomology Research & Education Center
PIF	Partners in Flight

PPT	Parts Per Thousand
QPX	Quahog Pathogen Unknown
RRCC	Robust Redhorse Conservation Committee
SAFMC	South Atlantic Fishery Management Council
SAMBI	South Atlantic Migratory Bird Initiative
SAV	Submerged Aquatic Vegetation
SC SRFSS	State Recreational Fisheries Statistics Survey
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCDOT	SC Dept of Transportation
SCECAP	South Carolina Estuarine and Coastal Assessment Program
SCR	Santee Coastal Reserve
SEAMAP	Southeast Area Monitoring and Assessment Program
SEAMAP-SA	Southeast Area Monitoring and Assessment Program – South Atlantic (Shallow Water Trawl Survey)
SEIT	Southeastern Right Whale Recovery Plan Implementation Team
SFA	Sustainable Fisheries Act
SHNWR	Carolina Sandhills National Wildlife Refuge
SMZ	Streamside Management Zones
SOD	Sudden Oak Death
SREL	Savannah River Ecological Laboratory
SRFAC	State Recreational Fisheries Advisory Committee
SRS	Savannah River Site
SRS-DOE	Savannah River Site – Dept of Energy
SR-USFS	Savannah River-U.S. Forest Service
TED	Turtle Excluder Device
TL	Total Length
TSRHP	Tillman Sand Ridge Heritage Preserve
UGA	The University of Georgia
UME	Unusual Mortality Event
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USSCP	U.S. Shorebird Conservation Plan
WCRP	World Climate Research Program
WHSRN	Western Hemisphere Shorebird Reserve Network
WMA	Wildlife Management Area
WNV	West Nile Virus
WRP	Wetlands Reserve Program
YONAH	Years of the North Atlantic Humpback
ZMRG	zero mortality rate goal

APPENDIX 7: TERRESTRIAL SPECIES HABITAT ASSOCIATION TABLE

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Acadian Flycatcher	Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Riverbanks, Stream-banks, and Alder Zones	Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
American Alligator		River Bottoms	River Bottoms	River Bottoms
American Kestrel		Oak-hickory Forest	Sandhills Pine Woodland	Pine Woodland Sandhill Pine Woodland
American Woodcock		Grassland & early Successional habitats River Bottoms	River Bottoms	Blackwater Stream Systems Grassland and early successional habitats River Bottoms
Appalachian Cottontail	Appalachian Oak & Oak-Pine Forest Low Elevation Acidic Mesic Forest Moist or wet types due to unique landform Vertical or Horizontal Rock Outcrop			
Bachman's Sparrow			Sandhills Pine Woodland	Pine Woodland Sandhill Pine Woodland
Bald Eagle				Hardwood Slopes and Stream Bottoms Upland Forest
Barn Owl		Grassland & early Successional habitats		Grassland and early successional habitats
Bewick's wren		Grassland & early Successional habitats		Grassland and early successional habitats
Bird-voiced Treefrog		River Bottoms	River Bottoms	River Bottoms
Black Bear		River Bottoms	River Bottoms	Hardwood Slopes and Stream Bottoms Pine Woodland River Bottoms Sandhill Pine Woodland Upland Forest
Black Swamp Snake		River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms
Black-throated Blue Warbler	Appalachian Oak & Oak-Pine Forest High-elevation Forest			
Black-throated Green Warbler ("Wayne's")		River Bottoms	River Bottoms	Hardwood Slopes and Stream Bottoms River Bottoms
Bog Turtle	Moist or wet types due to unique landform			
Broad-striped dwarf siren				Ponds and Depressions

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Brown-headed Nuthatch			Sandhills Pine Woodland	Pine Woodland Sandhill Pine Woodland
Carolina Gopher Frog			Ponds and Depressions	Ponds and Depressions
Chamberlain's dwarf salamander			Grassland and early successional habitats	Hardwood Slopes and Stream Bottoms Ponds and Depressions Upland Forest
Chestnut-sided Warbler	Appalachian Oak & Oak-Pine Forest High-elevation Forest			
Chicken Turtle			Ponds and Depressions	Ponds and Depressions
Coal Skink	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Common Ground-Dove				Grassland and early successional habitats
Common Raven	High-elevation Forest Vertical or Horizontal Rock Outcrop			
Common Snapping Turtle		River Bottoms	Ponds and Depressions River Bottoms	Ponds and Depressions River Bottoms
Coral snake			Sandhills Pine Woodland	
Dark-eyed Junco	High-elevation Forest Vertical or Horizontal Rock Outcrop			
Eastern Diamondback Rattlesnake				Pine Woodland Sandhill Pine Woodland
Eastern Fox squirrel		Oak-hickory Forest River Bottoms	River Bottoms Sandhills Pine Woodland	Hardwood Slopes and Stream Bottoms Pine Woodland River Bottoms Sandhill Pine Woodland Upland Forest
Eastern Meadowlark		Grassland & early Successional habitats		Grassland and early successional habitats
Eastern small-footed bat	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Riverbanks, Stream-banks, and Alder Zones Vertical or Horizontal Rock Outcrop			
Eastern Wood Peewee	Appalachian Oak & Oak-Pine Forest High-elevation Forest	Cove Forest Oak-hickory Forest	Blackwater Stream Systems Sandhills Pine Woodland	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms Upland Forest

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Eastern woodrat	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest	River Bottoms	River Bottoms Sandhills Pine Woodland	Grassland and early successional habitats Hardwood Slopes and Stream Bottoms Pine Woodland River Bottoms Sandhill Pine Woodland Upland Forest
Field Sparrow	Appalachian Oak & Oak-Pine Forest High-elevation Forest	Grassland & early Successional habitats		Grassland and early successional habitats
Flatwoods salamander				Ponds and Depressions
Florida Cooter			Ponds and Depressions	Ponds and Depressions
Florida Green Watersnake				Ponds and Depressions
Florida Softshell Turtle				Ponds and Depressions
Four-toed Salamander		Cove Forest		
Golden-crowned Kinglet	High-elevation Forest Low Elevation Acidic Mesic Forest			
Gopher Tortoise			Sandhills Pine Woodland	
Grasshopper Sparrow		Grassland & early Successional habitats		Grassland and early successional habitats
Great Blue Heron		Piedmont Small Stream Forest River Bottoms	Ponds and Depressions River Bottoms	Ponds and Depressions River Bottoms
Great Egret		Piedmont Small Stream Forest River Bottoms	Ponds and Depressions River Bottoms	Ponds and Depressions River Bottoms
Green Salamander	Appalachian Oak & Oak-Pine Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Gulf Coast Mud Salamander		River Bottoms	River Bottoms	Ponds and Depressions River Bottoms
Hairy-tailed mole	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest			
Hellbender	Riverbanks, Stream-banks, and Alder Zones			
Henslow's Sparrow				Pine Woodland Sandhill Pine Woodland
Jordan's Salamander	Low Elevation Basic Mesic Forest			
Kentucky Warbler	Appalachian Oak & Oak-Pine Forest	Cove Forest Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
Little Blue Heron		Piedmont Small Stream Forest River Bottoms	Ponds and Depressions River Bottoms	Ponds and Depressions River Bottoms

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Loggerhead Shrike	Appalachian Oak & Oak-Pine Forest	Grassland & early Successional habitats		Grassland and early successional habitats
Louisiana Waterthrush	Appalachian Oak & Oak-Pine Forest	Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
Masked shrew	High-elevation Forest Low Elevation Basic Mesic Forest			
Meadow Vole	Appalachian Oak & Oak-Pine Forest Moist or wet types due to unique landform	Grassland & early Successional habitats		Grassland and early successional habitats
Mimic Glass Lizard				Pine Woodland Sandhill Pine Woodland
Mink	Riverbanks, Stream-banks, and Alder Zones	Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms
Northern Bobwhite	Appalachian Oak & Oak-Pine Forest High-elevation Forest	Grassland & early Successional habitats	Sandhills Pine Woodland	Grassland and early successional habitats Pine Woodland Sandhill Pine Woodland
Northern cricket frog				Ponds and Depressions
Northern Yellow Bat		River Bottoms	River Bottoms	Hardwood Slopes and Stream Bottoms Pine Woodland River Bottoms Sandhill Pine Woodland Upland Forest
Painted Bunting				Grassland and early successional habitats
Peregrine Falcon	Vertical or Horizontal Rock Outcrop			
Pine barrens treefrog			Grassland and early successional habitats	
Pine Snake	Appalachian Oak & Oak-Pine Forest Vertical or Horizontal Rock Outcrop	Oak-hickory Forest	Sandhills Pine Woodland	
Pine Woods Snake		Oak-hickory Forest	Sandhills Pine Woodland	Pine Woodland Sandhill Pine Woodland
Prairie Warbler	Appalachian Oak & Oak-Pine Forest High-elevation Forest			
Pygmy shrew	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest			
Rafinesque's Big-eared Bat	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Vertical or Horizontal Rock Outcrop	River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems River Bottoms
Red Crossbill	High-elevation Forest Low Elevation Acidic Mesic Forest			

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Red-backed vole	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform Riverbanks, Stream-banks, and Alder Zones			
Red-breasted Nuthatch	High-elevation Forest Low Elevation Acidic Mesic Forest			
Red-cockaded woodpecker		Oak-hickory Forest	Sandhills Pine Woodland	Pine Woodland Sandhill Pine Woodland
River Cooter		Piedmont Small Stream Forest River Bottoms	River Bottoms	River Bottoms
Ruffed Grouse	High-elevation Forest Low Elevation Acidic Mesic Forest			
Rusty Blackbird	Riverbanks, Stream-banks, and Alder Zones	Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
Scarlet Tanager	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Basic Mesic Forest	Cove Forest Oak-hickory Forest		
Seepage Salamander	Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Shovel-nosed Salamander	Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Slender Glass Lizard	Appalachian Oak & Oak-Pine Forest			Pine Woodland Sandhill Pine Woodland
Southeastern Bat		River Bottoms	Ponds and Depressions River Bottoms Blackwater Stream Systems	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms Ponds and Depressions River Bottoms Upland Forest
Southern dusky salamander			Grassland and early successional habitats	Hardwood Slopes and Stream Bottoms Ponds and Depressions Upland Forest
Southern Hognose Snake		Grassland & early Successional habitats	Sandhills Pine Woodland	
Spiny Softshell Turtle		Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems River Bottoms
Spotted skunk	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest			
Spotted Turtle		River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms

SPECIES	BLUE RIDGE	PIEDMONT	SANDHILLS	COASTAL PLAIN
Star-nosed Mole	Moist or wet types due to unique landform Riverbanks, Stream-banks, and Alder Zones	River Bottoms	River Bottoms	Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
Striped Mud Turtle				River Bottoms
			River Bottoms	
		River Bottoms		
Swainson's Warbler	Low Elevation Acidic Mesic Forest	River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms River Bottoms Upland Forest
Swallow-tailed Kite				Hardwood Slopes and Stream Bottoms Upland Forest
Swamp Rabbit		Piedmont Small Stream Forest		
Tiger salamander		Piedmont Small Stream Forest	Ponds and Depressions	Ponds and Depressions
Timber Rattlesnake	Appalachian Oak & Oak-Pine Forest Vertical or Horizontal Rock Outcrop			
Timber Rattlesnake Wood Frog	High-elevation Forest			
Upland chorus frog				Ponds and Depressions
Webster's salamander		Cove Forest		
Wood Duck		River Bottoms	Blackwater Stream Systems River Bottoms	Blackwater Stream Systems River Bottoms
Wood Frog	High-elevation Forest Appalachian Oak & Oak-Pine Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Wood Thrush	Appalachian Oak & Oak-Pine Forest High-elevation Forest Low Elevation Basic Mesic Forest	Cove Forest Oak-hickory Forest Piedmont Small Stream Forest	Blackwater Stream Systems Sandhills Pine Woodland	Blackwater Stream Systems Hardwood Slopes and Stream Bottoms Upland Forest
Woodland jumping mouse	Appalachian Oak & Oak-Pine Forest Low Elevation Acidic Mesic Forest Low Elevation Basic Mesic Forest Moist or wet types due to unique landform			
Worm-eating Warbler	Appalachian Oak & Oak-Pine Forest			Hardwood Slopes and Stream Bottoms Upland Forest
Yellowbelly Turtle		Piedmont Small Stream Forest	Ponds and Depressions	Ponds and Depressions
Yellow-crowned Night-Heron		Piedmont Small Stream Forest River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms	Blackwater Stream Systems Ponds and Depressions River Bottoms

APPENDIX 8: MARINE SPECIES HABITAT ASSOCIATIONS

TABLE AP 8 – 1: Marine Invertebrate Species Habitat Associations

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Acanthohaustorius intermedius</i>					X	X	
<i>Acanthohaustorius millsi</i>				X	X	X	
<i>Americhelidium americanum</i>					X		
<i>Americorchestia longicornis</i>	Common Atlantic sandhopper			X			
<i>Americorchestia megalophthalma</i>	Northern big-eyed sandhopper					X	
<i>Americorophium aquafusum</i>					X		
<i>Ameroculodes edwardsi</i>					X	X	
<i>Ampelisca abdita</i>				X	X		X
<i>Ampelisca vadorum</i>				X	X		
<i>Ampelisca verrilli</i>					X		X
<i>Amphiporeia virginiana</i>						X	X
<i>Ampithoe valida</i>				X	X	X	
<i>Apocorophium acutum</i>				X	X		
<i>Apocorophium lacustre</i>			X	X	X		
<i>Apocorophium simile</i>			X	X	X		
<i>Atylus minikoi</i>					X	X	
<i>Batea catharinensis</i>					X		X
<i>Bathyporeia parkeri</i>					X	X	
<i>Bemlos unicornis</i>					X	X	X
<i>Caprella equilibra</i>				X	X		
<i>Caprella penantis</i>				X	X		X
<i>Cerapus tubularis</i>				X	X		X
<i>Colomastix halichondriae</i>					X		X
<i>Cymadusa compta</i>				X	X	X	
<i>Dulichella appendiculata</i>					X		X
<i>Elasmopus levis</i>					X		X
<i>Eobrolgus spinosus</i>					X		X
<i>Erichthonius brasiliensis</i>					X		X
<i>Eudevenopus honduranus</i>					X		X
<i>Gammaropsis sutherlandi</i>					X	X	X
<i>Gammarus daiberi</i>		X	X	X	X		
<i>Gammarus mucronatus</i>				X	X		
<i>Gammarus palustris</i>				X	X		
<i>Gammarus tigrinus</i>			X		X		
<i>Gitanopsis tortugae</i>				X	X	X	

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Globosolembos smithi					X		X
Haustorius canadensis						X	
Haustorius longirostris						X	
Hyale plumulosa						X	
Hyalella azteca			X				
Incisocalliope aestuarius				X	X		
Jassa marmorata				X	X		
Lembos hypacanthus					X	X	X
Lepidactylus dytiscus				X	X		
Leucothoe spinicarpa			X	X	X		X
Listriella barnardi					X		X
Listriella clymenellae					X		X
Lysianopsis alba	Gravel scud				X		X
Maera caroliniana					X		X
Maera williamsi							X
Melita nitida					X		X
Metharpinia floridana					X		X
Microprotopus raneyi							X
Microprotopus shoemakeri					X		
Monocorophium acherusicum				X	X		
Monocorophium tuberculatum					X		
Neohaustorius biarticulatus						X	
Neohaustorius schmitzi						X	
Orchestia grillus				X	X		
Paracaprella tenuis					X		X
Parahaustorius longimerus				X	X	X	
Parhyale hawaiiensis				X	X		
Photis pugnator							X
Protohaustorius deichmannae					X	X	X
Pseudohaustorius caroliniensis				X	X		
Rhepoxynius epistomus					X		X
Rhepoxynius hudsoni					X		X
Sextonia sp. A				X	X		
Stenothoe georgiana				X	X		
Stenothoe minuta					X		
Stenothoe valida					X		
Uhlorchestia spartinophila				X	X		
Uhlorchestia uhleri		X	X	X	X		
Unciola dissimilis					X	X	
Unciola irrorata					X	X	

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Unciola serrata					X	X	
Aplidium constellatum					X		X
Aplidium stellatum	Sea pork				X		X
Archidistoma aggregatum					X	X	
Ascidia interrupta	Interrupted tunicate				X	X	
Clavelina oblonga	Oblong tunicate				X	X	X
Didemnum candidum					X		X
Diplosoma macdonaldi					X		X
Distaplia bermudensis	Mottled encrusting tunicate				X		X
Ecteinascidia turbinata	Mangrove tunicate				X		X
Eudistoma carolinense					X	X	X
Eudistoma hepaticum					X	X	X
Molgula manhattensis	Sea grape				X	X	
Molgula occidentalis	Western sea squirt; Sandy sea squirt				X	X	X
Perophora viridis	Green colonial tunicate; Creeping tunicate				X	X	X
Styela partita	Divided tunicate				X		X
Styela plicata	Pleated sea squirt; Leathery tunicate				X		X
Glottidia pyramidata							X
Branchiostoma sp.					X		X
Balanus eburneus	Ivory barnacle			X	X		
Balanus improvisus	Bay barnacle				X	X	X
Balanus subalbidus		X	X				
Balanus venustus					X	X	X
Chelonibia patula	Crab barnacle			X	X	X	X
Chelonibia testudinaria	Turtle barnacle				X	X	X
Chthamalus fragilis	Fragile star barnacle			X	X	X	
Conopea galeata					X	X	X
Lepas anatifera	Smooth goose-neck barnacle; Tropical goose barnacle					X	X
Octolasmis mulleri			X		X	X	X
Aiptasia erupaurantia				X	X	X	X
Aiptasia pallida	Pale anemone			X	X	X	X
Amphinema dinema				X	X		
Astrangia poculata					X		X
Aurelia aurita	Moon jelly				X	X	X
Bimeria brevis					X		
Bougainvillia rugosa					X	X	X
Bunodosoma cavernata	Warty sea anemone; American warty anemone					X	X
Calliactis tricolor	Hitchhiking anemone; Tricolor anemone				X	X	X
Ceriantheopsis americanus	American tube-dwelling anemone				X		
Chiropsalmus quadrimanus	Multi-tentacled sea wasp				X	X	X

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf Shallow Atlantic Shelf
<i>Chrysaora quinquecirrha</i>	Sea nettle				X	X
<i>Clytia coronata</i>					X	
<i>Clytia cylindrica</i>						X
<i>Clytia hemispherica</i>					X	X
<i>Clytia kincaidi</i>					X	X
<i>Cyanea capillata</i>	Lion's mane jellyfish				X	X
<i>Dynamena cornicina</i>					X	X
<i>Ectopleura dumortieri</i>					X	
<i>Edwardsia leidy</i>				X	X	
<i>Eudendrium carneum</i>	Pink hydroid			X	X	X
<i>Eudendrium ramosum</i>				X	X	X
<i>Eudendrium tenellum</i>				X	X	X
<i>Garveia franciscana</i>					X	X
<i>Garveia humilis</i>					X	X
<i>Halecium gracile</i>					X	
<i>Halecium tenellum</i>				X	X	X
<i>Haloclava producta</i>				X	X	
<i>Halocordyle disticha</i>	Christmas tree hydroid				X	X
<i>Hebella scandens</i>					X	X
<i>Hydractinia echinata</i>	Hermit crab hydroid; Snail fur			X	X	X
<i>Leptogorgia virgulata</i>	Colorful sea whip				X	X
<i>Linvillea agassizi</i>					X	X
<i>Lovenella gracilis</i>						X
<i>Obelia bidentata</i>					X	
<i>Obelia dichotoma</i>				X	X	X
<i>Obelia geniculata</i>						X
<i>Oculina arbuscula</i>	a bush coral					X
<i>Paranthus rapiformis</i>	Onion anemone					X
<i>Paysa quadridentata</i>					X	
<i>Plumularia floridana</i>				X	X	
<i>Renilla reniformis</i>	Common sea pansy				X	X
<i>Rhopilema verrilli</i>	Mushroom jelly					X
<i>Schizotricha tenella</i>					X	X
<i>Stomolophus meleagris</i>	Cannonball jellyfish; Cabbagehead jelly; Jellyball				X	X
<i>Tamoya haplonema</i>	Sea wasp					X
<i>Telesto fruticulosa</i>	Orange telesto (octocoral)					X
<i>Titanideum frauenfeldii</i>	Brilliant sea fingers (octocoral)					X
<i>Tridentata distans</i>						X
<i>Tubularia crocea</i>					X	
<i>Turritopsis nutricula</i>					X	

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Acartia tonsa					X	X	X
Euterpina acutifrons					X	X	
Paracalanus crassirostris					X		
Pseudodiaptomus coronatus					X		
Tortanus setacaudatus							X
Mnemiopsis leidyi			X		X	X	X
Cyclaspis pustulata					X	X	X
Cyclaspis unicornis							X
Cyclaspis varians					X		X
Leucon americanus					X		
Mancocuma altera					X	X	
Oxyurostylis smithi					X	X	X
Spilocuma watlingi					X	X	
Acetes americanus					X	X	X
Albunea catherinae							X
Alpheus armillatus	Banded snapping shrimp				X		
Alpheus heterochaelis	Green snapping shrimp; Common snapping shrimp			X	X		
Alpheus normanni	Bigclaw snapping shrimp				X		X
Arenaeus cribrarius	Speckled swimming crab				X	X	X
Armases cinereum	Squareback marsh crab			X		X	
Austinia cristata	Cristate pea crab				X	X	X
Biffarius biformis	Biform ghost shrimp				X	X	X
Callichirus major	Carolinian ghost shrimp						X
Callinectes exasperatus	Rugose swimming crab				X		X
Callinectes larvatus	Masked swimming crab				X		X
Callinectes sapidus	Blue crab		X		X	X	X
Callinectes similis	Lesser blue crab				X		X
Cancer irroratus	Atlantic rock crab				X		X
Clibanarius vittatus	Thinstripe hermit crab; Green-stripe hermit crab			X	X	X	X
Cryptodromiopsis antillensis	Decorator crab				X		X
Dissodactylus mellitae	Sand-dollar pea crab					X	X
Dyspanopeus sayi	Say mud crab			X	X		
Emerita talpoida	Atlantic sand crab; Common mole crab					X	
Eucramus praelongus	Olivepit porcelain crab					X	X
Eurypanopeus depressus	Flatback mud crab; Depressed mud crab			X	X		
Eurytium limosum	Broadback mud crab; Mangrove mud crab			X	X		
Exhippolysmata oplophoroides	Cock shrimp; Redleg humpback shrimp				X		
Farfantepenaeus aztecus	Brown shrimp		X		X		X
Farfantepenaeus duorarum	Pink shrimp; Northern pink shrimp		X		X		X
Gilvossius setimanus					X	X	X

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
<i>Hepatus epheliticus</i>	Calico box crab; Shame faced crab; Gulf calico crab				X	X	X
<i>Hexapanopeus angustifrons</i>	Smooth mud crab			X	X		
<i>Hippolyte zostericola</i>	Zostera shrimp; Eelgrass broken-back shrimp				X		X
<i>Hypoconcha arcuata</i>	Granulate shellback crab						X
<i>Hypoconcha parasitica</i>	Rough shellback crab						X
<i>Latreutes fucorum</i>	Slender sargassum shrimp				X		X
<i>Latreutes parvulus</i>	Sargassum shrimp				X		X
<i>Leander tenuicornis</i>	Brown glass shrimp				X		X
<i>Lepidopa websteri</i>	Webster's mole crab				X	X	X
<i>Leptalpheus forceps</i>	Forceps shrimp						X
<i>Leptochela serratorbita</i>	Combclaw shrimp				X		X
<i>Libinia dubia</i>	Longnose spider crab; Southern spider crab				X		X
<i>Libinia emarginata</i>	Portly spider crab; Common spider crab				X		X
<i>Litopenaeus setiferus</i>	White shrimp; Northern white shrimp		X		X		X
<i>Lucifer faxoni</i>					X		X
<i>Lysmata wurdemanni</i>	Peppermint shrimp; Veined shrimp				X		X
<i>Macrobrachium acanthurus</i>	Cinnamon river shrimp		X				
<i>Macrobrachium ohione</i>	Ohio river shrimp		X				
<i>Macrobrachium olfersii</i>	Bristled river shrimp		X				
<i>Megalobrachium soriatum</i>	Pentagonal porcelain crab						X
<i>Menippe mercenaria</i>	Florida stone crab			X	X	X	X
<i>Metoporphaphis calcarata</i>	False arrow crab; Gulf arrow crab				X		
<i>Neopontonides beaufortensis</i>	Seawhip shrimp				X		X
<i>Ocypode quadrata</i>	Atlantic ghost crab					X	
<i>Ogyrides alphaerostris</i>	Estuarine longeye shrimp				X	X	X
<i>Ogyrides hayi</i>	Sand longeye shrimp				X	X	X
<i>Ovalipes ocellatus</i>	Lady crab; Ocellate lady crab				X	X	X
<i>Ovalipes stephensoni</i>	Coarsehand lady crab				X	X	X
<i>Pachygrapsus transversus</i>	Mottled shore crab; Common shore crab			X		X	
<i>Pagurus annulipes</i>	Banded dwarf hermit crab				X		X
<i>Pagurus carolinensis</i>	Worm reef hermit crab				X		X
<i>Pagurus longicarpus</i>	Long-armed hermit; Longwrist or Long-clawed hermit			X	X		X
<i>Pagurus pollicaris</i>	Flatclaw hermit crab; Gray hermit crab			X	X		X
<i>Palaemonetes intermedius</i>	Brackish grass shrimp		X		X		
<i>Palaemonetes pugio</i>	Daggerblade shrimp		X		X		
<i>Palaemonetes vulgaris</i>	Marsh grass shrimp		X		X		
<i>Panopeus herbstii</i>	Atlantic mud crab; Common mud crab		X	X	X		
<i>Panopeus obesus</i>	Saltmarsh mud crab		X	X	X		
<i>Panulirus argus</i>	Caribbean spiny lobster				X		X
<i>Pelid mutica</i>	Cryptic teardrop crab; Humpback or Red-spotted spider crab				X		X

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
<i>Periclimenes americanus</i>	American grass shrimp				X		X
<i>Periclimenes iridescent</i>	Iridescent shrimp				X		X
<i>Periclimenes longicaudatus</i>	Longtail grass shrimp				X		X
<i>Persephona aquilonaris</i>					X		X
<i>Persephona mediterranea</i>	Mottled purse crab; Purse crab				X		X
<i>Petrochirus diogenes</i>	Giant hermit crab; Red hermit crab				X		X
<i>Petrolisthes galathinus</i>	Banded porcelain crab; Lined porcelain crab				X	X	X
<i>Pilumnus sayi</i>	Spineback hairy crab; Hairy wharf crab				X		X
<i>Pinnixa chaetoptera</i>	Tube pea crab; Parchment-worm pea crab				X	X	X
<i>Pinnixa lunzi</i>	Lunz pea crab				X		
<i>Pinnixa retinens</i>					X		
<i>Pinnixa sayana</i>					X		X
<i>Polyonyx gibbesi</i>	Eastern tube crab				X		X
<i>Porcellana sayana</i>	Spotted porcelain crab				X		X
<i>Portunus gibbesii</i>	Iridescent swimming crab				X		X
<i>Portunus sayi</i>	Sargassum swimming crab				X		X
<i>Portunus spinimanus</i>	Blotched swimming crab				X		X
<i>Rhithropanopeus harrisii</i>	Estuarine mud crab; Harris mud crab		X	X	X		
<i>Rimopenaeus constrictus</i>	Roughneck shrimp				X	X	X
<i>Sesarma reticulatum</i>	Heavy marsh crab; Purple marsh crab	X	X	X	X		
<i>Sicyonia laevigata</i>	Coral shrimp; Hardback; Rock shrimp				X		X
<i>Speocarcinus carolinensis</i>	Carolinian squareback crab				X		X
<i>Synalpheus fritzmuelleri</i>	Speckled snapping shrimp				X		X
<i>Thor floridanus</i>	Bryozoan shrimp				X		X
<i>Tozeuma carolinense</i>	Arrow shrimp				X		X
<i>Tumidotheres maculatus</i>	Squatter pea shrimp				X		X
<i>Uca minax</i>	Red-jointed fiddler crab	X	X	X			
<i>Uca pugilator</i>	Atlantic sand fiddler crab	X	X	X			
<i>Uca pugnax</i>	Mud fiddler crab; Atlantic marsh fiddler	X	X	X			
<i>Upogebia affinis</i>	Coastal mud shrimp				X	X	
<i>Xiphopenaeus kroyeri</i>	Atlantic seabob				X		X
<i>Zaops ostreum</i>	Oyster pea crab			X	X		
<i>Amphiodia atra</i>					X		
<i>Amphioplus abditus</i>					X		X
<i>Amphipholis gracillima</i>					X		
<i>Arbacia punctulata</i>	Purple-spined sea urchin; Brown rock urchin					X	X
<i>Asterias forbesii</i>	Forbes' sea star					X	X
<i>Axiognathus squamatus</i>					X	X	X
<i>Echinaster brasiliensis</i>						X	X
<i>Hemipholis elongata</i>	Burrowing brittle star			X	X		

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Leptosynapta tenuis</i>					X		
<i>Luidia clathrata</i>	Lined sea star; Striped sea star; Netted sea star				X	X	X
<i>Lytechinus variegatus</i>	Green sea urchin; Variegated urchin				X	X	X
<i>Mellita isometra</i>	Sand dollar					X	X
<i>Moira atropos</i>	Heart urchin; Mud urchin						X
<i>Ophioderma brevispinum</i>	Short spined brittle star; Short-armed brittle star				X		X
<i>Ophiophragmus wurdemanni</i>	Mud brittle star				X	X	
<i>Ophiothrix angulata</i>	Angular brittle star				X		X
<i>Pentamera pulcherrima</i>							X
<i>Pseudothyone belli</i>	Hidden sea cucumber					X	X
<i>Sclerodactyla briareus</i>	Hairy sea cucumber				X	X	X
<i>Thyonella gemmata</i>	Striped sea cucumber			X	X	X	
<i>Thalassema hartmani</i>				X	X		
<i>Aeверrillia armata</i>					X	X	X
<i>Aeверrillia setigera</i>					X	X	X
<i>Alcyonidium hauffi</i>	Hauff's alcyonidium				X	X	X
<i>Amathia convoluta</i>	Common sheep's-wool bryozoan				X	X	X
<i>Amathia distans</i>	Delicate sheep's-wool bryozoan				X	X	X
<i>Amathia vidovici</i>					X		
<i>Anguinella palmata</i>	Muddy-tuft bryozoan				X	X	X
<i>Bowerbankia gracilis</i>					X	X	X
<i>Bowerbankia imbricata</i>					X	X	X
<i>Bugula fulva</i>					X	X	X
<i>Bugula neritina</i>	Purple tuft bryozoan; Common bugula				X	X	X
<i>Bugula stolonifera</i>					X	X	X
<i>Conopeum seurati</i>					X		
<i>Conopeum tenuissimum</i>					X		
<i>Crisia eburnea</i>					X	X	X
<i>Cryptosula pallasiana</i>					X	X	X
<i>Cupuladria doma</i>							X
<i>Discoporella umbellata</i>							X
<i>Electra monostachys</i>					X	X	X
<i>Hippoporidra janthina</i>						X	X
<i>Hippoporina verrilli</i>					X		
<i>Membranipora arborescens</i>				X	X		
<i>Membranipora tenuis</i>	Common sea mat				X	X	X
<i>Nolella stipata</i>					X	X	X
<i>Parasmittina nitida</i>	Toothed crust bryozoan			X	X		
<i>Schizoporella errata</i>	Variable crust bryozoan						X
<i>Schizoporella unicornis</i>				X	X	X	X

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Sundanella sibogae					X	X	X
Synnotum aegyptiacum						X	X
Thalamoporella floridana	Lettuce bryozoan				X	X	X
Triticella elongata					X	X	X
Zoobotryon verticillatum					X		
Barentsia laxa					X	X	X
Loxosomella cricketae					X		
Loxosomella tethyae					X		
Pedicellina cernua					X	X	X
Balanoglossus aurantiacus	Golden acorn worm			X	X		
Balanoglossus gigas					X		
Saccoglossus kowalevskii					X		
Schizocardium brasiliense					X		
Calliobdella vivida					X	X	X
Anurida maritima	Seashore springtail			X			
Telmatogeton japonicus				X			
Aegathoa oculata					X		X
Amakusanthura magnifica					X		
Ancinus depressus					X	X	
Cassidinidea ovalis					X	X	
Chiridotea almyra					X	X	
Chiridotea arenicola					X	X	
Chiridotea caeca	Beach sowbug				X	X	
Cleantioidea planicauda			X		X		
Cyathura burbancki					X		X
Cyathura polita			X		X		
Edotia triloba				X	X	X	X
Erichsonella filiformis	Seaweed sowbug				X		X
Exosphaeroma diminutum					X	X	X
Idotea balthica					X		X
Jaeropsis rathbunae						X	X
Kupellonura formosa					X		X
Livoneca redmanii					X	X	X
Livoneca reniformis					X	X	X
Paracerceis caudata					X	X	
Probopyrinella latreuticola							X
Pseudione upogebiae					X	X	
Sphaeroma quadridentatum					X	X	
Abra aequalis	Atlantic abra				X		X
Acteocina canaliculata	Channeled barrel-bubble			X	X	X	

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
<i>Acteocina candeii</i>							X
<i>Aligena elevata</i>	Eastern aligena				X		
<i>Anadara brasiliana</i>	Incongruous ark						X
<i>Anadara ovalis</i>	Blood ark				X		X
<i>Anadara transversa</i>	Transverse ark				X		X
<i>Ancula evelinae</i>				X	X		
<i>Anisodoris prea</i>					X		
<i>Anomia simplex</i>	Common jingle				X	X	X
<i>Aplysia brasiliana</i>	Mottled seahare; Sooty seahare				X	X	X
<i>Armina tigrina</i>	Tiger armina				X		X
<i>Astyris lunata</i>	Lunar dovesnail			X	X	X	X
<i>Bankia gouldii</i>	Cupped shipworm; Gould shipworm				X		
<i>Barnea truncata</i>	Atlantic mud piddock; Truncate borer				X		
<i>Berghia bentvea</i>				X	X	X	X
<i>Berghia coerulescens</i>				X	X	X	X
<i>Boonea impressa</i>	Impressed odostome			X	X		
<i>Boonea seminuda</i>	Half-smooth odostome			X	X		
<i>Brachidontes exustus</i>	Scorched mussel			X	X	X	X
<i>Busycon carica</i>	Knobbed whelk			X	X		X
<i>Busycon sinistrum</i>	Lightning whelk						X
<i>Busycotypus canaliculatus</i>	Channeled whelk			X	X		X
<i>Calliostoma euglyptum</i>	Sculptured topsnail; Florida top shell				X	X	X
<i>Calliostoma pulchrum</i>	Beautiful topsnail; Beautiful top shell						X
<i>Catriona perca</i>					X	X	X
<i>Cerithiopsis emersoni</i>	Emerson's cerith				X	X	X
<i>Cerithiopsis greeni</i>	Green's cerith				X	X	X
<i>Chaetopleura apiculata</i>	Eastern bearded chiton; Bee chiton; Common eastern chiton				X	X	X
<i>Chama congregata</i>	Corrugate jewelbox					X	X
<i>Chione elevata</i>				X	X		
<i>Chione grus</i>	Gray pygmy venus; Gray pygmy chione			X	X	X	
<i>Cochliolepis parasitica</i>	Parasitic scalesnail				X		
<i>Corbula contracta</i>	Contracted corbula				X		X
<i>Corbula swiftiana</i>	Radial-ridged corbula; Swift corbula				X		
<i>Costoanachis avara</i>	Greedy dovesnail			X	X	X	X
<i>Costoanachis lafresnayi</i>	Well-ribbed dovesnail				X		X
<i>Crassinella martinicensis</i>	Martinique crassinella				X		X
<i>Crassostrea virginica</i>	Eastern oyster			X	X	X	X
<i>Cratena pilata</i>					X		
<i>Crepidula fornicata</i>	Common Atlantic slippersnail			X	X	X	X
<i>Crepidula plana</i>	Eastern white slippersnail; Flat slipper snail			X	X	X	X

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Cumingia tellinoides	Tellin semele			X	X		
Cyclostremiscus pentagonus				X	X		
Cyrtopleura costata	Angelwing				X	X	X
Dinocardium robustum	Atlantic giant cockle						X
Diodora cayenensis	Cayenne keyhole limpet; Little keyhole limpet			X	X	X	X
Diplodonta punctata	Atlantic diplodon				X		
Diplothyra smithii	Oyster piddock			X	X	X	
Divaricella quadrisulcata	Cross-hatched lucine				X		
Donax variabilis	Variable coquina (delete clam)				X	X	
Dondice occidentalis	Western dondice				X	X	
Doridella obscura	Obscure corambe			X	X	X	
Doriopsilla pharpha	Lemon drop			X	X		
Doris verrucosa	Sponge slug				X		
Dosinia discus	Disk dosinia; Disk shell; Disk clam				X	X	
Doto sp. A					X	X	
Ensis directus	Atlantic jackknife clam; Common razor clam				X	X	X
Entovalva sp. A					X		X
Entovalva sp. B					X		X
Epitonium multistriatum	Many-ribbed wentletrap; Crowded wentletrap				X		X
Ercolania fuscata	Dusky stiliger				X		
Ervilia concentrica	Concentric ervilia						X
Eupleura caudata	Thick-lip drill			X	X		
Fargoa bushiana					X		
Fargoa dianthophila	Serpulid odostome			X	X	X	
Fasciolaria hunteria	Banded tulip			X	X	X	X
Fiona pinnata	Fiona				X		
Gemma gemma	Amethyst gemclam			X	X		
Geukensia demissa	Ribbed mussel			X	X		
Kurtziella limonitella	Punctate mangelia				X		
Learchis poica				X	X	X	
Lepton sp. A					X		
Lima pellucida	Antillean fireclam; Inflated file shell			X	X		X
Lithophaga bisulcata	Mahogany datemussel; Two-furrowed datemussel			X	X		X
Littoraria irrorata	Marsh periwinkle			X	X		
Littoridinops monroensis	Cockscomb hydrobe	X	X	X	X		
Lolliguncula brevis	Atlantic brief squid; Brief thumbstall squid				X	X	X
Lomanotus sp. A				X	X		
Lyonsia (Entodesma) beana	Pearly lyonsia					X	
Lyonsia (Entodesma) hyalina	Glassy lyonsia				X	X	X
Macoma tenta	Elongate macoma; Narrowed macoma				X		

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Macrocallista nimbosa	Sunray venus; Sunray shell				X		X
Martesia cuneiformis	Wedge piddock; Wood piddock				X		
Melampus bidentatus	Eastern melampus; Saltmarsh snail; Duck snail			X	X		
Mercenaria campechiensis	Southern quahog			X	X	X	
Mercenaria mercenaria	Northern quahog			X	X	X	
Miesea evelinae					X	X	
Modiolus americanus	American horsemussel; Tulip mussel				X	X	
Montacutidae sp. A					X		
Mulinia lateralis	Dwarf surfclam; Little surfclam			X	X		X
Musculus lateralis	Lateral mussel			X	X	X	X
Mysella sp. B					X		X
Mysella sp. C					X		X
Nassarius obsoletus	Eastern mudsnail; Mud dog whelk			X	X		
Nassarius trivittatus	Threeline mudsnail; New England dog whelk					X	X
Nassarius vibex	Bruised nassa; Mottled dog whelk				X	X	
Neverita duplicata	Shark eye			X	X	X	X
Noetia ponderosa	Ponderous ark				X		
Nototeredo knoxi	Foliaceous shipworm; Knox shipworm				X	X	X
Nucula proxima	Atlantic nutclam; Near nut shell				X		X
Octopus vulgaris	Common octopus; Common Atlantic octopus						X
Okenia impexa					X	X	
Okenia sapelona	Sapelo okenia			X	X		
Okenia sp. A					X		
Okenia sp. B					X		
Oliva sayana	Lettered olive				X	X	X
Olivella mutica	Variable dwarf olive; Dwarf olive						X
Onobops jacksoni	Fine-lined hydrobe			X	X		
Ostrea equestris	Crested oyster				X	X	X
Pandora trilineata	Three-line pandora; Three-lined pandora						X
Paramya subovata	Subovate softshell clam; Ovate paramya				X		
Parvanachis obesa	Fat dovesnail				X		
Parvilucina multilineata	Many-lined lucine				X		X
Petricola pholadiformis	False angelwing				X	X	
Pisania tinctoria	Tinted cantharus				X	X	
Polycera hummi					X	X	
Polycerella emertoni				X	X	X	
Polymesoda caroliniana	Carolina marshclam			X	X		
Pteria colymbus	Atlantic wing-oyster; Winged pearl oyster				X	X	X
Pyrgocythara plicosa	Plicate mangelia			X	X	X	
Rangia cuneata	Atlantic rangia; Wedge rangia	X	X				

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
<i>Rupellaria typica</i>	Atlantic rupellar; Atlantic rupellaria				X	X	
<i>Scyllaea pelagica</i>	Sargassum nudibranch					X	X
<i>Seila adamsi</i>					X		X
<i>Semelina nukuloides</i>	Nut semele; Tiny semele						X
<i>Simnialena uniplicata</i>	One-tooth simnia; Single-toothed simnia			X	X	X	X
<i>Solemya velum</i>	Atlantic awningclam; Veiled clam				X		
<i>Solen viridis</i>	Green jackknife clam; Little green razor clam				X		X
<i>Sphenia antillensis</i>	Antillean sphenia			X	X	X	
<i>Spisula solidissima</i>	Atlantic surf clam; Skimmer clam				X	X	X
<i>Spurilla neapolitana</i>	Neapolitan spurilla			X	X	X	
<i>Strigilla mirabilis</i>	White strigilla						X
<i>Tagelus divisus</i>	Purplish tagelus				X		
<i>Tagelus plebeius</i>	Stout tagelus			X	X		
<i>Tectonatica pusilla</i>	Miniature moonsnail						X
<i>Tellina aequistriata</i>	Striate tellin				X		
<i>Tellina agilis</i>	Northern dwarf tellin				X	X	X
<i>Tellina alternata</i>	Alternate tellin; Lined tellin				X		
<i>Tellina americana</i>	American tellin						X
<i>Tellina iris</i>	Rainbow tellin; Iris tellin				X		X
<i>Tellina probrina</i>	Slandered tellin						X
<i>Tellina sybaritica</i>	Sybaritic tellin; Dall's dwarf tellin						X
<i>Tellina texana</i>	Texas tellin				X		
<i>Tenellia pallida</i>					X	X	
<i>Terebra dislocata</i>	Eastern auger; Common auger						X
<i>Thais haemastoma floridana</i>	Florida rocksnail; Florida rock shell				X	X	
<i>Thecacera pennigera</i>					X		
<i>Trachycardium muricatum</i>	Yellow pricklycockle; Common cockle; Yellow cockle				X		X
<i>Trapania</i> sp. A				X	X	X	
<i>Tritonia bayeri</i>				X	X		X
<i>Turbonilla acicula</i>				X	X		
<i>Turbonilla buteonis</i>					X		
<i>Turbonilla wrightsvillensis</i>				X	X		
<i>Urosalpinx cinerea</i>	Atlantic oyster drill			X	X		
<i>Vitrinellidae</i> sp. A				X	X		
<i>Americamysis almyra</i>					X		X
<i>Americamysis bahia</i>			X		X		
<i>Americamysis bigelowi</i>					X		X
<i>Bowmaniella dissimilis</i>					X	X	X
<i>Bowmaniella mexicana</i>							X
<i>Brasilomysis castroi</i>					X		X

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Heteromysis formosa					X		X
Metamysidopsis swifti						X	X
Mysidopsis furca					X		X
Neomysis americana					X		X
Theristus polychaetophilus					X		
Amphiporus cruentatus				X	X		
Amphiporus ochraceus				X	X	X	X
Carcinonemertes carcinophila					X	X	X
Carinoma tremaphoros				X	X		
Carinomella lactea					X		
Cerebratulus lacteus	Milky ribbon worm				X	X	
Cerebratulus lineolatus					X	X	
Cerebratulus sp. A						X	
Lineus bicolor				X	X	X	
Lineus socialis				X	X	X	
Lineus sp. A					X	X	
Micrura leidyi	Red nemertean worm; Leidy's nemertean worm				X		
Nemertopsis bivittata					X	X	
Oerstedia dorsalis						X	
Pantionemertes agricola						X	
Paranemertes biocellatus					X	X	
Tetrastemma candidum					X	X	
Tubulanus pellucidus					X	X	
Tubulanus rhabdotus					X	X	
Zygeupolia rubens					X	X	
Zygonemertes virescens				X	X	X	
Enchytraeidae sp. A				X	X		
Monopylephorus rubroniveus				X	X		
Paranais (frici?)				X	X		
Peloscolex sp. A					X		
Tubificoides brownae					X		
Tubificoides heterochaetus				X	X		
Tubificoides wasselli					X		
Phoronis architecta					X		X
Phoronis ovalis					X		X
Bdelloura candida	Horseshoe-crab flatworm				X		
Conjuguterus parvus					X		
Coronadena mutabilis				X	X	X	
Digynopora americana					X	X	
Oligoclado floridanus					X	X	

		Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Scientific Name	Common Name						
Plagiosomum sp. A				X	X	X	
Prosthiosomum pulchrum					X	X	
Pseudoceros crozieri	Lined flatworm; Crozier's flatworm				X		
Stylochus ellipticus	Oyster flatworm			X	X	X	
Stylochus oculiferus					X	X	
Stylochus zebra	Zebra oyster flatworm				X		
Thysanozoon brocchi						X	
Aglaophamus verrilli	Dwarf sandworm				X		X
Amphinome rostrata						X	X
Amphitrite ornata	Ornate worm			X	X		
Ancistrosyllis commensalis					X		
Ancistrosyllis jonesi					X		
Aphelochaeta marioni				X	X	X	X
Aphelochaeta sp.					X		X
Arabella iricolor	Opal worm			X	X	X	
Arabella mutans					X		X
Arenicola cristata	Southern lugworm				X		
Aricidea bryani					X		
Aricidea fragilis					X		
Aricidea wassi					X		X
Armandia agilis					X		X
Armandia maculata					X		X
Asabellides sp. A					X		
Asychis elongata					X		
Autolytus dentalius				X	X	X	X
Autolytus prolifera				X	X	X	X
Axiothella mucosa					X		X
Bhawania goodei					X		
Bhawania heteroseta					X		X
Boccardiella hamata				X	X		
Branchioasychis americana				X	X		
Brania clavata				X	X	X	
Capitella capitata	Capitellid threadworm			X	X		X
Carazziella hobsonae					X		
Caulleriella killariensis					X		X
Caulleriella sp.					X	X	X
Ceratonereis irritabilis	Long-palped sandworm				X		X
Chaetopterus variopedatus	Parchment worm				X		
Cirriformia filigera					X	X	X
Cirriformia grandis					X		

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Cirrophorus lyriformis</i>					X		X
<i>Cirrophorus</i> sp.					X		X
<i>Cistenides gouldii</i>	Ice cream cone worm				X		X
<i>Clymenella torquata</i>	Bamboo worm				X	X	X
<i>Ctenodrilus serratus</i>					X		
<i>Dasybranchus lumbricoides</i>				X	X	X	
<i>Demonax microphthalmus</i>				X	X	X	X
<i>Dentatisyllis carolinae</i>				X	X	X	
<i>Dexiospira corrugata</i>				X	X		
<i>Diopatra cuprea</i>	Plumed worm; Periscope tubeworm			X	X	X	X
<i>Dispia uncinata</i>					X		X
<i>Dodecaceria concharum</i>						X	X
<i>Dorvillea sociabilis</i>				X	X	X	X
<i>Drilonereis magna</i>				X	X		X
<i>Drilonereis monroi</i>					X		
<i>Enoplobranchus sanguineus</i>				X	X	X	
<i>Eteone heteropoda</i>	Eteone worm			X	X		X
<i>Eteone lactea</i>					X		X
<i>Eulalia sanguinea</i>				X	X	X	X
<i>Eunice antennata</i>					X	X	X
<i>Eusyllis lamelligera</i>				X	X	X	X
<i>Exogone dispar</i>				X	X	X	X
<i>Exogone verugera</i>				X	X		X
<i>Fabricia sabella</i>				X	X	X	
<i>Glycera americana</i>	Bloodworm			X	X		X
<i>Glycera dibranchiata</i>				X	X		X
<i>Glycera robusta</i>				X	X		X
<i>Glycera sphyrabranca</i>				X	X		
<i>Glycinde solitaria</i>					X		X
<i>Goniada littorea</i>					X		X
<i>Haplosyllis spongicola</i>	Sponge threadworm				X	X	X
<i>Harmothoe aculeata</i>				X	X	X	X
<i>Harmothoinae</i> sp. A					X		
<i>Heteromastus filiformis</i>				X	X		X
<i>Hyboscolex longiseta</i>						X	
<i>Hydroides dianthus</i>				X	X	X	X
<i>Kinbergonuphis jenneri</i>					X	X	
<i>Laeonereis culveri</i>	Culver's sandworm	X	X				
<i>Leitoscoloplos fragilis</i>				X	X		X
<i>Leitoscoloplos robustus</i>				X	X		X

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Lepidametria commensalis</i>	Many-scaled worm			X	X	X	X
<i>Lepidasthenia varia</i>				X	X		
<i>Lepidonotus sublevis</i>	Twelve-scaled worm			X	X	X	X
<i>Lepidonotus variabilis</i>	Fringed scaleworm			X	X	X	X
<i>Loimia medusa</i>	Medusa worm			X	X	X	X
<i>Loimia viridis</i>				X	X		X
<i>Lumbrineris coccinea</i>				X	X	X	X
<i>Lysidice ninetta</i>				X	X	X	X
<i>Lysilla alba</i>				X	X		X
<i>Macroclymene zonalis</i>					X	X	
<i>Magelona papillicornis</i>				X	X		X
<i>Magelona phyllisae</i>				X	X		X
<i>Magelona</i> sp.					X		X
<i>Malmgrenia lunulata</i>					X		
<i>Manayunkia aestuarina</i>				X			
<i>Marphysa sanguinea</i>				X	X	X	
<i>Mediomastus ambiseta</i>					X		X
<i>Mediomastus californiensis</i>				X	X		X
<i>Megalomma lobiferum</i>				X	X	X	
<i>Melinna maculata</i>				X	X		
<i>Mesochaetopterus taylori</i>				X	X		
<i>Montecellina</i> sp.					X		X
<i>Mooreonuphis nebulosa</i>					X		
<i>Myrianida pachycera</i>					X		
<i>Myriochele oculata</i>							X
<i>Nephtys bucera</i>				X	X	X	X
<i>Nephtys picta</i>				X	X		X
<i>Nereiphylla fragilis</i>				X	X	X	X
<i>Nereis acuminata</i>					X		X
<i>Nereis falsa</i>				X	X	X	X
<i>Nereis succinea</i>	Common southern clamworm; Large sandworm			X	X	X	X
<i>Notaulax nudicollis</i>	Brown fanworm			X	X	X	
<i>Notomastus hemipodus</i>				X	X		X
<i>Notomastus latericeus</i>				X	X		X
<i>Notomastus lobatus</i>				X	X		X
<i>Odontosyllis fulgurans</i>				X	X	X	
<i>Onuphis eremita</i>	Shaggy parchment tubeworm						X
<i>Ophryotrocha puerilis</i>				X	X		
<i>Ophryotrocha</i> sp. A				X	X		
<i>Orbinia ornata</i>					X		

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Orbinia riseri</i>					X		
<i>Owenia fusiformis</i>	Roofing worm				X		X
<i>Parahesion luteola</i>				X	X		
<i>Paranaitis gardineri</i>					X		
<i>Paranaitis speciosa</i>				X	X		X
<i>Paraonis fulgens</i>				X	X	X	X
<i>Parapionosyllis longicirrata</i>				X	X		X
<i>Parapionosyllis</i> sp.					X		X
<i>Paraprionospio pinnata</i>	Fringe-gilled mudworm			X	X		X
<i>Phyllodoce arenae</i>				X	X		X
<i>Piromis eruca</i>				X	X		
<i>Pista palmata</i>				X	X		
<i>Platynereis dumerilii</i>						X	X
<i>Podarke obscura</i>					X		X
<i>Podarkeopsis levifusca</i>					X		X
<i>Polycirrus carolinensis</i>					X		X
<i>Polycirrus eximius</i>				X	X		X
<i>Polycirrus</i> sp.					X		X
<i>Polydora colonia</i>					X		
<i>Polydora cornuta</i>					X		X
<i>Polydora socialis</i>					X		X
<i>Polydora websteri</i>	Blisterworm			X	X		
<i>Polydotes lupina</i>	Silkworm of the sea			X	X		
<i>Potamilla reniformis</i>					X		
<i>Potamilla torelli</i>					X		
<i>Prionospio cirrifer</i>				X	X		
<i>Prionospio cristata</i>					X		X
<i>Prionospio dayi</i>							X
<i>Proceraea fasciata</i>				X	X	X	
<i>Pseudeurythoe ambigua</i>					X		X
<i>Sabellaria floridensis</i>	Honeycomb tubeworm			X	X	X	X
<i>Sabellaria vulgaris vulgaris</i>				X	X	X	X
<i>Schistomeringos rudolphi</i>				X	X	X	
<i>Scolecoides viridis</i>					X	X	
<i>Scolecopsis squamata</i>					X	X	X
<i>Scolecopsis texana</i>							X
<i>Scoletoma impatiens</i>					X	X	
<i>Scoletoma tenuis</i>				X	X		X
<i>Scoloplos rubra</i>	Red threadworm				X	X	
<i>Sphaerosyllis longicauda</i>				X	X		X

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
<i>Spio multioculata</i>					X		
<i>Spio setosa</i>					X		
<i>Spiochaetopterus costarum oculatus</i>				X	X	X	X
<i>Spiophanes bombyx</i>	Bee spionid				X		X
<i>Sthenelais boa</i>	Boa scaleworm				X		X
<i>Streblospio benedicti</i>			X	X	X		X
<i>Streptosyllis arenae</i>					X		
<i>Syllis cornuta</i>				X	X	X	X
<i>Syllis gracilis</i>					X	X	X
<i>Syllis hyalina</i>					X	X	X
<i>Synelmis ewingi</i>							X
<i>Terebella rubra</i>				X	X	X	
<i>Tharyx acutus</i>					X		X
<i>Tharyx setigera</i>				X	X		
<i>Thelepus setosus</i>				X	X	X	X
<i>Travisia parva</i>					X		X
<i>Trypanosyllis zebra</i>	Zebra worm					X	
<i>Adocia tubifera</i>					X	X	
<i>Aplysilla sulphurea</i>					X	X	
<i>Calcarea</i> sp. A					X		
<i>Cliona celata</i>	Yellow boring sponge; Sulfur sponge			X	X	X	X
<i>Cliona lobata</i>				X	X		X
<i>Cliona robusta</i>				X	X		
<i>Cliona spirilla</i>				X	X		
<i>Cliona vastifica</i>				X	X		
<i>Craniella laminaris</i>					X		
<i>Halichondria bowerbanki</i>	Crumb-of-bread sponge; Bowerbank's halichondria				X		X
<i>Haliclona loosanoffi</i>	Loosanoff's haliclona				X	X	
<i>Haliclona permollis</i>					X	X	
<i>Hymeniacidon heliophila</i>				X	X		
<i>Keratosa</i> sp. A				X	X		
<i>Leucosolenia canariensis</i>						X	X
<i>Lissodendoryx isodictyalis</i>	Garlic sponge				X	X	X
<i>Microciona prolifera</i>	Red beard sponge				X	X	X
<i>Mycale cecilia</i>					X		
<i>Mycale</i> sp. A					X	X	
<i>Poecilosclerida</i> sp. A					X		
<i>Prosuberites microsclerus</i>					X	X	
<i>Scypha barbadensis</i>					X	X	X
<i>Tenaciella obliqua</i>					X	X	X

Scientific Name	Common Name	Tidal Fresh/Brackish Intertidal	Tidal Fresh/Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Ocean Beach/Surf	Shallow Atlantic Shelf
Xestospongia halichondrioides						X	X
Achelia sawayi				X	X	X	X
Anoplodactylus lentus					X	X	X
Anoplodactylus petiolatus					X	X	X
Anoplodactylus pygmaeus					X	X	
Callipallene brevirostris				X	X		
Nymphopsis duodorsospinosa					X	X	
Pycnogonum cessaci						X	
Tanystylum orbiculare				X	X	X	
Phascolion strombus					X		
Themiste alutacea				X	X	X	
Coronis excavatrix					X	X	
Gibbesia neglecta					X		X
Squilla empusa	Common mantis shrimp				X		X
Halmyrapseudes bahamensis				X	X	X	
Hargeria rapax				X	X		
Tanaissus psammophilus							X
Limulus polyphemus	Horseshoe Crab			X	X	X	X

TABLE AP 8 – 2: Marine Fish Species Habitat Association Table

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Sea Lamprey	<i>Petromyzon marinus</i>		X		X				
Spiny Dogfish	<i>Squalus acanthias</i>				X	X	X		
Nurse Shark	<i>Ginglymostoma cirratum</i>				X		X		
Sand Tiger Shark	<i>Carcharias taurus</i>				X	X	X		
Smooth Dogfish	<i>Mustelus canis</i>				X	X	X		
Blacknose Shark	<i>Carcharhinus acronotus</i>					X	X		
Spinner Shark	<i>Carcharhinus brevipinna</i>				X	X	X		
Finetooth Shark	<i>Carcharhinus isodon</i>				X	X	X		
Bull Shark	<i>Carcharhinus leucas</i>		X		X	X	X		
Blacktip Shark	<i>Carcharhinus limbatus</i>				X	X	X		
Sandbar Shark	<i>Carcharhinus plumbeus</i>		X		X	X	X		
Tiger Shark	<i>Galeocerdo cuvieri</i>						X		
Lemon Shark	<i>Negaprion brevirostris</i>				X	X	X		
Sharpnose Atlantic Shark	<i>Rhizoprionodon terraenovae</i>				X	X	X		
Scalloped Hammerhead	<i>Sphyrna lewini</i>				X	X	X		
Bonnethead	<i>Sphyrna tiburo</i>				X	X	X		
Lesser Electric Ray	<i>Narcine bancroftii</i>					X	X		
Atlantic Guitarfish	<i>Rhinobatos lentiginosus</i>				X		X		
Clearnose Skate	<i>Raja eglanteria</i>				X	X	X		
Southern Stingray	<i>Dasyatis americana</i>				X	X	X		
Roughtail Stingray	<i>Dasyatis centroura</i>						X		
Atlantic Stingray	<i>Dasyatis sabina</i>				X	X	X		
Bluntnose Stingray	<i>Dasyatis say</i>					X	X		
Smooth Butterfly Ray	<i>Gymnura micrura</i>				X	X	X		
Bullnose Ray	<i>Myliobatis freminvillei</i>						X		
Cownose Ray	<i>Rhinoptera bonasus</i>				X	X	X		
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>		X		X		X		
Atlantic Sturgeon	<i>Acipenser oxyrinchus</i>		X		X	X	X		
Ladyfish	<i>Elops saurus</i>		X		X	X	X		X
Tarpon	<i>Megalops atlanticus</i>		X		X		X		
American Eel	<i>Anguilla rostrata</i>		X		X	X	X		X
Speckled Worm Eel	<i>Myrophis punctatus</i>		X		X		X		X

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Shrimp Eel	<i>Ophichthus gomesii</i>						X		
Palespotted Eel	<i>Ophichthus puncticeps</i>						X		
American Conger	<i>Conger oceanicus</i>				X	X	X		
Striped Anchovy	<i>Anchoa hepsetus</i>				X		X		
Dusky Anchovy	<i>Anchoa lyolepis</i>						X		
Bay Anchovy	<i>Anchoa mitchilli</i>		X		X		X		
Blueback Herring	<i>Alosa aestivalis</i>		X				X		
Hickory Shad	<i>Alosa mediocris</i>		X				X		
American Shad	<i>Alosa sapidissima</i>		X		X	X	X		
Atlantic Menhaden	<i>Brevoortia tyrannus</i>		X		X		X		
Round Herring	<i>Etrumeus teres</i>						X		
Scaled Sardine	<i>Harengula jaguana</i>						X		
Atlantic Thread Herring	<i>Opisthonema oglinum</i>						X		
Spanish Sardine	<i>Sardinella aurita</i>						X		
Hardhead Catfish	<i>Ariopsis felis</i>		X		X	X	X		
Gafftopsail Catfish	<i>Bagre marinus</i>		X		X	X	X		
Inshore Lizardfish	<i>Synodus foetens</i>				X		X		
Blotched Cusk-eel	<i>Ophidion grayi</i>						X		
Bank Cusk-eel	<i>Ophidion holbrooki</i>						X		
Striped Cusk-eel	<i>Ophidion marginatum</i>				X		X		
Carolina Hake	<i>Urophycis earllii</i>						X		
Southern Hake	<i>Urophycis floridana</i>				X		X		
Spotted Hake	<i>Urophycis regia</i>				X		X		
Oyster Toadfish	<i>Opsanus tau</i>				X	X	X		
Striped Mullet	<i>Mugil cephalus</i>		X		X	X	X		X
White Mullet	<i>Mugil curema</i>				X		X		
Rough Silverside	<i>Membras martinica</i>				X	X			
Inland Silverside	<i>Menidia beryllina</i>		X		X	X			
Atlantic Silverside	<i>Menidia menidia</i>				X	X			
Atlantic Needlefish	<i>Strongylura marina</i>		X		X	X	X		
Marsh Killifish	<i>Fundulus confluentus</i>		X					X	X
Mummichog	<i>Fundulus heteroclitus</i>		X		X				X
Spotfin Killifish	<i>Fundulus luciae</i>				X				
Striped Killifish	<i>Fundulus majalis</i>					X			

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Rainwater Killifish	<i>Lucania parva</i>		X					X	X
Sailfin Molly	<i>Poecilia latipinna</i>		X		X			X	X
Sheepshead Minnow	<i>Cyprinodon variegatus</i>		X		X	X		X	X
Lined Seahorse	<i>Hippocampus erectus</i>				X	X	X		
Opossum Pipefish	<i>Micropis brachyurus</i>								
Northern Pipefish	<i>Syngnathus fuscus</i>				X		X		
Chain Pipefish	<i>Syngnathus louisianae</i>				X		X		
Gulf Pipefish	<i>Syngnathus scovelli</i>		X		X		X		
Bull Pipefish	<i>Syngnathus springeri</i>						X		
Northern Seabrook	<i>Prionotus carolinus</i>					X	X		
Striped Seabrook	<i>Prionotus evolans</i>				X	X	X		
Leopard Seabrook	<i>Prionotus scitulus</i>				X	X	X		
Bighead Seabrook	<i>Prionotus tribulus</i>				X	X	X		
Striped Bass	<i>Morone saxatilis</i>		X		X	X	X		X
Rock Sea Bass	<i>Centropomus philadelphicus</i>				X	X	X		
Black Sea Bass	<i>Centropomus striata</i>				X		X		
Sand Perch	<i>Diplectrum formosum</i>						X		
Goliath Grouper	<i>Epinephelus itajara</i>		X		X	X	X		X
Red Grouper	<i>Epinephelus morio</i>				X		X		
Black Grouper	<i>Mycteroperca bonaci</i>				X		X		
Gag	<i>Mycteroperca microlepis</i>				X	X	X		
Belted Sandfish	<i>Serranus subligarius</i>						X		
Bluefish	<i>Pomatomus saltatrix</i>				X	X	X		
Sharksucker	<i>Echeneis naucrates</i>						X		
Cobia	<i>Rachycentron canadum</i>				X		X		
Blue Runner	<i>Caranx crysos</i>						X		
Crevalle Jack	<i>Caranx hippos</i>		X		X	X	X		
Horse-eye Jack	<i>Caranx latus</i>		X				X		
Atlantic Bumper	<i>Chloroscombrus chrysurus</i>				X	X	X		
Atlantic Moonfish	<i>Selene setapinnis</i>				X		X		
Lookdown	<i>Selene vomer</i>				X		X		
Florida Pompano	<i>Trachinotus carolinus</i>				X	X			
Permit	<i>Trachinotus falcatus</i>				X	X			
Mutton Snapper	<i>Lutjanus analis</i>				X	X	X		

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Red Snapper	<i>Lutjanus campechanus</i>						X		
Gray Snapper	<i>Lutjanus griseus</i>		X		X	X	X		
Lane Snapper	<i>Lutjanus synagris</i>				X	X	X		
Atlantic Tripletail	<i>Lobotes surinamensis</i>				X		X		
Spotfin Mojarra	<i>Eucinostomus argenteus</i>		X			X	X		
Silver Jenny	<i>Eucinostomus gula</i>					X	X		
Tomtate	<i>Haemulon aurolineatum</i>						X		
Pigfish	<i>Orthopristis chrysoptera</i>				X	X	X		
Sheepshead	<i>Archosargus probatocephalus</i>				X	X	X		
Pinfish	<i>Lagodon rhomboides</i>		X		X	X	X		
Scup	<i>Stenotomus chrysops</i>						X		
Silver Perch	<i>Bairdiella chrysoura</i>		X		X		X		X
Spotted Seatrout	<i>Cynoscion nebulosus</i>		X		X	X			
Silver Seatrout	<i>Cynoscion nothus</i>					X	X		
Weakfish	<i>Cynoscion regalis</i>		X		X	X	X		
Banded Drum	<i>Larimus fasciatus</i>				X	X	X		
Spot	<i>Leiostomus xanthurus</i>		X		X	X	X		X
Southern Kingfish	<i>Menticirrhus americanus</i>				X	X	X		
Gulf Kingfish	<i>Menticirrhus littoralis</i>					X	X		
Northern Kingfish	<i>Menticirrhus saxatilis</i>					X	X		
Atlantic Croaker	<i>Micropogonias undulatus</i>		X		X	X	X		
Black Drum	<i>Pogonias cromis</i>				X	X	X		
Red Drum	<i>Sciaenops ocellatus</i>		X		X	X	X		X
Star Drum	<i>Stellifer lanceolatus</i>				X	X	X		
Dwarf Goatfish	<i>Upeneus parvus</i>						X		
Northern Stargazer	<i>Astroscopus guttatus</i>						X		
Southern Stargazer	<i>Astroscopus y-graecum</i>					X	X		
Striped Blenny	<i>Chasmodes bosquianus</i>				X	X			
Crested Blenny	<i>Hypleurochilus geminatus</i>				X	X	X		
Feather Blenny	<i>Hypsoblennius hentz</i>				X				
Freckled Blenny	<i>Hypsoblennius ionthas</i>				X				
Skilletfish	<i>Gobiesox strumosus</i>				X	X	X		
Fat Sleeper	<i>Dormitator maculatus</i>		X						X
Largescaled Spinycheek Sleeper	<i>Eleotris amblyopsis</i>		X						X

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Darter Goby	<i>Ctenogobius boleosoma</i>				X				
Freshwater Goby	<i>Ctenogobius shufeldti</i>		X						X
Emerald Goby	<i>Ctenogobius smaragdus</i>								
Lyre Goby	<i>Evorthodus lyricus</i>		X		X				X
Highfin Goby	<i>Gobionellus oceanicus</i>				X				
Naked Goby	<i>Gobiosoma bosc</i>				X				
Seaboard Goby	<i>Gobiosoma ginsburgi</i>				X				
Green Goby	<i>Microgobius thalassinus</i>				X				
Atlantic Spadefish	<i>Chaetodipterus faber</i>				X	X	X		
Guaguanche	<i>Sphyræna guachancho</i>				X	X	X		
Atlantic Cutlassfish	<i>Trichiurus lepturus</i>				X	X	X		
King Mackerel	<i>Scomberomorus cavalla</i>						X		
Spanish Mackerel	<i>Scomberomorus maculatus</i>						X		
Harvestfish	<i>Peprilus paru</i>				X		X		
Butterfish	<i>Peprilus triacanthus</i>						X		
Windowpane	<i>Scophthalmus aquosus</i>						X		
Ocellated Flounder	<i>Ancylosetta quadrocellata</i>				X	X	X		
Spotted Whiff	<i>Citharichthys macrops</i>						X		
Bay Whiff	<i>Citharichthys spilopterus</i>		X		X		X		
Fringed Flounder	<i>Etropus crossotus</i>		X		X	X	X		
Shelf Flounder	<i>Etropus cyclosquamus</i>						X		
Gulf Flounder	<i>Paralichthys albigitta</i>				X		X		
Summer Flounder	<i>Paralichthys dentatus</i>				X		X		
Southern Flounder	<i>Paralichthys lethostigma</i>		X		X	X	X		
Broad Flounder	<i>Paralichthys squamilentus</i>					X			
Dusky Flounder	<i>Syacium papillosum</i>						X		
Naked Sole	<i>Gymnachirus melas</i>						X		
Hogchoker	<i>Trinectes maculatus</i>		X		X	X	X		
Blackcheek Tonguefish	<i>Symphurus plagiosa</i>				X	X	X		
Dotterel Filefish	<i>Aluterus heudelotii</i>						X		
Orange Filefish	<i>Aluterus schoepfii</i>				X		X		
Planehead Filefish	<i>Stephanolepis hispidus</i>		X		X	X	X		
Smooth Puffer	<i>Lagocephalus laevigatus</i>						X		
Northern Puffer	<i>Sphoeroides maculatus</i>				X	X	X		

Common Name	Scientific Name	Tidal Fresh & Brackish Intertidal	Tidal Fresh & Brackish Submerged	Estuarine Intertidal	Estuarine Submerged	Beach Surf	Shallow Shelf	Pools and Ponds	Impoundments
Striped Burrfish	<i>Chilomycterus schoepfi</i>				X	X	X		

APPENDIX 9: FRESHWATER FISH SPECIES HABITAT ASSOCIATIONS

Ecobasins		Blue Ridge		Piedmont			Southeastern Plains			Coastal Plains			
Scientific Name	Common Name	Santee	Savannah	Santee	Savannah	Pee Dee	Santee	Savannah	ACE	Santee	Savannah	Pee Dee	ACE
Fishes													
Acantharchus pomotis	Mud sunfish						X	X	X	X	X	X	X
Ameiurus brunneus	Snail bullhead		X	X	X	X	X	X	X				
Ameiurus catus	White catfish	X		X	X	X	X	X	X	X	X	X	X
Ameiurus platycephalus	Flat bullhead			X	X	X	X	X	X	X	X	X	X
Campostoma anomalum	Central stoneroller	X	X	X	X								
Carpiodes cyprinus	Quillback			X	X		X	X					
Carpiodes sp.	Highfin carpsucker			X		X	X	X					
Cottus bairdii complex	"Smoky sculpin"		X		X								
Cyprinella analostana	Satinfin shiner					X							
Cyprinella chloristia	Greenfin shiner	X		X		X	X						
Cyprinella galactura	Whitetail shiner		X		X								
Cyprinella pyrrhomelas	Fieryblack shiner	X		X		X	X						
Cyprinella sp. (c.f. zanema)	"Thinlip" chub					X							
Elassoma boehlkei	Carolina pygmy sunfish						X			X		X	
Elassoma okatie	Bluebarred pygmy sunfish							X			X		
Elliptio roanokensis	Roanoke slabshell			X			X	X				X	
Enneacanthus chaetodon	Blackbanded sunfish					X	X	X	X	X	X	X	X
Etheostoma collis	Carolina darter			X									
Etheostoma flabellare	Fantail darter	X	X	X		X							
Etheostoma fricksium	Savannah darter				X			X	X				X
Etheostoma hopkinsi	Christmas darter		X		X			X					
Etheostoma inscriptum	Turquoise darter		X	X	X			X	X				
Etheostoma mariae	Pinewoods darter												
Etheostoma saludae	Saluda darter			X			X						
Etheostoma thalassinum	Seagreen darter	X		X			X						
Etheostoma zonale	Banded darter				X								

AP 9 Freshwater Species Habitat Associations
SC CWCS

Ecobasins		Blue Ridge		Piedmont			Southeastern Plains			Coastal Plains			
Scientific Name	Common Name	Santee	Savannah	Santee	Savannah	Pee Dee	Santee	Savannah	ACE	Santee	Savannah	Pee Dee	ACE
Fundulus diaphanus	Banded killifish											X	
Hybopsis hypsinotus	Highback chub	X		X		X	X						
Hybopsis labrosa	Thicklip chub	X		X									
Hybopsis rubrifrons	Rosyface chub	X	X	X	X								
Hybopsis zanema	Santee chub	X		X									
Lampsilis splendida/radiata	Rayed pink fatmucket/			X			X	X			X	X	X
Lepisosteus platyrhinchus	Florida gar										X		
Ligumia nasuta	Eastern pondmussel			X			X					X	
Lucania goodei	Bluefin killifish									X			
Luxilus coccogenis	Warpaint shiner		X		X								
Micropterus coosae	Redeye bass	X	X	X	X								
Morone saxatilis	Striped bass						X			X	X	X	X
Moxostoma collapsum	Notchlip redhorse			X	X	X	X						
Moxostoma pappillosum	V-lip redhorse	X		X									
Moxostoma robustum	Robust redhorse							X			X	X	
Nocomis micropogon	River chub				X								
Notropis alborus	Whitemouth shiner					X							
Notropis amoenus	Comely shiner					X							
Notropis bifrenatus	Bridle shiner						X						
Notropis chiliticus	Redlip shiner					X							
Notropis chlorocephalus	Greenhead shiner			X		X							
Notropis hypselopterus	Sailfin shiner			X	X								
Notropis leedsii	Bannerfin shiner							X	X		X		X
Notropis leuciodus	Tennessee shiner		X		X								
Notropis spectrunculus	Mirror shiner		X		X								
Noturus spp. (c.f. insignis)	“Broadtail” madtom					X			X			X	X
Opsopoeodus emiliae	Pugnose minnow							X	X		X		X
Percina crassa	Piedmont darter	X		X		X	X						
Pteronotropsis stonei	Lowland shiner						X	X	X	X	X	X	X
Rhinichthys cataractae	Longnose dace		X										

AP 9 Freshwater Species Habitat Associations

SC CWCS

Rhynchithys atratulus	Blacknose dace	X	X	X	X								
Ecobasins		Blue Ridge		Piedmont			Southeastern Plains			Coastal Plains			
Scientific Name	Common Name	Santee	Savannah	Santee	Savannah	Pee Dee	Santee	Savannah	ACE	Santee	Savannah	Pee Dee	ACE
Salvelinus fontinalis	Brook trout	X	X	X	X								
Semotilus lumbee	Sandhills chub			X		X	X						
Crayfish													
Cambarus carolinus	Red burrowing crayfish	X		X									
Cambarus chaugaensis	Oconee stream crayfish		X	X									
Cambarus hobbsorum	Rocky river crayfish			X									
Cambarus reflexus	A crayfish							X					
Cambarus sp. "B"	A crayfish		X		X								
Cambarus spicatus	Broad River spiny			X									
Distocambarus carlsoni	Mimic crayfish			X									
Distocambarus crockeri	A crayfish			X									
Distocambarus hunteri	A crayfish			X									
Distocambarus youngineri	A crayfish			X									
Foxonella clypeata	Ditch fencing crayfish			X	X								
Gillia altilis	Buffalo pebblesnail											X	
Procambarus ancylus	Edisto crayfish						X		X	X		X	X
Procambarus barbatus	A crayfish										X		
Procambarus blandingii	Santee crayfish						X			X		X	
Procambarus braswelli	Waccamaw crayfish											X	
Procambarus chacei	A crayfish						X	X	X	X	X		X
Procambarus echinatus	A crayfish								X				X
Procambarus enoplosternum	A crayfish						X	X		X	X		
Procambarus hirsutus	A crayfish						?	X			X		X
Procambarus lepidodactylus	Pee Dee lotic crayfish						X		X	X		X	X
Procambarus lunzi	A crayfish									X	X		
Procambarus pearsei	Sandhills crayfish											X	
Procambarus pubescens	A crayfish				X			X			X		
Procambarus reflexus	A crayfish										X		

AP 9 Freshwater Species Habitat Associations

SC CWCS

Ecobasins		Blue Ridge		Piedmont			Southeastern Plains			Coastal Plains			
Scientific Name	Common Name	Santee	Savannah	Santee	Savannah	Pee Dee	Santee	Savannah	ACE	Santee	Savannah	Pee Dee	ACE
Mussels													
Alasmidonta undulata	Triangle floater				X								
Alasmidonta varicosa	Brook floater				X	X							
Anodonta couperiana	Barrel floater							X	X		X		X
Elliptio angustata	Carolina lance			X		X	X		X			X	X
Elliptio complanata complex	Eastern elliptio			X	X	X	X				X	X	X
Elliptio congarea	Carolina slabshell	X		X	X		X	X	X		X	X	X
Elliptio folliculata	Pod lance			X								X	
Elliptio folliculata	Pod lance				X							X	
Elliptio fraterna	Brother spike				X								
Elliptio icterina complex	Variable spike	X		X	X		X		X		X	X	X
Elliptio producta	Atlantic spike				X				X			X	
Elliptio waccamawensis	Waccamaw spike											X	
Lampsilis cariosa	Yellow lampmussel			X	X		X	X			X	X	X
Lasmigona decorata	Carolina heelsplitter			X	X	X							
Leptodea ochracea	Tidewater mucket											X	
Strophitus undulatus	Creeper			X	X	X							
Toxolasma pullus	Savannah lilliput			X			X	X					
Villosa constricta	Notched rainbow			X		X							
Villosa delumbis	Eastern creekshell			X	X	X		X	X		X	X	X
Villosa vauhniana	Carolina creekshell			X									
Villosa vibex	Southern rainbow				X				X			X	X
Snails													
Lioplax subcarinata	Ridged lioplax											X	
Physa sp. "A"	A snail							X		X			X
Somatogyrus tenax	Savannah pebblesnail		X	X	X								

**SOUTH CAROLINA
COMPREHENSIVE WILDLIFE CONSERVATION STRATEGY
SUPPLEMENTAL DOCUMENT
2005-2010**



**SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES
1000 ASSEMBLY STREET
P.O. BOX 167
COLUMBIA, SC 29202**

**SUPPLEMENTAL DOCUMENT
SEPTEMBER 28, 2005**

SUPPLEMENTAL VOLUME TABLE OF CONTENTS

Table of Contents	i
Species Index	SI-1
Chapter 1: Mammals.....	1-1
Chapter 2: Birds.....	2-1
Chapter 3: Amphibians and Reptiles	3-1
Chapter 4: Diadromous Fish.....	4-1
Chapter 5: Freshwater Fish	5-1
Chapter 6: Marine Fish	6-1
Chapter 7: Crayfish	7-1
Chapter 8: Freshwater Mussels.....	8-1
Chapter 9: Freshwater Snails	9-1
Chapter 10: Insects	10-1
Chapter 11: Marine Invertebrates	11-1
Chapter 12: Terrestrial Habitats	12-1
Chapter 13: Aquatic Habitats	13-1
Literature Cited	LC-1
Acronyms	A-1
Glossary	G-1

Mammals

Appalachian Cottontail	1-1
Black Bear.....	1-5
Bottlenose Dolphin	1-9
Carolina Red-backed Vole.....	1-13
Dwarf Sperm Whale.....	1-59
Eastern Small-footed Myotis	1-16
Eastern Spotted Skunk	1-23
Eastern Woodrat	1-25
Florida Manatee	1-29
Hairy-tailed Mole.....	1-44
Humpback Whale.....	1-32
Masked Shrew	1-55
Meadow Vole.....	1-36
Mink.....	1-39
North Atlantic Right Whale	1-48
Northern Yellow Bat.....	1-52
Pygmy Shrew	1-55
Pygmy Sperm Whale	1-57
Rafinesque's Big-eared Bat.....	1-16
Southeastern Bat	1-16
Southern Fox Squirrel	1-59
Star-nosed Mole	1-44
Swamp Rabbit.....	1-63
Woodland Jumping Mouse	1-66

Birds

Acadian Flycatcher	2-39
American Avocet.....	2-61
American Bittern.....	2-56
American Coot	2-56
American Golden Plover.....	2-61
American Kestrel	2-79
American Oystercatcher.....	2-1
American Woodcock.....	2-4
Bachman's Sparrow	2-79
Bald Eagle.....	2-7
Barn Owl.....	2-46
Bewick's Wren	2-36
Black Duck.....	2-110
Black Rail.....	2-56
Black Scoter.....	2-99
Black Skimmer.....	2-19
Black-bellied Plover.....	2-61
Black-crowned Night Hero	2-25n

Black-throated Blue Warbler.....	2-30
Black-throated Green Warbler	2-16
Blue-winged Teal	2-110
Brown-headed Nuthatch	2-79
Buff-breasted Sandpiper	2-61
Canvasback	2-11
Chestnut-sided Warbler.....	2-36
Common (Wilson's) Snipe.....	2-56
Common Ground-dove	2-46
Common Loon	2-110
Common Raven.....	2-93
Common Tern	2-19
Dark-eyed Junco	2-56
Dunlin	2-61
Eastern Brown Pelican.....	2-19
Eastern Meadowlark	2-46
Eastern Wood Peewee	2-30
Field Sparrow	2-46
Forster's Tern	2-19
Glossy Ibis	2-25
Golden-crowned Kinglet.....	2-64
Grasshopper Sparrow.....	2-46
Gray Kingbird	2-54
Great Blue Heron	2-25
Great Egret.....	2-25
Greater Scaup.....	2-11
Greater Yellowlegs	2-61
Green Heron.....	2-25
Gull-billed Tern.....	2-19
Henslow's Sparrow	2-79
Horned Grebe.....	2-110
Kentucky Warbler	2-39
King Rail.....	2-56
Least Bittern.....	2-56
Least Sandpiper.....	2-61
Least Tern.....	2-19
Lesser Scaup	2-11
Lesser Yellowlegs.....	2-61
Little Blue Heron	2-25
Loggerhead Shrike	2-46
Long-billed Curlew	2-61
Long-billed Dowitcher.....	2-61
Louisiana Waterthrush	2-39
Mallard.....	2-110
Marbled Godwit	2-61
Mottled Duck	2-110

Northern Bobwhite.....	2-68
Northern Pintail.....	2-110
Painted Bunting.....	2-72
Pectoral Sandpiper.....	2-61
Peregrine Falcon.....	2-77
Pied-billed Grebe.....	2-56
Piping Plover.....	2-61
Prairie Warbler.....	2-36
Purple Gallinule.....	2-56
Purple Sandpiper.....	2-61
Red Crossbill.....	2-64
Red Knot.....	2-61
Red-breasted Nuthatch.....	2-64
Red-cockaded Woodpecker.....	2-85
Redhead.....	2-11
Ringneck.....	2-11
Royal Tern.....	2-19
Ruffed Grouse.....	2-96
Rusty Blackbird.....	2-39
Sanderling.....	2-61
Sandwich Tern.....	2-19
Scarlet Tanager.....	2-30
Seaside Sparrow.....	2-103
Semipalmated Plover.....	2-61
Semipalmated Sandpiper.....	2-61
Short-billed Dowitcher.....	2-61
Snowy Egret.....	2-25
Solitary Sandpiper.....	2-61
Spotted Sandpiper.....	2-61
Stilt Sandpiper.....	2-61
Swainson's Warbler.....	2-39
Swallow-tailed Kite.....	2-104
Tricolor Heron.....	2-25
Tundra Swan.....	2-107
Upland Sandpiper.....	2-61
Western Sandpiper.....	2-61
Whimbrel.....	2-61
White Ibis.....	2-25
White-rumped Sandpiper.....	2-61
White-winged Scoter.....	2-99
Willet.....	2-19
Wilson's Plover.....	2-19
Wood Duck.....	2-39
Wood Stork.....	2-118
Wood Thrush.....	2-30
Worm-eating Warbler.....	2-30

Yellow Rail.....	2-56
Yellow-crowned Night Heron.....	2-25

Amphibians and Reptiles

American Alligator.....	3-1
Bird-voiced Treefrog.....	3-44
Black Swamp Snake.....	3-44
Bog Turtle.....	3-3
Broad-striped Dwarf Siren.....	3-49
Canebrake Rattlesnake.....	3-3
Carolina Gopher Frog.....	3-49
Chamberlain's Dwarf Salamander.....	3-60
Chicken Turtle.....	3-19
Coal Skink.....	3-3
Common Snapping Turtle.....	3-19
Coral Snake.....	3-38
Diamondback Terrapin.....	3-13
Eastern Diamondback Rattlesnake.....	3-38
Eastern Milk Snake.....	3-3
Flatwoods Salamander.....	3-49
Florida Cooter.....	3-19
Florida Green Watersnake.....	3-18
Florida Pine Snake.....	3-38
Florida Softshell Turtle.....	3-19
Four-toed Salamander.....	3-44
Gopher Tortoise.....	3-26
Green Salamander.....	3-3
Green Turtle.....	3-56
Gulf Coast Mud Salamander.....	3-44
Hawksbill Turtle.....	3-56
Hellbender.....	3-3
Island Glass Lizard.....	3-44
Kemp's Ridley Turtle.....	3-56
Leatherback Turtle.....	3-31
Loggerhead Turtle.....	3-34
Mimic Glass Lizard.....	3-38
Northern Cricket Frog.....	3-49
Pickrel Frog.....	3-44
Pine Barrens Treefrog.....	3-47
Pine Snake.....	3-38
Pine Woods Snake.....	3-38
River Cooter.....	3-19
Seepage Salamander.....	3-3
Shovel-nosed Salamander.....	3-3
Slender Glass Lizard.....	3-38
Southern Dusky Salamander.....	3-60

Southern Hognose Snake	3-38
Spiny Softshell Turtle	3-19
Spotted Turtle.....	3-62
Striped Mud Turtle.....	3-44
Tiger Salamander	3-49
Timber Rattlesnake	3-3
Upland Chorus Frog.....	3-49
Webster's Salamander.....	3-64
Wood Frog	3-3
Yellowbelly Turtle.....	3-19

Diadromous Fish

American eel	4-12
American shad	4-1
Atlantic sturgeon.....	4-18
Blueback herring.....	4-1
Hickory shad	4-1
Shortnose sturgeon.....	4-18

Freshwater Fish

Banded Darter	5-55
Banded Killifish	5-39
Bannerfin Shiner	5-21
Blackbanded Sunfish.....	5-21
Blacknose Dace.....	5-43
Bluebarred Pygmy Sunfish	5-4
Bluefin Killifish.....	5-39
Bridle Shiner	5-4
"Broadtail" Madtom.....	5-4
Carolina Darter.....	5-27
Carolina Fantail Darter	5-18
Carolina Pygmy Sunfish	5-4
"Carolina" Redhorse	5-16
Central Stoneroller	5-43
Christmas Darter	5-11
Comely Shiner	5-51
Eastern Brook Trout.....	5-43
Fireyblack Shiner	5-36
Flat Bullhead.....	5-48
Florida Gar	5-55
Greenfin Shiner	5-36
Greenhead Shiner.....	5-27
Highback Chub	5-36
Highfin Carpsucker	5-1
Longnose Dace.....	5-55
Lowland Shiner	5-36

Mirror Shiner	5-55
Mud Sunfish	5-39
Notchlip Redhorse	5-31
Piedmont Darter	5-24
Pinewoods Darter	5-21
Pugnose Minnow	5-39
Quillback.....	5-16
Redeye Bass	5-11
Redlip Shiner	5-51
River Chub	5-55
Robust Redhorse	5-1
Rosyface Chub	5-36
Saluda Darter	5-11
Sandhills Chub	5-4
Santee Chub	5-27
Satinfin Shiner.....	5-51
Savannah Darter	5-4
Seagreen Darter.....	5-24
Smoky Sculpin	5-18
Snail Bullhead.....	5-48
Striped Bass	5-31
Tennessee Shiner.....	5-55
Thicklip Chub	5-36
"Thinlip" Chub.....	5-4
Turquoise Darter	5-24
V-lip Redhorse	5-31
Warpaint Shiner	5-55
White Catfish	5-31
Whitemouth Shiner	5-51
Whitetail Shiner	5-55

Marine Fish

Atlantic croaker.....	6-1
Atlantic spadefish.....	6-6
Bay anchovy.....	6-11
Blackcheek tonguefish	6-63
Cobia	6-13
Crevalle jack	6-18
Finetooth shark.....	6-20
Gag	6-24
Gulf kingfish	6-31
Hardhead catfish.....	6-28
Lined Seahorse.....	6-34
Mummichog.....	6-37
Naked goby	6-39
Northern kingfish	6-31

Off-shore tonguefish	6-63
Sailfin molly	6-43
Sheepshead.....	6-45
Southern flounder.....	6-50
Southern kingfish	6-31
Spot	6-53
Striped killifish.....	6-55
Striped mullet.....	6-57
Tarpon	6-60

Crayfish

Broad River Spiny Crayfish	7-1
<i>Cambarus reflexus</i>	7-5
<i>Cambarus</i> sp. "B"	7-6
<i>Distocambarus crockery</i>	7-8
<i>Distocambarus hunteri</i>	7-9
<i>Distocambarus youngineri</i>	7-11
Ditch Fencing Crayfish	7-2
Edisto Crayfish.....	7-3
Mimic Crayfish	7-4
Oconee Stream Crayfish	7-20
Pee Dee Lotic Crayfish	7-21
<i>Procambarus barbatus</i>	7-12
<i>Procambarus chacei</i>	7-14
<i>Procambarus echinatus</i>	7-15
<i>Procambarus enoplosternum</i>	7-16
<i>Procambarus hirsutus</i>	7-17
<i>Procambarus lunzi</i>	7-18
<i>Procambarus pubescens</i>	7-19
Red Burrowing Crayfish	7-22
Rocky River Stream Crayfish.....	7-23
Sandhills Crayfish	7-24
Santee Crayfish	7-26
Waccamaw Crayfish.....	7-27

Freshwater Mussels

Alewite Floater	8-1
Atlantic Pigtoe	8-2
Atlantic Spike.....	8-4
Barrel Floater	8-5
Brook Floater	8-7
Brother Spike	8-8
Carolina Creekshell.....	8-10
Carolina Heelsplitter	8-12
Carolina Lance	8-14
Carolina Slabshell	8-15

Creepers	8-17
Eastern Creekshell	8-19
Eastern Elliptio.....	8-21
Eastern Pondmussel	8-22
Northern Lance	8-24
Notched Rainbow	8-26
Pod Lance.....	8-27
Rayed Pink Fatmucket/ Eastern Lampshell.....	8-29
Roanoke Slabshell.....	8-31
Savannah Lilliput	8-33
Southern Rainbow.....	8-35
Tidewater Mucket	8-37
Triangle Floater.....	8-39
Variable Spike	8-40
Waccamaw Spike	8-42
Yellow Lampmussel.....	8-44

Freshwater Snails

Pebblesnail	9-2
Buffalo Pebblesnail	9-1
Ridged Lioplax.....	9-5
<i>Physa</i> sp. nov "A"	9-4

Insects

American Sand Burrowing Mayfly	10-1
Black Fly	10-5
Calvert's Emerald.....	10-7
Coyle's Purseweb Spider	10-9
Diana Fritillary	10-11
Elephant (or Treehole) Predatory Mosquito	10-13
Forestiera Lace Bugs.....	10-16
Moretti's Caddisfly	10-18
Moth species	10-21
Pointy-lobed Firefly	10-23
Pyramid Ants.....	10-26
Sandhills Earth Boring Scarab Beetle.....	10-28
Smokies Needlefly	10-29
White Beach Tiger Beetle	10-32
Zigadenus Sawfly	10-34

Marine Invertebrates

Atlantic ghost crab	11-1
Brackish grass shrimp	11-20
Brief squid.....	11-4

Cannonball jellyfish	11-7
Colorful sea whip	11-11
Coquina clam	11-14
Daggerblade grass shrimp	11-20
Hard clams	11-24
Horseshoe crab	11-28
Knobbed whelk	11-31
Marsh grass shrimp	11-20
Marsh periwinkle	11-34
Mud fiddler crab	11-16
Ohio shrimp	11-36
Redjointed fiddler crab	11-16
Ribbed mussel	11-39
Sand fiddler crab	11-16
Stone crab	11-42

CHAPTER 1: MAMMALS

Appalachian Cottontail

Sylvilagus obscurus

Contributors: Mary Bunch, Rickie Davis, Stanlee Miller and Rob Harrison

Description

Taxonomy and Basic Description

Appalachian cottontails were recently described by Chapman, Cramer, Deppenaar, and Robinson in 1992. The species was previously known as New England cottontail (*Sylvilagus transitionalis*) but was reclassified to Appalachian cottontail (*Sylvilagus obscurus*) based on chromosome number and exacting skull measurements. Ruedas et al. (1989) described the southern cytotype, now known as the Appalachian cottontail (Chapman et al. 1992), as having a smaller diploid chromosome complement than the northern cytotype (the New England cottontail) (46 and 52, respectively). Although analysis of a region of mitochondrial DNA does not support the new species designation (Litvaitis et al. 1997), the Integrated Taxonomic Information System (USDA 2005) recognizes the new designation.

New England and Appalachian cottontails are indistinguishable without cranial examination or karyotyping (Chapman et al. 1992). The two are distinguished in the field by geographical location rather than by external features; those that occur south or west of the Hudson River in New York are Appalachian cottontails.

As with all “cottontails,” including the sympatric eastern cottontail (*Sylvilagus floridanus*), the underside of the Appalachian’s tail is white. The fur is rusty-brown with black hairs. There are seldom any white hairs on the forehead and the ears are somewhat rounded (Chapman 1975) and less ‘mulish’ in appearance than eastern cottontails. Sometimes the anterior ear margin is black or very dark in sharp contrast to the white hairs inside. Eastern cottontails have a rusty orange patch at the nape of the neck and often have the appearance of a dark saddle across their backs (Chapman 1975); the Appalachian cottontail has a reddish nape patch but is more uniformly dark. Live specimens have a very dark iris relative to eastern cottontails (Bunch and Dye 1999). Appalachian cottontails have a diffuse gray cheek patch, lacking in the eastern cottontail. The most reliable characteristic to distinguish Appalachian from eastern cottontails is the presence of a dark patch between the ears in Appalachian cottontails (Litvaitis et al. 1991; Chapman et al. 1992). These differences between the eastern and Appalachian cottontails are so subtle that identification usually requires handling of the animal. These two species are easily distinguished by skull characteristics (Chapman 1975).

The Appalachian cottontail is the smallest rabbit species in the southeast; adults weigh 0.8 to 1.1 kg (1.75 to 2.42 pounds). They range in total length from 386 to 430 mm (15.5 to 17 inches), with an average ear length of about 58 mm (2.3 inches) (Chapman 1975). Weights of South Carolina specimens in the Campbell Museum of Natural History at Clemson University average 1.05 kg (2.32 pounds).

Status

In South Carolina, Appalachian cottontails are considered as uncommon or rare (S3). They are also considered rare in Georgia (Ozier 1999), Tennessee and North Carolina (NatureServe 2004).

NatureServe (2004) recognizes the species as *Sylvilagus transitionalis*; the global rank under that designation is apparently secure (G4). The fact that populations that occur in South Carolina are at the limit of the range of the species increases the responsibility of SCDNR to monitor the status of the population. Any changes to the viability of the species might likely occur on the periphery of its range.

Population Size and Distribution

Appalachian cottontails occur in mountain habitat and range from the Hudson River in New York, southward through Pennsylvania and Maryland, and continue southward in the Appalachian Mountains into northwestern South Carolina, northern Georgia and Alabama. Appalachian cottontails are better adapted to colder climates than eastern cottontails (Chapman et al. 1977). The Blue Ridge escarpment represents the extreme southeastern extent of the range for Appalachian cottontails.



The noncontiguous arrangement of Appalachian cottontails in the southeast is described as a mosaic distribution (Chapman et al. 1992). In South Carolina, the species is found only in the mountains of the three northwestern counties at elevations as low as 274 m (900 feet), but more typically above 487 m (1600 feet) (Bunch and Dye 1999). The Blue Ridge Mountain province in South Carolina has elevations between 365 and 1066 m (1,200 and 3,500 feet) above sea level (Myers et al. 1986). Appalachian cottontails are restricted to the southern Appalachian ecoregion in South Carolina, which comprises only 1.7 percent of the state's total land area (Myers et al. 1986).

Distribution is patchy across the mountains of Oconee, Pickens and Greenville Counties. Suitable habitat is not uniform and continuous throughout the mountains. However, the Appalachian cottontail does not occur in all suitable mountain habitats. Some sites that appear suitable based on cover, forage and elevation are occupied by eastern cottontails, both eastern and Appalachian cottontails or no rabbits at all. Therefore, estimates of Appalachian cottontail populations cannot be extrapolated using remote sensing such as aerial photographs to identify habitat.

Density estimates have not been made for this rabbit in the southern end of their range; however, densities in South Carolina are expected to be similar to those found in other states. A density estimate from Virginia approximates one rabbit per two hectares in six to seven year-old clearcuts (Blymer 1976). Laseter (1999) estimated a density of 0.8 rabbits per hectare in eastern Tennessee. In western Maryland, home ranges are identified as 2 to 10 hectares (4.9 to 24.7 acres) for females and 4 to 9 hectares (9.9 to 22.2 acres) for males (Sommer 1997).

Habitat and Natural Community Requirements

Ericaceous cover (heath-like plants) is a component of all sites occupied by Appalachian cottontails in the state (Bunch et al. 1997), which is consistent with previous reported requirements (Chapman et al. 1992). The cover varies and includes mountain laurel (*Kalmia latifolia*), blueberries (*Vaccinium* spp.), blackberry vines (*Rubus* spp.), greenbrier (*Smilax* spp.) and cane (*Arundinaria gigantea*). Sites with Appalachian cottontails range from ridgetops of pine-heath communities to mixed pine hardwoods and extend down slopes into riparian sites (Paul and Quay 1963). Forest or stand ages vary and include young clearcuts and pine plantations

less than 4 years old; overstocked pine plantations approaching thinning age; and mature pine, pine-hardwood and hardwood forests (Bunch et al. 1997; Bunch and Dye 1999). Appalachian cottontails have not been noted in pastures, orchards or wildlife plots, but have been captured near the edges of linear food plots. Sole (1999) reported captures at reclaimed mine sites.

Good rabbit habitat is not thoroughly understood. Reproduction and rabbit health have been linked to salt availability (McCready and Weeks 1992), stem density and quality (Lochmiller et al. 1995) and availability of cover (Barbour and Litvaitis 1993; Smith and Litvaitis 2001). Appalachian cottontails require dense understory vegetation (Laseter, 1999). Appalachian cottontails consume more forbs and are less dependent on grasses than eastern cottontails. However, both rabbits eat significant amounts of woody material in the winter (Spencer and Chapman 1986).

Challenges

Due to regional differences between habitats in the southern Appalachian mountains and the New England area, management needs for the Appalachian cottontail are likely very different from management needs for the New England cottontail. Therefore, lack of species-specific makes it difficult to successfully manage for the Appalachian cottontail.

Small patch size (less than 2.5 hectares or 6.1 acres) and habitat fragmentation are known to lead to low survival rates of New England cottontails (Barbour and Litvaitis 1993). Habitat fragmentation, often due to development, may limit Appalachian cottontails to public lands with extensive private inholdings and to areas where large public tracts are separated by private holdings; such areas currently exist in northeastern Greenville County.

Indirect displacement by eastern cottontails is a possible threat, particularly where both species are found sympatrically and permanent clearing takes place for pastures, lawns, orchards, golf courses and housing developments. Eastern cottontails benefit more from grasses (Spencer and Chapman 1986) and large grassy areas than Appalachian cottontails; the latter needs more cover (Litvaitis et al. 1985; Barbour and Litvaitis 1993; Sommer 1997). Although eastern cottontails are not capable of evicting New England cottontails from occupied habitats and vice versa (Probert and Litvaitis 1996), once habitats are modified to favor eastern cottontails and they move into the site, it is unlikely that New England cottontails will displace them. Because Appalachian cottontails are similar to New England cottontails behaviorally and in cover and habitat requirements (Tefft and Chapman 1987; Probert and Litvaitis 1996), they are expected to respond similarly.

Hunting is not known to adversely affect the species in South Carolina; however, pregnant and lactating rabbits have been captured in February before the end of hunting season on March 1. Species-specific rabbit hunting data are not currently collected and small game hunting pressure is believed to be light in the mountains. However, it is currently legal to possess and move all native rabbit species in the state of South Carolina. Release of eastern cottontails into habitat of Appalachian cottontails remains a threat of undetermined proportion or likelihood. Historically, moving and releasing rabbits was a common practice (Chapman and Fuller 1975). Once eastern cottontails are established, they cannot be displaced via interspecific competition. Eastern cottontails can colonize neighboring disturbance patches more quickly than Appalachians because the latter requires dense cover in close proximity while eastern cottontails are well adapted to foraging in open areas (Smith and Litvaitis 2000). Therefore the eastern cottontail more easily accesses new habitat (Probert and Litvaitis 1996).

Cottontails are taken by a wide variety of predators including cats, dogs, coyotes, foxes, bobcats, mink, weasels, birds of prey and snakes. Any activity that increases the density of predators, or any changes in habitat that make Appalachian cottontails more vulnerable to predation (Litvaitis and Villafuerte 1996), are a threat.

Conservation Accomplishments

The species was first documented in South Carolina by a 1940 museum specimen collected by W. Perrygo and J. Hoyt. In the 1980's, the South Carolina Department of Natural Resources (SCDNR), initiated survey work with Check for Wildlife funds to verify the species' presence in South Carolina.

SCDNR tested a discriminate model developed by Litvaitis et al. (1991) for field identification of Appalachian (then known as New England) cottontails. Identifications were confirmed by mtDNA analysis and skull characteristics. The model was 77.7 percent accurate on southeastern specimens. One consistent external feature was the black spot or strip between the ears in Appalachian cottontails (Bunch and Dye 1999).

A study was conducted in the Sumter National Forest to assess whether Appalachian cottontails would be displaced after timber harvest in a mature pine-hardwood forest. This forest was adjacent to or near two habitats: a young clear cut and an orchard, which were occupied by eastern cottontails. The mature pine-hardwood stand was cut and burned. Eastern cottontails used the site as it regenerated and Appalachian cottontails did not reappear at the site until seven years after site regeneration (Bunch and Dye 1999).

In South Carolina, a significant amount of appropriate Appalachian cottontail habitat in the southern Appalachian ecoregion is on public land or is otherwise protected, including the Andrew Pickens Ranger District of the Sumter National Forest, ten Heritage Preserves and the Jocassee Gorges; the latter is managed by SCDNR. Suitable habitat is also on several large state parks and some tracts owned or held in easement by various land trusts, including over 12,140 ha (30,000 acres) of mountain land under a conservation easement held by The Nature Conservancy. Over 65,559 ha (162,000 acres) of mountain lands are protected in some capacity.

Conservation Recommendations

- Encourage land acquisitions or conservation easements, which will provide mountain habitat linkage. Consider regional partnerships for habitat protection in the Blue Ridge Escarpment.
- Discourage or avoid creation of new permanent early successional habitat on mountain sites on public lands adjacent to existing populations of eastern cottontails until the impact of eastern cottontails on Appalachian cottontails is better understood.
- Evaluate the impact of hunting on Appalachian cottontails. Breeding condition should also be noted in harvested animals to evaluate seasons and bag limits. If rabbit identification by hunters is unreliable, heads and tissue samples can be collected and used to improve accuracy.
- Conduct an ecoregion-wide Appalachian cottontail distributional and density survey using mtDNA analysis of fresh fecal pellets.
- Partner with states throughout the entire range of both Appalachian and New England cottontails to provide materials and samples for expanded mtDNA analysis of these rabbit

populations and support nuclear genome analysis for these species.

- Determine best management practices for Appalachian cottontails in the southeast through habitat measurements and manipulations.
- Measure the effectiveness of salt licks and fertilizing sites on Appalachian cottontail condition and reproduction.
- Evaluate prescribed burning as a tool for proper habitat management.
- Periodically survey selected sites for Appalachian and eastern cottontails.
- Discourage moving and releasing eastern cottontails.
- A demonstration area for Appalachian cottontails could be developed in the mountains in conjunction with efforts to highlight other species of conservation concern in South Carolina. This demonstration area would also provide research opportunities for new information on management and ecological needs of the species.
- Develop web links and educational materials to help educate the public about wildlife diversity, especially that of rabbits, in the mountain ecosystems.

Measurements of Success

Surveys of distribution and density, paired with long-term monitoring of harvests and use at specific sites will help assign status information to the species and set appropriate harvest limits and seasons. Researching the effects of controlled burns and supplemental salt will help public and private landowners know if those actions will benefit Appalachian cottontails.

Black Bear

Ursus americanus

Contributors: Skip Still and Jay Butfiloski

Description

Taxonomy and Basic Description

Pallas first described the American black bear in 1780. Black bears are the most common bear in North America, occurring in 39 of the 50 United States and throughout Canada. Usually covered in a shaggy black coat, these bears can vary in color depending on subspecies. Bears found west of the Mississippi River range from white, through chocolate, cinnamon and blonde while those found east of the river are typically black. Occasionally, the bears will display a white chest blaze as well (Wilson and Reeder 1993).

Black bears are typically 1.5 m (5 feet) long (Wilson and Burnie 2001). In South Carolina, the average adult male weighs between 82 and 159 kg (180 and 350 pounds) (Willey 1995; Harter 2001); however there are some harvest reports of bears exceeding 226 kg (500 pounds) (SCDNR unpubl. data). Adult female average weights are between 56 and 69 kg (123 and 152 pounds). Cubs usually weigh between 200 and 450 g (7 ounces to 1 pound) at birth. These bears have small eyes and rounded ears with a long snout and prehensile lips. Their ears are usually more erect than those of the brown bear (*Ursus arctos*), and they lack the characteristic shoulder hump of that species (Wilson and Burnie 2001).

Black bears can stand and walk on their hind legs but usually move about on four legs. Their hind

legs are slightly longer than their front, giving the bear a flat-footed, slightly shuffling gait. Each paw has five sharp claws for digging, tearing and climbing. The black can sustain enough force with a front paw swipe to kill an adult deer. Ninety-five percent of this bear's diet, however, is vegetarian including nuts, roots, berries, shoots buds and fruits. They may become accomplished fishers or feed on fawns when other foods are sparse (Wilson and Reeder 1993).

Status

Black bear populations are described as vulnerable (S3) in South Carolina and secure globally (G5) (NatureServe 2005). There are two populations of black bear in South Carolina: one is located in the mountainous region along the South Carolina/North Carolina border and the other in the upper coastal plain. Black bear in the mountains of South Carolina seem to be expanding their range southward and westward and their population is increasing. The upper coastal plain population is presently stable. However, loss of viable habitat through land conversion threatens the status of this species within South Carolina.



Population Size and Distribution

The mountain black bear population of South Carolina is located primarily in Oconee, Pickens, Greenville and Spartanburg Counties; the coastal population is found in Georgetown and Horry Counties.

In 1999, a study was initiated to determine general biological characteristics of black bears in the northern coastal plain of South Carolina. With known movements of captured bears into North Carolina and suspected movements of North Carolina bears into South Carolina, researchers felt this population estimate was low (Harter 2001). There were 25 and 19 road kills in the coastal area for 2003 and 2004, respectively. Forty-nine complaints resulted in one bear relocation in the lowcountry in 2004 with no data available for 2003.

Black bear populations in the upstate region of South Carolina are increasing and expanding. A recently completed interstate and interagency study conducted in a section of the mountains of North Carolina, South Carolina and Georgia indicated a preliminary population estimate of approximately one bear per square mile. (Settlage et al. 2004) This study would indicate that approximately 900 bears are located in the upstate. Previous estimates had been 300 to 500 bears.

There are an estimated 200 to 250 bears established in roughly 300,000 acres of occupied bear habitat in Horry, Georgetown and Marion Counties. Of that habitat, around 44,000 acres is protected property; however, these acres are scattered and disjunct (Jamie Dozier SCDNR, pers. comm.).

Habitat and Natural Community Requirements

In coastal South Carolina, bears typically use early successional areas, bottomland hardwoods or mixed pine-hardwoods as well as Carolina bays. Areas used less often include upland hardwoods, pine plantations, existing developments or areas currently being developed.

The average home ranges of males and females in South Carolina were found to be significantly different in the coastal plain study (Harter 2001). Male home ranges averaged 80.1 km² (19,793 acres²) and female home ranges averaged 30.4 km² (7,512 acres²). Movement data also indicated that all bears reduced home range size during winter months. Average home range size was reduced 70 percent (67 percent for males and 76 percent for females) during winter months. Even though home ranges were reduced, bears continued to move throughout the year.

Home range size for the upstate population was 44.1 km² (10,897 acres²) for males and 16.6 km² (4,102 acres²) for females (Butfiloski 1996). Female bears in the upstate population utilized young yellow poplar stands less than 10 years old and riparian zones 30 to 50 years old more often than expected and used yellow poplar stands 11 to 30 years old and pine stands over 10 years old less often than expected. Analysis of road disturbance indicated a significantly greater presence of bears within 500 meters of primary logging roads in the study area before the roads were opened than after the public was allowed in the area (Butfiloski 1996).

Challenges

The primary challenge to South Carolina's bear population appears to be residential and commercial development. Human populations in the counties with existing bear populations grew 20.1 percent from 1990 to 2000. Persons per square mile averaged 213.4. Thirty-three percent of the human populations in the six counties mentioned live in a rural environment (SC Statistical Abstract 2005; US Census Bureau). Humans have varying reactions to bears but generally do not tolerate bear activity near residential or commercial development. Bear hunting has also been controversial in many states (Maryland and New Jersey Status Reports 2003).

The coastal bear population is becoming more fragmented due to highway construction, urbanization and general development. More protected contiguous acreage is available for the mountain population but human population growth and subsequent development adjacent to and between these properties may preclude expansion and fragment the population. Some areas of the state offer good bear habitat but are isolated from current bear populations by development.

Education of the general public is the key component to bear population expansion and, in some areas, survival. While bears learn to live with people, people have a hard time living around bears. Educational programs, bear-proof demonstration kits and displays and brochures are all effective.

Conservation Accomplishments

South Carolina Department of Natural Resources (SCDNR) personnel have successfully cooperated with sportsmen groups, industry, other state and federal agencies and universities to enhance black bear habitat and conduct black bear research and management in South Carolina. Cooperative efforts have included hard and soft mast surveys, black bear scent station surveys, black bear trapping and research, DNA research and analysis, nuisance bear control, bear related legislation, co-sponsoring bear related meetings, wildlife management area litter collection, educational and nature related youth events, youth hunting opportunities and shrub plantings. South Carolina is also a member of the Southern Appalachian Black Bear Study Group with three nearby states (Georgia, North Carolina and Tennessee). This group meets to discuss and monitor bear related research and activities. SCDNR acted as a leader in many of these activities but were also a cooperator in many others. Many individuals within these groups were knowledgeable of local fauna and flora. Cooperative projects satisfied their need to be actively associated with enhancing the black bear and generally aligned them with SCDNR.

Cooperators were also more inclined to protect the resource they actively surveyed and managed. Data collected has been consistent with SCDNR data collection and no known data bias has occurred. Benefits to the SCDNR included the ability to draw upon local knowledge, funding, constituency support, interaction with other knowledgeable groups, education, area protection and enhanced data. Cooperator benefits included interaction with SCDNR personnel, educational opportunities, publicity, hands on projects, improved public image and increased industry employee moral. Cooperation with other state and federal agencies has allowed for a pooling of data, manpower and equipment, funding opportunities and information sharing. Cooperators included US Forest Service, Clemson University, University of Tennessee, Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency and North Carolina Department of Environment and Natural Resources, South Carolina Department of Parks, Recreation and Tourism, South Carolina Department of Transportation, Upper South Carolina Bearhunters and Houndsmen Association, Oconee County Bearhunters, South Carolina Sporting Protection League, Duke Power Company, Crescent Resources, Fluor Daniel Company, Davis and Floyd Inc., Hobbs & Upchurch Company and local Boy Scout troops. These activities and cooperators have greatly enhanced knowledge and habitats related to the black bear in South Carolina.

SCDNR personnel in cooperation with the National Wild Turkey Federation, US Forest Service, and others annually plant approximately 50 acres of wildlife openings in bear range. About 250,000 acres of bear habitat in South Carolina is publicly owned. Considerable work has been completed to improve access roads in the Jocassee Gorges, which is a 32,000-acre area owned by SCDNR. SCDNR personnel serve on the Southern Appalachian Black Bear Committee and the Southeastern Black Bear Committee. Posters on “Cooperative Black Bear Management Activities of the South Carolina Department of Natural Resources” were presented at the International Bear Conference and the Southeastern Association of Wildlife and Freshwater Fisheries Conference during 2004.

SCDNR was also part of a multi-state and agency research project to look at the effectiveness of DNA sampling to monitor black bear abundance in the southern Appalachians. Partners included the natural resource agencies of Georgia, North Carolina, and Tennessee as well as the University of Tennessee, US Geological Survey and US Forest Service. This pilot study was initiated during the summer of 2003 to determine whether genetic sampling for population estimation was feasible and to develop appropriate sampling regimes to obtain desired levels of precision. The overall goal of this study was to establish the proper sampling regimes and protocols for the southern Appalachian region and provide baseline population abundance estimates. The study area was divided into two sections based on relative densities of black bears in the region, the northern study area in the northwest portion of Great Smoky Mountains National Park in Tennessee and the southern study area on national forest lands in Georgia, South Carolina and North Carolina. Hair-sample sites consist of a barbed-wire enclosure with bait. Sites were checked for samples once a week for ten weeks and each hair sample with more than five hairs was collected. Twenty-eight of these sample sites were located in South Carolina. Results of this study should be available during the summer of 2005. A poster entitled “Effectiveness of DNA Sampling to Monitor Black Bear Abundance in the Southern Appalachians” (Settlage et al. 2004) was presented at the Southeastern Association of Wildlife and Freshwater Fisheries Conference. Results of this study indicated approximately one bear per square mile.

The vast majority of survey, study, cooperative efforts and research in South Carolina have been done in the upstate area. The Harter study (2001) has been the only major study completed

on coastal bear. Various survey techniques have been tried with little success on the coastal population. New methodologies such as the DNA studies may be successful but are expensive and time consuming.

Conservation Recommendations

- Distribute educational brochures and posters.
- Place bear-proof trashcans and food lockers at all public facilities in bear habitat.
- Consider initiation of a program encouraging private housing and industry in bear areas to use bear-proof trashcans and food lockers.
- Continue or initiate DNA studies of bear populations in both the coastal plain and mountain ecoregions.
- Initiate studies of bear travel corridors in the coastal plain and zone ecoregions.
- Consider land acquisition to connect isolated populations of black bear.
- Consider a multi-phase project of repatriation of bear to other regions of the state including efforts to survey human concerns and education of landowners. Facilitate such repatriation with long-term monitoring.

Measures of Success

A reduction in nuisance complaints would indicate a successful education program. Bear sightings and reproduction in other areas would suggest an expanding population. Use of bear-proof containers could be easily measured through survey. Repatriation success could be measured in successfully reproducing bear that are staying in the repatriation area without sufficient human conflict.

Bottlenose Dolphin

Tursiops truncatus

Contributors: David Cupka and Margaret Murphy

Description

Taxonomy and Basic Description

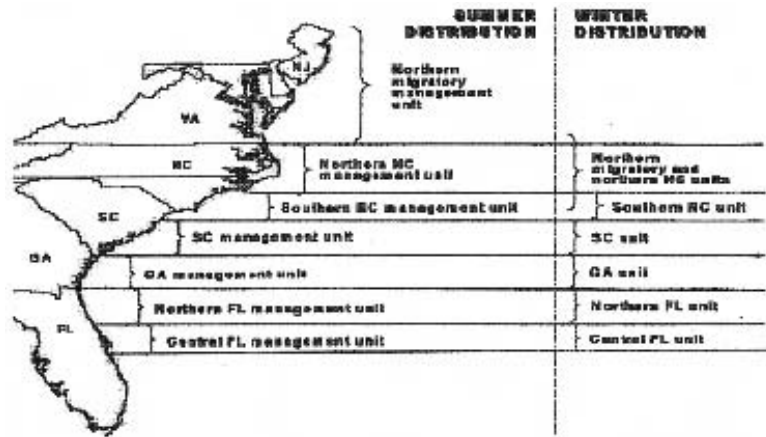
The bottlenose dolphin, *Tursiops truncatus*, was first described by Montagu in 1821. Currently most researchers agree that there is a single species, *Tursiops truncatus*, with a number of regional forms. The body and head are robust with a short, thick, well-defined beak. Based on distribution, genetics, morphology, parasites and prey items, two “ecotypes” are recognized; the “coastal form” is shorter and slimmer than the larger “offshore form.” The flippers are pointed with deeply notched flukes. The teeth are small and conical and number between 40 to 52 in the upper row and 36 to 48 in the lower row. The dorsal fin, located mid-back, is tall and falcate with a broad base. Adult size varies considerably, ranging from 1.9 to 3.6 m (6 to 12 feet) (Wynne & Schwartz 1999). The bottlenose has been reported to weigh up to 650 kg (1,432 lb) (Minasian et al. 1984).

Status

The bottlenose dolphin is not listed as threatened or endangered under the Endangered Species Act (ESA). In 1993, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service

(National Marine Fisheries Service or NMFS), treating the coastal population as a single migratory stock, designated the stock as “strategic” under the Marine Mammal Protection Act (MMPA). The action was due to a massive die-off of coastal bottlenose dolphins between 1987 and 1988 (Waring et al. 2002). From 1995 through 2001, the NMFS recognized only a single migratory stock

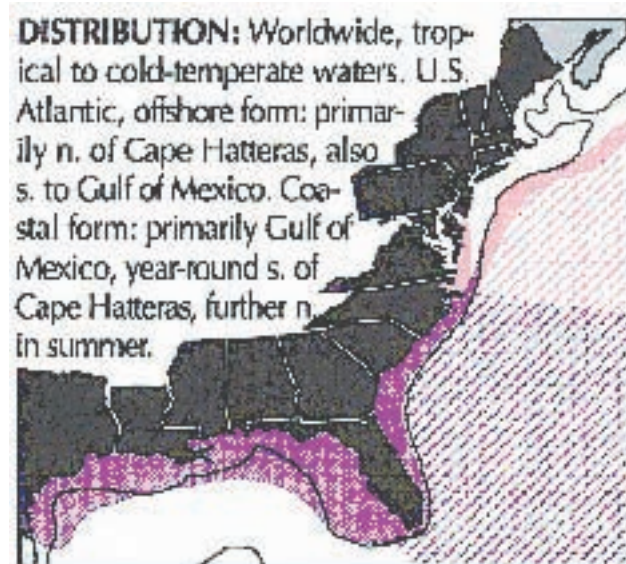
of coastal bottlenose dolphins in the western North Atlantic; therefore, the entire stock was listed as depleted. Separate management units have recently been recognized as an interim measure, pending additional research to better identify stock structure. Seven management units within the range of the “coastal migratory stock” have been defined and are illustrated in the figure below (Hohn 1997). These management units now replace the single coastal migratory stock assumption. Because one or more of the management units may be depleted, all management units retain the depleted designation. Even though the bottlenose dolphin is the most common marine mammal along the U.S. southeastern coast, certain coastal stocks do appear to be depleted based on the most recent stock assessments (Waring et al. 2002; MMC 2004).



The western North Atlantic offshore bottlenose dolphin (offshore ecotype) is also not listed as threatened or endangered under the ESA. Potential Biological Removal level or PBR is an estimate of the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its Optimum Sustainable Population (OSP). PBR's are established under the MMPA. The average annual fishery-related mortality and serious injury for western North Atlantic offshore bottlenose dolphin from 1996 to 2000 does not exceed the PBR of 242 animals; therefore this is not a strategic stock under the MMPA. However, the total fishery related mortality and serious injury for this stock is not less than 10 percent of the calculated PBR; therefore, this stock cannot be considered to be insignificant or approaching zero mortality and serious injury rate.

Population Distribution and Size

Two bottlenose dolphin ecotypes inhabit waters in the western North Atlantic Ocean: a shallow water or nearshore/coastal ecotype and a deep water or offshore ecotype (Curry and Smith 1997). Based on work to date, it appears that the western North Atlantic offshore stock consists primarily of the offshore ecotype. Relatively little is known about the distribution of the offshore ecotype



Map from Winne & Scharzt, 1999

except that it is typically concentrated along the continental shelf break in deeper waters and can, in lower concentrations, extend beyond the continental shelf into continental slope waters (Kenney 1990). Although the ranges of the coastal and offshore ecotypes overlap to some degree, Torres et al. (2003) found a statistically significant break in the distribution of the two ecotypes at 34 km (18 nautical miles) from shore. Torres reports that the offshore ecotype is found seaward of 34 km and in waters deeper than 34 m (112 feet), and the coastal ecotype is found within 7.5 km (4 nautical miles) offshore. The best available abundance for the offshore stock of bottlenose dolphins is 29,774 animals (northern U.S. Atlantic: 16,689; southern U.S. Atlantic: 13,085). Data are insufficient to determine current population trends for the offshore stock (Waring et al. 2004).

The coastal ecotype is continuously distributed along the Atlantic coast south of Long Island, around peninsula Florida, and along the Gulf of Mexico coast. However, based on genetic studies, Curry (1997) concluded that the nearshore animals in the northern Gulf of Mexico and the western North Atlantic are separate stocks. Within the western North Atlantic, the stock structure of coastal bottlenose dolphins is complex. Efforts to distinguish stocks are complicated by the fact that animals from different stocks cannot be separated on the basis of appearance and by the fact that different stocks sometimes have geographic ranges that overlap temporally and spatially (MMC 2004). Preliminary results from studies involving genetics, photo-identification, telemetry and stable isotopes suggest the existence of at least seven stocks of the coastal ecotype in the western North Atlantic from which the current management units were defined (Waring et al. 2002). Estimates of abundance for each management unit of western North Atlantic coastal bottlenose dolphins during the summer (May through October) are as follows: Northern migratory (5681); Northern NC oceanic (3,383); Northern NC estuary (919); Northern NC both (4,302); Southern NC oceanic (1,157); Southern NC estuary (141); and Southern NC both (1,298). Estimates of abundance for the winter (November through April) are: NC mixed (includes northern migratory, Northern NC and Southern NC) (6,474); South Carolina (3,513); Georgia (767); Northern Florida (354); and Central Florida (10,652). There are insufficient data to determine the population trend for the coastal bottlenose dolphin stock (Waring et al. 2002).

Habitat and Natural Community Requirements

Bottlenose dolphins are both a coastal and an oceanic species, with the coastal ecotype preferring waters of less than 30 meters (98 feet) in depth. The habitats they occupy are diverse, ranging from rocky reefs to calm lagoons and open waters. The coastal ecotype is adapted for warm shallow waters. Its smaller body and larger flippers suggest increased maneuverability and heat dissipation. These dolphins occur along the outer coastline and in bays, sounds, inlets, estuaries and other inland waters (Hersh and Duffield 1990).

The offshore ecotype seems to be adapted for cooler, deeper waters. Certain characteristics of their blood indicate that this form may be better suited for deep diving. They typically occur in deep waters of the continental shelf and inner continental slope (Hersh and Duffield 1990).

Challenges

A variety of factors both natural and human-related can affect bottlenose dolphins. Natural factors include predation by large sharks, disease, parasites, exposure to naturally occurring biotoxins, changes in prey availability and reduction or loss of habitat due to environmental variation. Human-related causes of mortality and injury to this species include loss of habitat due to coastal development, exposure to pollutants, vessel strikes, entanglement in debris, noise and pollution related to oil and gas development. Bottlenose dolphins have also increasingly become

the target of dolphin watching and wild dolphin interaction programs. There is growing concern that these activities may result in altered behavioral patterns, especially where people enter the water with dolphins and where they are fed. In the latter case, behavioral patterns are altered significantly and increased aggression may occur (Bryant 1994).

In addition, recreational and commercial fisheries directly and indirectly affect bottlenose dolphins. Coastal bottlenose dolphins are taken as bycatch in various kinds of fishing gear including gillnets, seines, longlines, shrimp trawls and crab pots (Waring et al. 2002). Bycatch of offshore bottlenose dolphins has been observed in the pelagic drift gillnet, pelagic pair trawl, New England multispecies sink gillnet, North Atlantic bottom trawl, mid-Atlantic coastal gillnet and pelagic longline fisheries. The pelagic drift gillnets and pelagic pair trawl fisheries no longer exist. Mortalities of bottlenose dolphins due to ingestion of hooks and/or line have also been documented (Gorzeleny 1998; Well et al. 1998). The gear most likely had been discarded or was consumed by the dolphin by eating a fish that had been hooked then broke away with the gear. Estimates of fishery-attributed interactions suggest that mortality exceeds the PBR of several coastal stocks considered depleted by the 1987 through 1988 die-off and, thus, may be impeding their recovery.

Conservation Accomplishments

SCDNR and South Atlantic Fishery Management Council (SAFMC) personnel serve as members of the Bottlenose Dolphin Take Reduction Team (BDTRT), which was convened in 2001. The BDTRT works with NOAA Fisheries to develop the Bottlenose Dolphin Take Reduction Plan (BDTRP) for coastal stocks. The short term goal of the plan is to reduce, within six months of its implementation, the incidental mortality or serious injury of western North Atlantic coastal bottlenose dolphins incidentally taken in commercial fishing operations to levels less than the potential biological removal (PBR) level. The long term goal of the take reduction plan is to reduce, within five years of plan implementation, incidental mortality and serious injury of coastal bottlenose dolphins incidentally taken in the course of commercial fishing operations to insignificant levels approaching a zero mortality rate goal (ZMRG). The BDTRT has developed a number of recommendations to achieve these goals and to be incorporated into the BDTRP. The National Marine Fisheries Service is currently in the process of developing a regulatory package based on the BDTRT's recommendations and public comment to implement the recommendations of the BDTRT and the provisions of the BDTRP.

The BDTRT has made a number of recommendations to be incorporated into the BDTRP for coastal stocks including regulatory suggestions, based on management units, which apply to specific fisheries. Generally, these recommendations seek to reduce soak times, the amount of fishing gear in the water at any given time, or to modify practices in order to limit interactions with and the take of bottlenose dolphins. The BDTRT also adopted non-regulatory recommendations for all management units including education and outreach, as well as improved research, monitoring, collection of strandings data, and observer coverage. The finalized specific recommendations will be published shortly and SCDNR will continue to explore avenues to implement these recommendations working together with members of the BDTRT as funding opportunities become available.

SCDNR has been conducting a marine mammals stranding program since 1991 in order to obtain data on marine mammals that strand along the South Carolina coast. Last year, we applied for and obtained a Prescott Grant for \$87,000 to continue our stranding program. Data from the program are used to further our knowledge regarding these animals and the extent to which anthropogenic

factors are responsible for or contribute to their stranding.

Conservation Recommendations

- Improve understanding of stock structure and population trends in order to assess the greatest threats to bottlenose dolphins.
- Determine the significance of periodic die-offs especially to relatively small, isolated populations of bottlenose dolphins.
- Assess the impact of contaminants on marine mammals, particularly the repercussions of high contaminant loads in individual bottlenose dolphins as well as their offspring.
- Measure the effects of interactions between humans and dolphins in the wild, including behavioral disruption, habituation, injury and death.
- Mitigate threats to bottlenose dolphins posed by entanglement in fishing gear through support of methods proposed by the BDTRT
- Continue to explore avenues to partner in implementation of recommendations to be published by the BDTRT

Measurements of Success

A take reduction plan has been developed for coastal bottlenose dolphins to reduce the incidental take of animals in commercial fishing operations to below the Potential Biological Removal (PBR) level. SCDNR personnel will continue to serve on the BDTRT in order to help develop and implement programs and activities designed to reduce bottlenose dolphin non-natural mortalities to insignificant levels approaching a zero mortality and serious injury rate (the Zero Mortality Rate Goal or ZMRG).

Carolina Red-backed Vole

Clethrionomys gapperi carolinensis

Contributors: Edward Pivorun and Mary Bunch.

Description

Taxonomy and Basic Description

The red-backed vole was first described by Vigors in 1830 and is readily distinguished from the other voles in South Carolina by the presence of a reddish dorsal pelage, with grayish sides and a silvery white to pale yellow underside pelage. The reddish color is usually present as a broad band running from the forehead to the rump. The tail is bi-colored. The ears are relatively prominent and extend above the fur. Young voles are gray until their post-juvenile molt, which occurs at approximately 30 days of age. There is no sexual dimorphism. Adult length is 116 to 172 mm (4.57 to 6.77 inches) with a tail length of 30 to 50 mm (1.18 to 1.98 inches). Adult weight varies from 14 to 42 g (0.49 to 1.48 ounces). In general, the animals from the Appalachians are larger than their northern counterparts (Whitaker and Hamilton 1998).

The subspecies of red-backed vole that occurs in South Carolina is the Carolina red-backed vole, *Clethrionomys gapperi carolinensis*. The separation line between *C.g. carolinensis* and *Clethrionomys gapperi gapperi* is farther to the north in Virginia and West Virginia is not well understood (Whitaker and Hamilton 1998).

Status

This species is tracked by the South Carolina Department of Natural Resources (SCDNR) Heritage Trust database and is of special concern in South Carolina. The state rank for the red-backed vole is S2/S3, which indicates it is rare; the factor that makes the species vulnerable is the limitation of suitable habitat within South Carolina. This species has a global rank of secure (G5) (NatureServe 2004). The red-backed vole is apparently secure in West Virginia, Tennessee and North Carolina (NatureServe 2004). Georgia and Kentucky have designated it as vulnerable. Southern red-backed voles are included on the IUCN Red List as a species at “Lower Risk, Least Concern.” (Cook and Kirkland, Jr. 1998).

Population Size and Distribution

The southern red-backed vole is distributed throughout Canada and the northern tier of states in the US. The range of this species extends south in the Appalachian Mountains to northern Georgia (Wharton and White 1967).

There are no population estimates available in the southern Appalachian Mountains, which represent the southern end of the red-backed vole’s range.

Trapping records from collections in Highlands, North Carolina and the Smoky Mountains National Park indicate that this species can attain high densities and

maintain viable populations in suitable habitats (Pivorun, pers. obs). In addition, the population was observed to cycle over five to eight year intervals in the Highlands, North Carolina National Forest lands (Pivorun, pers. obs.); six to ten year cycles have been observed in other localities (Patric 1962). There is such a paucity of trapping records from South Carolina that no data are available on population cycles. This species was one of the most abundant mammals on the summit of Mt. Rogers in western Virginia (Linzey 1998). High-density populations are usually located at altitudes above 610 to 915 m (2,000 to 3,000 feet). The majority of suitable habitat in South Carolina is located at lower altitudes and one would expect smaller population numbers in this state. The presence of voles in South Carolina may also be dependent upon movements of voles from higher altitudes in North Carolina that occur when population cycles result in high densities in the North Carolina mountains.

The red-backed vole is restricted to the higher elevation habitats of South Carolina within the southern Appalachians ecoregion. Currently the only published records for this species are from Oconee (Pivorun et al. 1984) and Pickens Counties (Laerm et al. 1995). Suitable habitat for the Carolina red-backed vole is present in Greenville County. Current population studies are not being conducted on the distribution and abundance of this species in South Carolina.

Predators of red-backed voles include snakes, owls, foxes, bobcats and weasels. Presumably, coyotes will use these as a food source. Although these voles are prey of several species, survival of the red-backed vole population is usually not threatened by these predators.



Carolina Red-backed Vole Distribution

Habitat and Natural Community Requirements

The red-backed vole is found in the southern Appalachians ecoregion. Within that ecoregion, the vole can be found in habitat with mesic mixed forests, mesic deciduous hardwood, and high altitude coniferous forests and beech gaps. A mesic environment with an abundance of litter, rotting logs, moss covered rocks, exposed roots and rock crevices would be considered an ideal habitat. Generally, the presence of a bog area or streambed at altitudes above 762 m (2,500 feet) offers an appropriate habitat (Webster et al. 1985). Neither forest age, nor successional stage, has been reported as critical factors in determining habitat preference. Red-backed voles do not colonize post burn communities as readily as other species (Merritt and Zegler 1991) but will inhabit clear cuts (Kirkland 1990; Schloyer 1977; Martell 1983; Monthey and Soutiere 1985).

In South Carolina, red backed voles are only found in Oconee and Pickens County at altitudes above 915 m (3,000 feet) in mixed deciduous forests associated with boggy and stream bed habitats that contain rhododendron. In the Southern Appalachians, associated species include the woodland jumping mouse (*Napaeozapus insignis*), star-nosed mole (*Condylura cristata*), the hairy-tailed mole (*Parscalops breweri*) and masked shrew (*Sorex cinereus*) (Watts 1970).

The red-backed vole utilizes underground tunnels of other species such as shrews and moles for den and nest sites; they also use crevices among exposed roots and rocks for these purposes.

These voles forage along the ground and around downed trees. There is very little known about the use of subterranean fungi by this species, even though this is considered a primary food source (Fisher 1968).

Challenges

In South Carolina, a large portion of the habitat in the Blue Ridge ecoregion that is appropriate for red-backed voles is on public land, including National Forests, State Parks and SCDNR managed properties. Additionally, some lands that contain red-backed vole habitat are owned or held in easement by various land trusts. None of these properties were purchased specifically to protect the red-backed vole; however, the species benefits from acquisition and protection of its habitat. While these protected areas provide needed habitat, populations on private lands are still impacted by land conversion.

Land development in the southern Appalachians represents a major challenge to the red-backed vole. Land use in this region is rapidly changing from rural/agricultural to urban. An unpublished study conducted by SCDNR showed a 4-fold increase in development to every one-fold increase in population between 1983 and 1998 (Richard Lacy, pers. comm.). As these conversions occur, habitat for this species is being lost. Even when development proceeds in close proximity to existing red-backed vole habitat, the species may be adversely affected as these animals require relatively undisturbed habitats. Additionally, the changes in hydrology that result from urbanization will affect habitat for this species. Red-backed voles require wet areas, like bogs; these areas are expected to diminish as development continues.

Conservation Accomplishments

Terrestrial small mammal surveys that have been conducted in the South Carolina mountains have provided data to better understand habitat requirements and population dynamics of the various rodent and insectivore species. These studies were possible as a result of partnerships between several interested parties including the University of Georgia, the US Forest Service, Clemson University and SCDNR.

Conservation Recommendations

- Discourage major developments in known red-backed vole habitat in the Blue Ridge ecoregion
- Complete ecoregion-wide surveys for red-backed vole distribution and density. Surveys and survey techniques should be standardized throughout the southeast so that results and data are readily comparable. All capture data should be made available to the statewide Heritage Trust database as well as shared with neighboring states.
- Concurrent with surveys, resolve the subspecies designation for red-backed voles (*C. c. carolinensis*) and distribution using molecular data and intensive morphometric analysis. This will require cooperation or partnerships with neighboring states.
- Provide information on the ecological role and benefits of red-backed voles. This species is not considered a nuisance species. This information would allow for better management of private, state and federal lands in the montane regions of the state; management would be partially based on consideration of the impact on mammalian species that are major prey items for predators such as fox, bobcat and birds of prey.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs.

Colonial Cavity Roosting Bats

Rafinesque's Big-eared Bat *Corynorhinus rafinesquii*

Southeastern Bat *Myotis austroriparius*

Eastern Small-footed Myotis *Myotis leibii*

Contributors: Mary Bunch, Susan Loeb, Wendy Hood, Mary K. Clark and Travis Perry

Description

Taxonomy and Basic Description

Colonial bats are those that gather in groups, forming maternity and/or hibernation colonies. The colony size can vary from three to four individuals to thousands. Cavity roosting bats use cavities or crevices for shelter. Most species of South Carolina bats are colonial cavity or crevice roosting. They include Rafinesque's big-eared bats (*Corynorhinus rafinesquii*), southeastern bats (*Myotis austroriparius*), big brown bats (*Eptesicus fuscus*), evening bats (*Nycticeius humeralis*), eastern pipistrelles (*Pipistrellus subflavus*), little brown bats (*Myotis lucifugus*), northern long-eared bats (*Myotis septentrionalis*), eastern small-footed myotis (*Myotis leibii*) and Brazilian free-tailed bats (*Tadarida brasiliensis*). Three of these species, Rafinesque's big-eared bat, the eastern small-footed myotis and the southeastern myotis were determined to be of conservation concern. Rafinesque's big-eared bat was first described by Lesson in 1827; the southeastern bat by Rhoads in 1897; and the eastern small-footed myotis by Audubon and Bachman in 1842.

All South Carolina bats are nocturnal, feed on insects and navigate or locate prey by ultrasonic echolocation. Echolocation is the use of reflected sound waves to locate objects; ultrasonic

echolocation means the sound waves used are typically above the human hearing range. Reproductive productivity is low; mature female bats each produce one to four young (pups) annually in the summer. Both the Rafinesque's big-eared bat and the small-footed myotis only have a single pup; the southeastern myotis typically produces one to two young per year.

Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) have enormous ears, 27 to 37 mm (1.06 to 1.5 inches), which they fold up (deflate) while resting or hibernating. These distinctive bats have hairy toes, relatively large feet (9 to 13 mm or 0.4 to 0.5 inches) and two distinct facial glands that appear as protuberances on either side the nose. They weigh 7 to 10 g (0.24 to 0.35 ounces). Fur color in adults is a dark brown on back with dark rooted whitish hairs on the underside of the animal. Juveniles appear dark gray. The first upper incisor tooth has two cusps or points.

Previously accepted designations for Rafinesque's bats were *Corynorhinus macrotis* and *Plecotus rafinesquii* (Hall and Kelson 1959; Jones 1977). The current accepted scientific name, *Corynorhinus rafinesquii*, is based on chromosomal variation and morphometric measurements (Bogdanowicz et al. 1998). Two subspecies of Rafinesque's big-eared bats are recognized within South Carolina. *Corynorhinus rafinesquii rafinesquii* is the subspecies found in the mountains of South Carolina, North Carolina, Georgia and beyond along the Appalachian Mountains. The disjunct coastal plain populations are recognized as *C. r. macrotis*. The validity of the current subspecies designations is unknown (Piaggio and Perkins 2005; Piaggio In Review).

The Eastern small-footed myotis (*Myotis leibii*) is a monotypic species and is South Carolina's smallest bat. Adults typically weigh only 3 to 6 g (0.1 to 0.2 ounces) and have a wingspan of 212 to 247 mm (8.3 to 9.7 inches). They have distinctively small feet, only 6 to 8 mm (0.2 to 0.3 inches) long; a dark mask at the eyes; and black ears. Their fur is shiny brown on the back and whitish or buff on the belly. The wing and tail membranes, as well as the muzzle, are a dark chocolate color.

One subspecies of the southeastern myotis occurs in South Carolina: *Myotis austroriparius austroriparius*. Southeastern bats have a pinkish face or muzzle. The fur of the southeastern bat has a wooly texture and is generally a dull-grayish brown. Fur color may vary with season; some individuals have a bright reddish-orange appearance in the summer. These bats weigh 5 to 12 g (0.17 to 0.42 ounces). The hind foot is hairy and averages 10 mm (0.39 inches) long.

Status

In South Carolina, Rafinesque's big-eared bats are imperiled and are listed as state endangered (S2?). In North Carolina, they are listed as state threatened. Georgia and Kentucky rank these bats as rare or vulnerable, while Virginia, Florida and Arkansas rank them as imperiled. West Virginia considers the species to be critically imperiled. They have a global status of rare or vulnerable (G3/G4) (NatureServe 2005).

The southeastern myotis is critically imperiled in South Carolina (S1) and is designated as "in need of management." Kentucky, Virginia, and North Carolina rank the species as imperiled, while it is considered rare or vulnerable in Georgia, Tennessee and Florida. The global status of the southeastern myotis is rare or uncommon (G3/G4) (NatureServe 2005).

Eastern small-footed bats have a global rank of rare (G3) and are on the IUCN Red List in the lower risk category. In South Carolina, small-footed bats are critically imperiled (S1) and are designated as "in need of management" which equates to state threatened. Virginia, West

Virginia, Alabama and Arkansas also rank eastern small-footed bats as critically imperiled. The species is considered imperiled in Georgia, Tennessee and Kentucky and is under review in North Carolina (NatureServe 2005).

Population Size and Distribution

Rafinesque's Big-eared Bat Distribution

The coastal plain subspecies of Rafinesque's big-eared bats range from North Carolina southward along the entire coastal plain and into the sandhills of South Carolina. They extend southward through Georgia and into Florida. The mountainous subspecies of Rafinesque's big-eared bats (*C. r. rafinesquii*) are distributed along within the southern Appalachian ecoregion from West Virginia southward into South Carolina and Georgia. They also reach into Alabama. The piedmont of North and South Carolina and Georgia represents a gap in distribution.

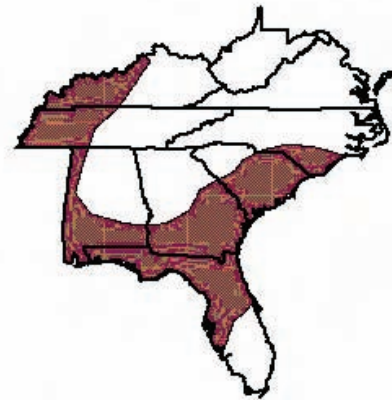
Rafinesque's big-eared bats have never been considered abundant. Colony sizes are larger in the northern end of their range where the species often inhabits caves and mines, but tend to be smaller in the southern portions of the range where caves and mines are less abundant. Southern roosts tend to be in tree cavities and man-made structures. Colony sizes are often less than 30 individuals (usually 5 to 12) and seldom over 100 (Jones 1977; Clark 1990; Bunch and Dye 1999b; Bennett et al. In Review). Population trend information is sparse, but most states suspect declines. Dispersal of Rafinesque's big-eared bats may be female-biased (Jones and Suttikus 1975; Piaggio In Review). Home ranges vary; they average 93.2 ha (230.3 acres) in the inner coastal plain ecoregion (Menzel et al. 2001) and range from 64 to 89 ha (158-220 acres) in forested old growth swamps on the outer coastal plain (Clark et al. 1998).

Southeastern Myotis Distribution

The southeastern myotis occurs from Florida northward, mostly in the coastal plain through South Carolina, North Carolina and into the southern coastal plain of Virginia. Their distribution extends westward along the coastal plain of Georgia, Alabama, Louisiana and Mississippi and northward along the Mississippi River into western Tennessee, Kentucky and southern Illinois and Indiana. Population trends are not known in South Carolina, but Florida reports significant declines (Gore and Hovis 1992).



Rafinesque's Big-eared Bat Distribution



Southeastern Myotis Distribution



Eastern Small-footed Myotis Distribution

Eastern Small-footed Myotis Distribution

The range of the eastern small-footed myotis extends from the mountains of South Carolina and Georgia, northward along the Appalachian Mountains into Virginia, West Virginia, Pennsylvania and southern New England and Canada. They extend westward into Kentucky, Tennessee, and Alabama and into Oklahoma.

Population trends for this species are largely unknown. Declines have been reported from other states. The species has never been regarded as abundant anywhere (Barbour and Davis 1969).

Habitat and Natural Community Requirements

Several species of colonial bats are sometimes nuisances or unwanted residents of homes, businesses, stadiums and other man-made structures. Most often, nuisance colonies in South Carolina can be attributed to four species: big brown bats, free-tailed bats, evening bats and eastern pipistrelles. While Rafinesque's big-eared bats, southeastern myotis and eastern small-footed myotis do sometimes use buildings, those buildings are usually unoccupied (Clark 1990; Bunch et al. 1997; Bunch et al. 1998b; Menzel et al. 2003a); it is very uncommon for these three species to use sites frequented by humans.

Rafinesque's Big-eared Bats

In South Carolina, some coastal and southeastern plains and sandhills populations use T-beam and I-beam bridges (Bennett In review), abandoned buildings, old bunkers, tunnels and cavity trees for roosting (Bunch et al. 1997; Bunch et al. 1998a; Clark 1990; Clark et al. 1998; Bennett 2004). The mountain populations apparently do not use bridges for roosts but use cavity trees, typically large hollow, tulip poplars (*Liriodendron tulipifera*), abandoned buildings, cave or cave-like structures called rock shelters and abandoned mines (Bunch et al 1998b; Bunch and Dye 1999a,b). Rafinesque's big-eared bats are non-migratory. Movement is described as localized (Menzel et al. 2003a) and distribution is patchy.

Habitat in the Blue Ridge Mountains for *C. r. rafinesquii* includes rock outcrops, mesic and cove hardwood forests, forested bottomlands, bottomland agricultural fields, dry deciduous forest, pine woodlands and forested riparian areas. Coastal zone and sandhills habitat of *C. r. macrotis* for roosting and foraging include black gum (*Nyssa sylvatica*) stands, bald cypress (*Taxodium distichum*) swamp forests, maritime forests, and mature forested (hardwood or mixed) bottomlands (Clark et al. 1998). Foraging has also been documented in young pine plantations (Menzel et al. 2003a)

Rafinesque's big-eared bats are reported to be moth specialists; however, other insects are also consumed. Studies have shown that consumption of moths varied, but 48 to 100 percent of guano samples contained moths (Lepidoptera) (Armbruster 2003).

Southeastern Myotis

Caves (including limestone sinks), mines, abandoned buildings and large hollow trees are used for roosting, maternity colonies and hibernation sites (Clark et al. 1998). In addition, they use forested bottomlands, forested swamps, Carolina bays, mesic deciduous forests and mixed forests (Bunch 1998; Menzel et al. 2003a; Louie et al. 2001). This bat forages and prefers to roost over or near water (Gardner, et al. 1992; Zinn 1977).

In Florida, studies show that food habits vary with season. In the summer, beetles (Coleoptera) and moths were the primary prey of southeastern myotis. Winter consumption included beetles, moths and mosquitoes (Culicidae) (Zinn and Humphrey 1981).

Eastern Small-footed Myotis

These small bat species are known to use caves, mines, abandoned buildings, rock crevices (Barbour and Davis 1969), shelters and crevices in bridges in wooded areas of the southern Appalachian ecoregion. In South Carolina, only two roosts of solitary small-footed bats have been found. They included a crevice in a rock outcrop in mature hardwoods and loose tarpaper on an abandoned log cabin (Bunch and Dye 1999a).

Hardwood and evergreen forests, mixed hardwood-conifer stands, bottomland and floodplains are considered important habitat for the eastern small-footed myotis. They appear to prefer to forage over streams and ponds. These bats are slow fliers with fluttery flight. It is likely they require forested corridors between roosts and foraging areas. The winter and summer roosting requirements and foraging habitats are poorly understood for this species.

Challenges

All three bats experience challenges related to disturbance of natural roost structures (cave and rock shelters). Increased predation by natural predators may be a threat due to habitat alterations that either make the bats more vulnerable to predation or increase the density of predators (Tuttle 2004a). Wind turbines erected near roosts, and colony sites, and along migratory routes can pose a potential harm to many flying animals, including bats. No wind turbines have been placed in South Carolina to date, but large turbines have been shown to adversely affect bats (Erickson et al. 2002; Tuttle 2004a; Tuttle 2004b; Williams 2004). Additionally, Sudden Oak Death (SOD) caused by *Phytophthora ramorum* could lead to extensive deforestation of oak (*Quercus* spp.) forests. The disease was recently detected on nursery stock, but has not been confirmed in natural settings to date (USDA APHIS 2005).

Rafinesque's big-eared bats and southeastern myotis face similar challenges in the destruction of natural roosts, particularly large hollow trees in the coastal plain as well as destruction and fragmentation of bottomland hardwood forests that are used for roosting and foraging (Menzel et al. 2001; Tuttle 2004a). Additionally, destruction of artificial roost structures such as girder-type bridges, abandoned houses, abandoned barns and mines and tunnels significantly impacts these two species (Bennett et al. In review; Bunch et al. 1998b). They also face threats increased by human encroachment on habitat from unnatural predation at roosts by feral cats (Barbour and Davis 1969; Tuttle 2004a). Pesticide (Geluso et al. 1978) and heavy metal contamination (Bennett 2004) also threatens bat populations. Alteration of natural flood regimes may affect the regeneration of important forest community types such as cypress-gum, thus preventing recruitment of future roost trees. Finally, alteration of local hydrology can increase flooding of natural roosts (Tuttle 2004a).

Rafinesque's big-eared bat also face challenges from destruction and fragmentation of mature forest in the mountain ecoregion as well as the potential loss of habitat from deforestation from gypsy moths (*Lymantria dispar*) and/or control measures for gypsy moths, such as broadcast usage of *Bacillus thuringiensis* var. *kurstalki* (btk) (McManus et al. 1992; Pearson 2002). Any large-scale alteration of habitat might also lead to genetic isolation of populations (Piaggio In press). Southeastern myotis populations are also imperiled by flooding or inundation of natural roost sites (Clark et al 1998; Tuttle 2004a).

Impacts to eastern small-footed bats are not well known in South Carolina. Roost destruction is one widely acknowledged problem for all colonial bat species (Barbour and Davis 1969; Mohr 1972; Tuttle 2004a). At best, the species is poorly understood throughout its range.

Conservation Accomplishments

Currently over 65,559 ha (162,000 acres) of that mountain habitat in South Carolina are protected by state, federal or nonprofit conservation organizations. Many of those tracts protect big-eared and small-footed myotis roosts or foraging areas. Examples include Ashmore Heritage Preserve, the Andrew Pickens District of the Sumter National Forest and the Greenville Water System's South Saluda watershed that is held in a conservation easement (Strayer 1992; Bunch et al. 1998b).

Several important roost and/or foraging sites in the coastal plain are in public ownership. An excellent example of old growth forest that contains Rafinesque's big-eared bats and southeastern myotis is the Francis Biedler Swamp, also known as Four Holes Swamp, owned by the Audubon Society.

Bats have benefited as knowledge about them have increased through surveys of mines, tunnels, bunkers and rock shelters/caves in Oconee, Pickens, Greenville, Cherokee, York, Richland, McCormick and Orangeburg Counties. In these surveys, thirteen sites were found to sometimes harbor Rafinesque's big-eared bats and two had southeastern bats (Bunch et al. 1997; Bunch et al. 1998a; Bunch et al. 1998b; Bunch and Dye 1999b). Many other more common bats were found, as well. Four of the sites are important maternity/hibernation sites.

In 1991, a survey of Pest Control and Wildlife Control Operators (NWCO's) was completed to evaluate the use of chemicals or pesticides versus exclusion on nuisance bat colonies at the South Carolina 33rd Annual Pest Control Operators School. The survey reported that 38 percent of the NWCO's had been using pesticides/chemicals on bats. Several training sessions on exclusion techniques and bat identification were provided to NWCO's and Clemson University Students. From these training sessions, a Referral list of NWCO's, trained in bat exclusion, was created and distributed to the public and numerous agencies. A "Bats of the United States" booklet (Harvey et al. 1999) was provided to all participating NWCO's. Numerous information and education programs on South Carolina's bats have been conducted. Additionally, a bat poster, "Bats of the Eastern United States," has been produced and is used for outreach; this poster is provided free to the public.

Specific knowledge about Rafinesque's big-eared bats was obtained through abandoned building surveys in the mountains of Pickens and Greenville Counties. These surveys located three *C. rafinesquii* colonies. Additionally, five natural roosts, two roosts in abandoned buildings and some foraging habitat were located using radio telemetry. Five tunnels were modified and/or gated to reduce human disturbance and allow free passage of bats at McCrady Training Site (formerly Leesburg Training Site) (Bunch et al. 1997; Bunch et al. 1998a).

Statewide bridge surveys were also completed from 2002 to 2003 to determine distribution of Rafinesque's big-eared bats. These surveys reported that 81 bridges were sometimes used by these bats; of those bridges, 24 housed colonies (Bennett 2004; Bennett et al. In Review). SCDNR and an environmental consulting firm for the SCDOT have discussed adapting two bridges to accommodate *C. r. macrotis* in a bridge replacement project.

Finally, good baseline data on the use of natural roosts and foraging area is available for the Frances Beidler Forest in the outer coastal plain for both the Rafinesque's big-eared bat and the Southeastern myotis (Clark et al. 1998).

Conservation Recommendations

- Three roosts in the mountains need protection through conservation easement or purchase. One, an abandoned mine, is the largest known nursery site and hibernaculum

for Rafinesque's big-eared bats in the mountains of South Carolina. The two other sites represent smaller Rafinesque's big-eared bat hibernacula.

- Protect foraging areas through landowner incentive programs, conservation easements, lease agreements or purchase.
- Develop Memoranda of Understanding (MOUs) between SCDNR and SCDOT to provide bat adaptations in new, long bridges over water, where feasible.
- Protect mature bottomland hardwood forests and connecting corridors in the inner and outer coastal plain for Rafinesque's big-eared bats and southeastern bats.
- Control human access to important mines, caves and rock shelter formations using signage or other restrictions; do not create trails or roads to these sites.
- Designate buffers (no-cut zones) around known roosts for these bats.
- Provide forested corridors between any harvested units and retain large snags.
- Retain and recruit cypress-gum swamp forests containing large cavity trees.
- Provide alternate roost structures at each significant roost site in abandoned buildings currently in use, or repair the structure to ensure roost longevity.
- Determine whether prescribed fire represents any threat to all three bat species and determine the acceptable distance for fire, smoke and fire lines from roosts.
- Determine summer and winter roost site requirements for eastern small-footed and southeastern myotis.
- Identify colonies of eastern small-footed and southeastern myotis and begin long-term monitoring of colony size, persistence and roost sites.
- Develop brochures, interactive websites and curricula about the benefits of bats and their importance in the ecosystem.
- Incorporate bats, particularly those of conservation concern, into forest plans and other land management plans.
- Encourage certification of NWCO's that includes exclusion training, restrictions or recommendations on appropriate timing of exclusion, and SCDNR notification if eastern small-footed, southeastern myotis or Rafinesque's big-eared bat colonies are involved. Partner with Clemson University's Pesticide Regulation and Control in administering this program.

Measures of Success

Any significant bat roost that is protected or created from these actions can be interpreted as success. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs. It is important to determine important roost site locations to provide long-term habitat for the species.

Eastern Spotted Skunk

Spilogale putorius

Contributors: Jay Butfiloski and Tom Swaynham

Description

Taxonomy and Basic Description

The eastern spotted skunk was described by Linnaeus (1758) and classified as *Viverra putorius*. In 1875, Coues reclassified the species *Spilogale putorius*, which essentially means, “stinking spotted weasel.” Traditionally, the spotted skunk was classified by taxonomists in the Mustelidae, or weasel family, and frequently listed in the subfamily Mephitinae (Jones et al. 1992; Kinlaw 1995). More recently, however, skunks have been classified as the separate family Mephitidae (Dragoo and Honeycutt 1997).

The spotted skunk is smaller than the more common striped skunk (*Mephitis mephitis*). The spotted skunk ranges from 0.5 to 1.8 kg (1 to 4 pounds) in weight and from 250 to 688 mm (10 to 27 inches) in overall length (Crabb 1944; Hall and Kelson 1959; Walker 1964; Patton 1974). Males are approximately 10 percent larger than females (Van Gelder 1959). Pelage is typically dark black with 4 to 6 broken white stripes, which give the animal the appearance of being spotted. An inverted white triangle-shaped nose patch is usually present and is separate of the broken white stripes. The fur is denser and finer than that of the striped skunk (Zeiner 1975).

Spotted skunks breed in late winter or early spring and may delay implantation for up to two weeks. Gestation lasts 45 to 60 days. One litter per year generally produces one to six young. Young are born from April through July and are weaned by about eight weeks of age; May and June are the peak breeding months for this species (Contantine 1961).

Like other members of the genus, spotted skunks have well developed scent glands that are often used for defense. The paired anal glands are located in nipples just inside the anus. Musk is discharged after the nipples protrude through the anus as the tail is elevated (Crabb 1948). One of the more curious behaviors displayed by the spotted skunk is a headstand that is used in defensive posturing. The skunk will move towards the threat, balance itself on its forelegs and direct the anal sacs towards the opponent (Johnson 1921).

Status

The spotted skunk is currently ranked as apparently secure in South Carolina and Georgia. The species is considered rare or vulnerable in North Carolina and Tennessee. Kentucky and West Virginia rank the eastern spotted skunk as rare and imperiled, respectively (NatureServe 2004). Few records of spotted skunks are included in the South Carolina Rare, Threatened, and Endangered Species Inventory and little is known about its true status in South Carolina. Accounts are only listed for Aiken, Edgefield, Greenville, Oconee and Pickens Counties. In many cases the lack of information about the spotted skunks in the state may be due to the lack of knowledge about the species's population status and distribution.

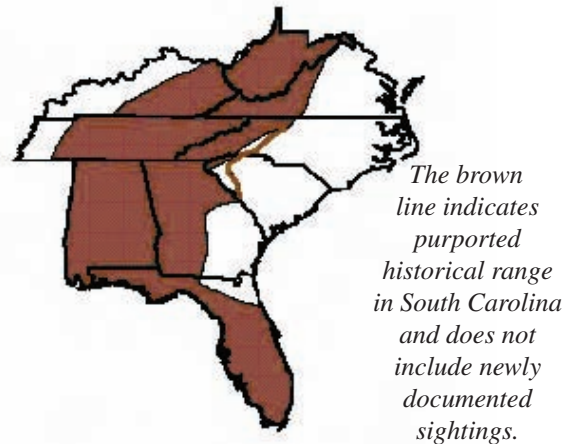
Population Size and Distribution

The brown line indicates *purported historical* range in South Carolina and does not include newly documented sightings.

The eastern spotted skunk's range extends from southern Pennsylvania, down the Appalachian

Mountain range and into Florida, with a portion of the eastern edge of its range encompassing the western portion of South Carolina. Unlike the striped skunk, which has a more uniform distribution within its geographic range, the spotted skunk is typically more localized in its distribution.

The brown line indicates purported historical range in South Carolina. Little is known about the population distribution and size of the spotted skunk in South Carolina. No data specific to the spotted skunk has been recorded because annual commercial fur harvest data does not differentiate between the two species of skunks found in South Carolina. The annual take by commercial fur harvesters has averaged 120 skunks per year over a 28-year period, most of which are presumed to be striped skunks.



Spotted Skunk Distribution

Habitat and Natural Community Requirements

The spotted skunk inhabits woods and brush and has a strong propensity to be near farmyards. It prefers dense cover like that which occurs along fences, embankments, gullies and hedgerows. Spotted skunks will also use barns and out buildings for cover. These animals are also found in rock outcrops (Crabb 1948). Spotted skunks are generally less tolerant of humans than the striped skunk (Henderson 1976).

Biologists on the Savannah River Site have documented spotted skunks associated with old fields, open forests and hedgerow habitats. Dead and downed trees and abundant coarse woody debris are important microhabitats required by spotted skunks.

Spotted skunks are omnivorous, feeding on small mammals, insects, reptiles and amphibians. Their diet may vary seasonally with the availability of food items (Howard and Marsh 1982).

Challenges

Both habitat fragmentation and destruction and public persecution of skunks are the most common challenges to spotted skunk populations. The mountain area of South Carolina is rapidly being developed and habitat for spotted skunks could be lost. As natural areas are transformed to developed areas, skunk populations are expected to decline. Because skunks prefer dense cover and such areas are generally not found in developed areas, habitat loss will lead to these population declines.

Further, humans tend to be very intolerant of skunks due to the animals' defensive behaviors. Skunks that do not attempt to relocate as development occurs are likely to be considered nuisance wildlife and may be removed or destroyed as development continues.

The lack of knowledge about the distribution of the spotted skunk in South Carolina represents another threat to this species. Little data about this species has been collected; what is known is the result of subjective reports from residents and conservation staff.

Conservation Accomplishments

In South Carolina, considerable portions of the Blue Ridge ecoregion have been protected for conservation by federal and state agencies including SCDNR and the U.S. Forest Service. While these areas were not designated to further conservation of this species, they are largely dense forest areas that are used by spotted skunks.

Conservation Recommendations

- Conduct education programs to promote early-successional vegetation adjacent to open areas in order to provide habitat for spotted skunks and other wildlife species.
- Manage currently protected lands for more early-successional vegetation by increasing the use of fire and silvicultural treatments.
- Cooperate with a multi-state effort to evaluate the genetic relationship of spotted skunks throughout the southeast using mtDNA analysis.
- Determine the distribution, abundance, and habitat requirements of spotted skunks in South Carolina. Inventories should target the upper piedmont and Blue Ridge ecoregions.
- Adjust reporting requirements of annual commercial fur harvest to differentiate between striped and spotted skunk harvests and utilize this data to evaluate long-term trends.
- Research ways to improve monitoring techniques for spotted skunks that will provide more precise information than scent station surveys that are conducted for all furbearers.
- Educate residents about the beneficial aspects of spotted skunks; these animals are predators that help control rodent populations that can be beneficial to humans in addition to their ecosystem value.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs.

Eastern Woodrat

Neotoma floridana

Contributors: Mary Bunch, Stan Miller and David Webster

Description

Taxonomy and Basic Description

The eastern woodrat was first described by Ord in 1818. Woodrats build extensive stick nests in which they larder bright, shiny objects, hence the nickname “packrats.” The Eastern woodrat (*Neotoma floridana*), the only woodrat species in South Carolina, has gray-brown or rusty brown fur on the back with darker hairs down the center of the back, a white belly and whitish paws. The white extends to the underside of the jaw. The well-furred tail is nearly as long as the body. It has short hairs and is bi-colored (dark on top and light underneath). Woodrats have long whiskers and large, unfurred ears. They are easily distinguished from black (*Rattus rattus*) or Norway rats (*Rattus norvegicus*) because woodrats have relatively large eyes, four white

feet, well-furred tails and rather blunt snouts. Both black and Norway rats, introduced invasive species, have scaly tails and pointy snouts (Webster et al. 1985).

Males are slightly larger than females (Wiley 1980). Specimen weights from South Carolina at the Campbell Museum of Natural History range from 119.5 to 306.4 grams (4.1 to 10.7 ounces) for males and 104 to 268.8 grams (3.6 to 9.4 ounces) for females. The average weight of woodrats captured at mountain sites in South Carolina during winter were 264 grams (9.2 ounces) in males and 207.5 grams (7.3 ounces) in females (Bunch and Dye 1999c).

The woodrats in South Carolina were formerly recognized as two distinct subspecies. The mountain or Appalachian population was referred to as the southern Appalachian eastern woodrat (*Neotoma floridana haematoreia*). Coastal populations were assigned *Neotoma floridana floridana* (Hall and Kelson 1959; Wiley 1980). They are now considered to be the same subspecies, *Neotoma floridana haematoreia*, based on molecular genetic comparisons (Hayes and Harrison 1992; Ray 2000).

Farther to the north and west, ranges of both the eastern woodrat and the less common Allegheny woodrat (*Neotoma magister*) overlap. Allegheny woodrats were once recognized as subspecies of *Neotoma floridana* but are now recognized as a discrete species (Hayes and Harrison 1992; Hayes and Richmond 1993; Ray 2000; Edwards and Bradley 2001). The differences between the two species are subtle. Woodrats in the mountains tend to have longer whiskers than their coastal counterparts (Ray 2000) and their tails are more distinctly bi-colored and hairier. In this regard, eastern woodrats from the southern Appalachians more closely resemble Allegheny woodrats; those from the coastal plain of North and South Carolina more closely resemble eastern woodrats from Florida.

Status

In South Carolina, the species is apparently secure (S3/S4). Currently, coastal and mountain populations are not ranked separately in South Carolina. North Carolina ranks coastal populations of eastern woodrats as critically imperiled and mountain populations as rare or uncommon. Georgia and Florida rank *N. floridana* as secure, and the global rank is secure (G5) (NatureServe 2004). Eastern woodrats are on the IUCN Red List in the “lower risk, least concern” category (Yensen and Kirkland, Jr. 1998).

Population Size and Distribution

Woodrats range along the coast from Pender County in southeastern North Carolina (Webster et al. 1985), southward along the entire coastal plain and into the sandhills of South Carolina. The distribution broadens westward into piedmont habitat as it continues southward into Georgia. The mountain populations of eastern woodrats are restricted to the southwestern mountains of North Carolina and northwestern South Carolina, ranging west and southward in Georgia.

A record of an eastern woodrat from York County, South Carolina (Dowda et al. 1981) in the upper piedmont suggests that the distribution in the midlands and upper piedmont of South and North Carolina is not well understood.



Distribution of Eastern Woodrats

Habitat and Natural Community Requirements

Woodrats use a wide variety of habitats in South Carolina. In the southern Appalachian ecoregion, they can be found in dry or mesic deciduous or mixed deciduous forests including coves, bottomlands and swamps. They also occur in pine-heath communities and early successional stands such as old fields and clear cuts. Woodrats will use harvested woodlands prepared mechanically if piles of woody debris are present, but do not use sites that have been treated with herbicides within the previous five years (O'Connell and Miller 1994). They are often found in, but are not limited to, rock outcrops, boulder fields and cliffs.

In the coastal plain, woodrats use floodplain and swamp forests, wet scrub thickets, logged areas, dry and mesic deciduous forests and hardwood pine forests. At the Naval Weapons Station near Charleston, woodrats were captured in natural pine regeneration areas that were approximately 12 years old; these areas were affected by Hurricane Hugo and contained abundant coarse woody debris. Woodrats were also captured in mature hardwood pine forest habitat and mixed stand edge with an adjoining field at the Naval Weapons Station (Louie et al. 2001). At coastal North Carolina sites, Webster et al. (1987) reported an apparent association of woodrat prevalence in deciduous forest with dense dwarf palmetto (*Sabal minor*) cover and circum-neutral soils.

Woodrats are opportunistic; they forage on a variety of items including berries, stems, buds, leaves, seeds, fruit, bark, fungi, insects, acorns and other nuts (McMurry et al. 1993; Monty and Feldhamer 2002; Schwartz and Schwartz 1981; Wiley 1980). Hard mast, such as acorns, may be an important food source in winter.

Two obvious items can be found to indicate the presence of woodrats: large bulky nests and latrines. Nests for woodrats are built inside a large house constructed of sticks, leaves, branches, and scavenged litter such as vinyl flagging, bottle caps and Mylar balloon remnants. The bulky houses are continually maintained. Several nests can be found in one large house or den structure. Often these structures are in or under rock outcroppings, large cavity trees, large slash piles or in abandoned buildings. Latrines are often found on rock ledge sites where large piles of droppings accumulate.

Challenges

Coastal populations of eastern woodrats in South Carolina are impacted by habitat loss and isolation due to development. Although some habitat for this species is protected on public lands, barriers of intense development isolate many preserved sites, particularly in the coastal plain. Much of the suitable habitat found in the midlands needs additional protection and many suitable areas found in the inner and outer coastal plain are not protected at all.

Predation (Monty and Feldhamer 2002) and factors that increase predator density or woodrat detection by predators also represent challenges to this species. Additionally, placement of recreational trails near suitable bolder or rock outcrop nest sites may adversely affect eastern woodrats by resulting in increased access to and, therefore, increased predation of nests.

Raccoons and their associated parasite, the raccoon roundworm (*Baylisascaris procyonis*) may also pose a threat to eastern woodrats (Monty and Feldhamer 2002). Although this parasite is not common in the south, the potential exists for parasite transmission to woodrats. Once transmission occurs, raccoon roundworm larvae migrate to the brain and death can occur. Such mortality has been documented in the rare Allegheny woodrat (*Neotoma magister*). As raccoon populations increase, an observable decrease in the woodrat population has been noted; transference of the roundworm is believed the cause (NatureServe 2004). Raccoons are

a cosmopolitan species that often coexist and benefit from human activity, readily foraging in garbage, gardens, agriculture fields, aquaculture areas, koi ponds, pet food and bird feeders. Anything that causes an increase of raccoons within woodrat habitat can therefore increase the likelihood of raccoon parasite transfers to woodrats.

The exotic gypsy moth (*Lymantria dispar*) may pose a threat to populations of woodrats. Gypsy moth caterpillars prefer oak trees, but will defoliate most hardwoods when present in large numbers. This defoliation reduces mast production; repeated defoliations lead to tree mortality (McManus et al. 1992; Pearson 2002). Gypsy moths were first reported in South Carolina in 1998 (Pete Bischoff personal communication 2005). To date, no significant outbreaks of gypsy moth caterpillars have occurred in this state; however, should such an outbreak occur, it could result in significant impacts to woodrat food sources.

Sudden Oak Death (SOD) results from an introduced fungus (*Phytophthora ramorum*) that recently arrived in South Carolina via nursery stock. The impacts of this fungus on our forests could be devastating as it attacks a many species of shrubs and trees (O'Brien et al. 2002). Specific impacts to the many types of oak trees (*Quercus* spp.) in the southeast are not yet known. If the blight is not contained, serious losses of oak trees can be expected. Red, northern pin and black oaks have been shown to be susceptible to the fungus in experimental exposures (Tooley and Kyde 2003). The warm, humid climate in the southeast is conducive to the spread of the fungus. Unfortunately, SOD is believed to be distributed by air borne spores; such distribution makes it very difficult to control this fungus. This threat is not unique to South Carolina; infected nursery stock has been shipped to several southeastern states. Fortunately, to date, it has not been detected in our South Carolina forests. Woodrats use acorns, as do many other species of wildlife. Losing a significant proportion of our mature oaks could create a forage bottleneck that could decimate woodrat populations.

Currently, very few people are aware of woodrats or packrats in South Carolina, except for the perception that they are a nuisance species. This perception contributes to the assumption that this species is responsible for nuisance rat infestations. However, this species is generally not found living in areas populated by humans. Lack of knowledge of the eastern woodrat and its relevance in the ecosystem can represent a challenge for protection of this species.

Conservation Accomplishments

Extensive holdings in various public ownerships and nonprofit conservation organizations or conservation easements have protected over 162,000 acres of land in the mountains of South Carolina. Most, if not all of the tracts, have woodrats (Bunch et al. 1999 a,b,c). Some habitat preservation exists in the midlands and lower coastal plain on sites such as the Congaree National Monument and the Silver Bluff Audubon sanctuary. Significant tracts, such as the SCDNR's system of Heritage Preserves, the Francis Marion National Forest, the multi-partnered ACE basin project and the various National Wildlife Refuges also protect some coastal populations.

Conservation Recommendations

- Conserve woodrat habitat linkages between sites that are already under protection through acquisition and/or conservation easement and encourage stewardship by private landowners.
- Encourage landowners and foresters to avoid use of herbicides as a site preparation technique in areas with woodrats.

- Survey the upper piedmont region in York County and surrounding counties to determine the distribution of woodrats in that region.
- Determine if trails by-passing outcrops and boulder fields lead to increased predation of woodrats.
- Acquire eastern woodrat density estimates for each ecoregion and designate selected sites for long-term monitoring in each of the following geographical area: southern Appalachians, inner and outer coastal plain, and piedmont.
- Educate the public about the relevance of the eastern woodrat in the ecosystem. Such education could occur at a demonstration site that illustrates important habitat and species in the mountain region of South Carolina.
- Continue to monitor the spread of raccoon roundworm, gypsy moths and SOD in South Carolina and develop an action plan in the event these threats adversely affect wildlife species within this state.

Measurements of Success

Surveys and density estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs.

Florida Manatee

Trichechus manatus latirostris

Contributors: Thomas M. Murphy and DuBose B. Griffin

Description

Taxonomy and Basic Description

Manatees are aquatic mammals in the order Sirenia. The order includes manatees, dugongs and the extinct Steller's sea cow. The West Indian manatee is one of three species in the family Trichechidae. Linnaeus named the single genus *Trichechus* in 1758. Two subspecies of West Indian manatee are now recognized: the Florida manatee, *T. manatus latirostris*, which occurs in the southeastern United States, and the Antillian manatee, *T. manatus manatus* that is found throughout the remainder of species' range (USFWS 1995).

Manatees are large, rotund mammals with a large round, horizontally flattened tail. Forelimbs are paddle-like and visible hind limbs are lacking. On average, manatees reach lengths of 3.5 m (11.5 feet) with females tending to be larger than males. Average weight is approximately 1000 kg (2200 pounds). Newborns average 1.2 to 1.4 m (4 to 4.5 ft) in length and weigh about 30 kg (66 pounds) (Odell 1981). In the murky waters of South Carolina, only the small head is sometimes seen as the animal surfaces for air. The skin is dark gray and sparsely covered with hair. The backs of manatees in South Carolina are frequently covered by a variety of marine organisms.

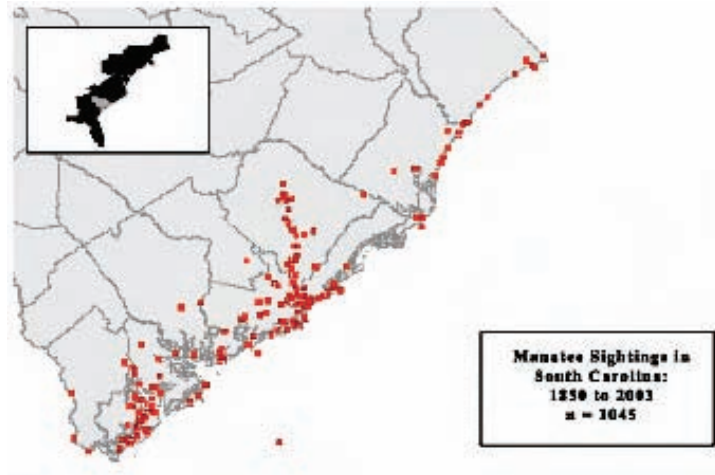
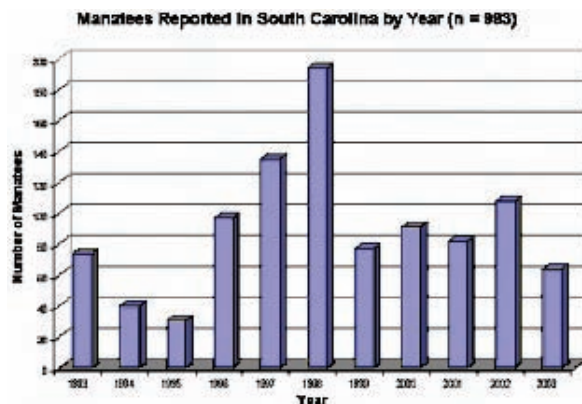
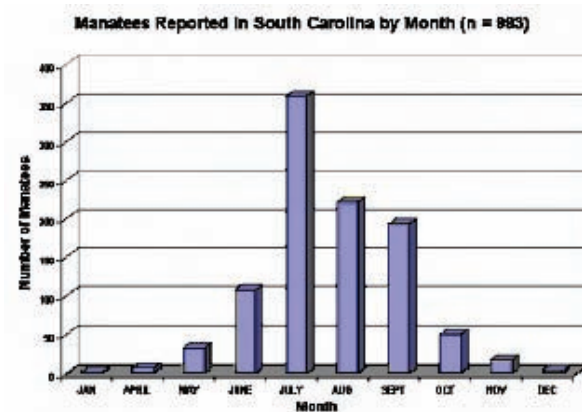
Status

The West Indian manatee is listed as endangered throughout its range under both the Endangered Species Act of 1973 as amended (16 U.S.C. 1531) and the South Carolina Nongame and Endangered Species Conservation Act. The manatee is also protected under the Marine Mammal Protection Act of 1972 as amended (16 U.S.C. 1461). Manatees are considered one of the most endangered marine mammals in the United States. Commercial and subsistence harvests in the

1800's probably significantly reduced the population. The largest population of manatees is found in the southeastern United States. Outside the United States, manatees occur in the Greater Antilles, on the east coast of Mexico and Central America, along the north and northeast coast of South America and in Trinidad and Tobago (Lefebvre et al. 1989).

Population Distribution and Size

Minimum population size has been based on counts of manatees at all known winter refuges in Florida and Georgia. Aerial and ground counts at winter refuges are highly variable depending on weather, water clarity, manatee behavior and other factors (Packard et al. 1985). In February 1996, a record 2,639 manatees were counted. However, standardized aerial survey methods for monitoring trends in manatee abundance have yet to be developed.



Between 1850 and 1981, a total of 23 records of manatees in South Carolina were documented (Rathbun et al. 1982). Four additional records were reported by O'Shea (1988) from 1981 through 1986. Between 1986 and 1992, an additional 25 records were recorded by SCDNR (unpublished data). Therefore, only 52 records of manatees were documented in South Carolina over a period of 142 years, suggesting that manatees are rare visitors. Since active surveillance was initiated in 1993, more than 1,000 manatee sightings have been reported in South Carolina. The number of manatees in the state at any given time appears to be in the tens of manatees during the warmer months. The total number of individual manatees using South Carolina waters in a given year is much higher than the number of resident manatees because several individuals use the state during part of a season or on less than an annual basis. The following two graphs demonstrate the frequency of manatee sightings by year and month, respectively.

Habitat and Natural Community Requirements

In the southeast, manatees are found in rivers, bays or estuaries with submerged aquatic vegetation and water temperatures above 20 degrees C (68 degrees F). In South Carolina, manatees occupy fresh, brackish and marine habitats and move freely between salinity extremes. Because of our high tidal amplitude, manatees feed on abundant *Spartina alterniflora* grasses at high tide and frequently move to submerged *Ulva sp.* beds at low tide. Manatees will move up rivers until the water is too shallow for passage or is blocked by a dam. There is no evidence that manatees concentrate on the upper Cooper River, which is the only site with extensive stands of the introduced exotic plant *Hydrilla verticillata* accessible to manatees in the state.

Challenges

The greatest known human-related cause of manatee mortality in the southeastern United States is collisions with ship/boat hulls and/or propellers. There is limited documented collision-mortality in South Carolina and few of the many manatees sighted are reported to have fresh wounds. However, the lack of extensive collision mortality may be a result of the low number of animals present. It is likely that manatees are prone to being struck by fast moving boats when foraging in shallow areas; however, most boat operators avoid shallow water hazards in South Carolina. The high tidal amplitude and abundant oyster beds present in this state reduce the frequency of collisions.

Cold stunning may have a significant effect on manatees in South Carolina because the state is in the northern range of manatees. The threat of cold stunning is complicated by use of heated water discharges at a variety of industrial sites in the fall. Unlike power plants and paper mills, many of these smaller discharge sites are not in continuous operation and do not provide a predictable source of warm water. Many are being eliminated as alternative treatments of heated effluent are being adopted. Although based on a limited sample, several manatee mortalities in South Carolina were related to low water temperature exposure.

In Florida, manatee mortality by trauma or drowning can be associated with the operation of locks and water control gates. The only such site in South Carolina is the lock on the upper Cooper River that transports boats between the river and Lake Moultrie. Manatee mortality has occurred in two ways at this site. Several manatees have died from exposure to cold-water temperatures after they failed to navigate back down the lock in the fall during its limited operation. The second source of mortality was from drowning in the lock during operation.

Although documented in Florida (O'Shea et al. 1991), harmful algal blooms have not been documented as a source of manatee mortality in South Carolina. However, documentation of the state's first large-scale marine algal bloom (*Heterosigma akashiwo*) in the spring of 2003 increases the likelihood of future blooms.

Several manatee mortalities have been associated with the shrimp trawl fishery. The interaction between shrimp trawlers and manatees appears to be rare because manatees should be able to out swim the approaching nets or surface to avoid them.

Conservation Accomplishments

There have been several accomplishments made towards conservation of the manatee in South Carolina. Geographic distribution of and seasonal use by manatees in South Carolina has been documented through reports from the public. Operation protocol changes at the Cooper River lock have reduced the likelihood that manatees will enter Lake Moultrie and subsequently cold stun. Installation of grates over the entrance to water-control tunnels in the lock have prevented

manatees from drowning when the lock is being drained. Additionally, close cooperation with the Sirenia Project has been established to share information from reported manatee sightings, mortality data and provide identification of individual manatees based on the Florida identification catalogue. Finally, a manatee web site has been established to inform the public about manatees in South Carolina and to provide an online form for reporting manatee sightings.

Conservation Recommendations

- Document annual residents, seasonal use, and evaluate the relationship between manatee reports and actual population size.
- Continue to collaborate with the Sirenia Project to document manatee activity through the US Geological Survey's Florida Integrated Science Center.
- Cooperate with the Sirenia Project in monitoring manatees tagged with radio instruments to determine manatee use areas in the northern portion of the range.
- Attempt to identify individual manatees in order to better understand patterns of use.
- Document the relationship between use of heated effluent by manatees and distribution of these animals in northern waters as well as any associated manatee mortality.
- Protect the quality of wetlands in South Carolina by preventing the rise of harmful algal blooms. This can be accomplished by reducing nutrient loading of coastal water bodies through best management practices and land use planning.
- Collaborate with port and shipping operation authorities to develop contingency plans for oil spill events that will result in protection to manatees.
- Continue to solicit and summarize sightings of manatees from the public.
- Monitor the causes of manatee injury and mortality.
- Monitor water uptake and discharge areas at industrial sites for manatee use and evaluate the potential for conflicts involving entrainment and cold stunning.
- Monitor the effectiveness of Turtle Excluder Devices in preventing drowning of manatees in trawl nests.
- Maintain an updated, interactive manatee web site at www.dnr.state.sc.us/manatee/ in an effort to increase public awareness of manatee threats while continuing to solicit sightings information from the public.

Measures of Success

Since low visibility in coastal waters limits the utility of aerial surveys for manatees, other means, mentioned above, will allow monitoring of manatees in South Carolina. Additional data on manatees in South Carolina will be used in the permit review process.

Humpback Whale

Megaptera novaeangliae

Contributors: David Cupka and Margaret Murphy

Description

Taxonomy and Basic Description

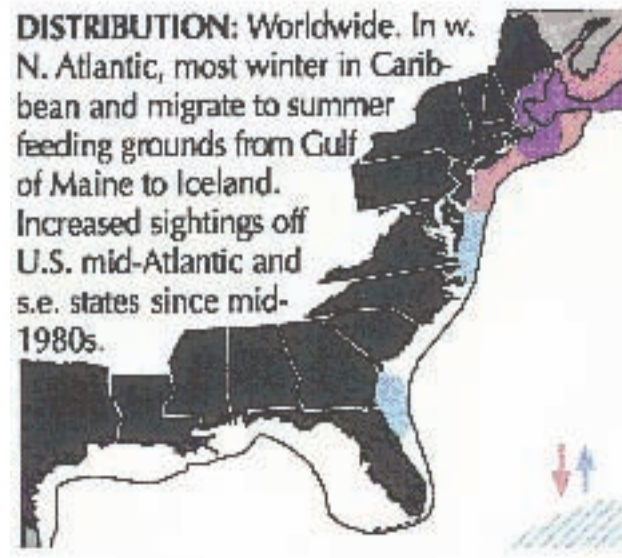
The humpback is a moderately large baleen whale. First described by Borowski (1781), the humpback's most distinguishable features include: a robust body with a broad, rounded head; a series of fleshy knobs on the rostrum and lower lip; long flippers (one-third of body length); broad flukes with an irregular trailing edge; ventral throat grooves (12 to 36) extending to the navel; black with white coloring on the throat and belly with variable amount of white on the underside of flukes and both sides of flippers; and a broad and bushy blow hole. Adults reach 11 to 16 m (36 to 52 feet) in length and a weight of 36 metric tons (40 tons); females are slightly larger than males (Wynne & Schwartz 1999).

Status

Humpback whales are federally listed as endangered under the Endangered Species Act. The U.S. Atlantic stock (Gulf of Maine stock) is defined as “strategic” under the Marine Mammal Protection Act because the average annual fishery-related mortality and serious injury exceeds its Potential Biological Removal (PBR) level. Further, the North Atlantic humpback is an endangered species.

Population Distribution and Size

The humpback whale is worldwide in its distribution. In the western North Atlantic, most winter in the West Indies, where they mate and calve. These whales then migrate to summer feeding grounds from the Gulf of Maine to Iceland. However, a notable number of humpbacks do not undertake this extensive seasonal migration but instead overwinter in mid- and high-latitude regions (Clapham et al. 1993; Swingle et al. 1993). There have been increased sightings of this species off the U.S. mid-Atlantic and southeastern states since the mid-1980s (Swingle et al. 1993; Wiley et al. 1995). In this region, sightings have been reported in all seasons but are more predominant from January to March (Barco et al. 2002). Whether these increased sightings represent a distributional change or are simply due to an increase in sighting effort and/or whale abundance, is currently unknown (Waring et al. 2004).



Map from Wynne and Schwartz, 1999

The best available estimate of the population size for the North Atlantic is 11,570 humpback whales; of these, 500 to 900 animals are estimated to use U.S. Atlantic waters (Gulf of Maine stock) (Waring et al. 2004). The most recent estimates indicate continued population growth; however, the size of the humpback stock in the U.S. Atlantic Exclusive Economic Zone (EEZ) may be below its Optimum Sustainable Population (OSP). There are insufficient data to reliably determine population trends for humpback whales in the North Atlantic overall.

Habitat and Natural Community Requirements

The humpback is considered a pelagic and coastal species. These whales are typically encountered over shallow banks and in shelf waters while feeding or breeding but may traverse open ocean

during migration (Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Feeding occurs in the cold, nutrient-rich waters of high latitudes. In the western North Atlantic, several discrete feeding grounds exist extending from the Gulf of Maine to off Iceland and northern Norway. Humpbacks exhibit strong fidelity to a particular feeding ground. Calves will typically return to the same feeding ground as their mother. Off the U.S. Atlantic coast, the primary feeding ground for humpbacks is the Gulf of Maine. Humpbacks begin to arrive in the waters off New England in early spring and remain through the fall. Their distribution in this area has been largely correlated to prey species and abundance, although behavior and bottom topography are also factors in foraging strategy (Payne et al. 1986, 1990). Humpbacks are generally piscivorous but krill are also frequently taken in the northern Gulf of Maine (Paquet et al. 1997).

Humpbacks fast while on breeding and calving grounds. During this time, these whales live off their vast reserve of blubber. Individuals from different feeding grounds mix while on the breeding grounds. Such mixing is also recorded within the group of humpback whales that winter off the U.S. mid-Atlantic coast. Most identified individuals from this group belong to the Gulf of Maine stock, but a few animals from stocks off Newfoundland and in the Gulf of St. Lawrence have been identified on the U.S. mid-Atlantic coast wintering grounds as well (Barco et al. 2001). This population, composed of mostly first-year animals and a smaller number of juveniles and adults, is thought to use the mid-Atlantic/southeast region as a supplemental winter feeding ground. Some individuals have been observed over multiple years indicating repeated use of this area.

Challenges

Although hunting previously caused a major decline in all humpback whale populations, these animals are no longer endangered by that activity. Ship collisions and entanglements in fixed fishing gear are the greatest causes of non-natural mortality in humpback whales. Other factors that may affect the recovery of humpback whales include disturbance or displacement caused by noise and other activities associated with shipping, recreational boating, whale watching or air traffic; pollutants from waste disposal; activities associated with mineral exploration and extraction; habitat degradation associated with coastal development; and competition with fisheries for prey species. These factors could affect reproductive success in individual whales, alter survival and impact habitat (NMFS 1991).

Conservation Accomplishments

SCDNR and SAFMC (South Atlantic Fishery Management Council) personnel serve as members of the Atlantic Large Whale Take Reduction Team (ALWTRT). The ALWTRT works with National Oceanic and Atmospheric Administration (NOAA) Fisheries to develop and amend the Atlantic Large Whale Take Reduction Plan. The goal of the plan is to reduce the incidental take of finback, humpback and right whales in commercial fishing operations so that they can reach or maintain their optimum sustainable population size.

To reduce the incidence of ship strikes, especially in the area of shipping lanes, NOAA Fisheries, in collaboration with other Federal agencies, state agencies including SCDNR, environmental groups, citizen groups and the shipping industry has been working to develop ship strike reduction measures along the U.S. Atlantic coast. Currently, the focus of this effort is on the northern right whale given its highly endangered status; however, such measures are also expected to benefit the humpback.

SCDNR has been conducting a marine mammals stranding program since 1991 in order to obtain

data on marine mammals that strand along the South Carolina coast. In 2004, we applied for and obtained a Prescott Grant for \$87,000 to continue our stranding program. Data from the program are used to further our knowledge regarding these animals and the extent to which anthropogenic factors are responsible for or contribute to marine mammal stranding. In 1993, a humpback whale stranded in South Carolina; this program allowed us to record this event and to gather data from the animal.

A take reduction plan has been developed for Atlantic large whales, including the humpback whale, to reduce the incidental take of animals in commercial fishing operations to below the Potential Biological Removal (PBR) level. PBR is an estimate of the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its Optimum Sustainable Population (OSP). Despite efforts of the plan to reduce large whale entanglements and other activities to reduce ship strikes, annual mortalities (2.6 whales from the Gulf of Maine stock for the period 1997 through 2001) are still exceeding PBR for this stock (1.3 whales) (Waring et al. 2004). SCDNR personnel will continue to serve on the ALWTRT in order to help develop and implement programs and activities designed to reduce humpback whale non-natural mortalities to insignificant levels approaching the Zero Mortality Rate Goal (ZMRG). The ZMRG (currently defined as 10 percent of PBR) for humpback whales is 0.13 animals.

Numerous individuals from scientific, management and conservation communities have been working for some time to improve the status of the humpback whale. One of the outcomes of these efforts has been development of the humpback whale recovery plan. Another was a major research initiative known as the Years of the North Atlantic Humpback (YONAH) (Smith et al. 1999) conducted from 1992 through 1993. This project was a large-scale intensive study of humpback whales throughout most of their entire North Atlantic range, from the West Indies to the Arctic. It addressed large-scale issues, such as size and structure of the population, vital population rates, migratory movement and structure of the mating system. Information resulting from this study will serve a baseline against which to evaluate, among other things, whether the population is increasing or decreasing over time.

Conservation Recommendations

- Identify essential/critical humpback whale habitat in U.S. waters.
- Identify and minimize possible adverse impacts of human activities and pollution on important habitat by commenting on such things as proposed offshore drilling activities and other energy development activities which could impact important humpback habitat such as offshore wind farms or proposed changes to ocean dumping laws.
- Reduce mortality and injury from entanglement in fishing gear and ship strikes by working with commercial fishermen and the maritime industry to modify fishing gear and harbor approach routes, vessel operational procedures and speeds, and by improving early warning systems to notify vessel traffic of whales in the area.
- Within South Carolina's waters, identify and implement seasonal and/or geographic regulations for fishing gear that may kill or injure humpback whales. Collaborate with other jurisdictions to implement similar fishing gear recommendations.
- Evaluate cumulative impacts of vessel collisions on humpback whale populations.
- Continue photo-identification studies of humpback whales.

- Continue biological studies on stranded humpback whales.
- Develop a standardized protocol for sampling tissues of humpback whales using strandings and biopsies.
- Identify and evaluate feeding competition between humpback whales and fish species and the impacts of prey abundance on whale populations.
- Employ radio tags, underwater listening stations and genetic techniques to define migration routes and transit times for humpback whales.
- Continue assessment of mortality levels and population structure of the wintering aggregation of humpback whales in the mid-Atlantic/southeast region.
- Develop a protocol for monitoring physical and chemical factors that could decrease habitat suitability for humpback whales.
- Assist in defining measurable criteria for monitoring the success of implemented management measures within the ALWTRP.
- Educate fishermen on the importance of reporting entangled whales to improve such counts.
- Improve coordination with federal, state and non-governmental agencies/groups involved in education, outreach and cooperative efforts by supporting regional meetings and workshops to facilitate the exchange of information on whale strandings and ship strikes and to develop and implement procedures to reduce fishing gear entanglements and ship strikes. Examples would include such things as educational brochures for fishermen and maritime interests informing them about regulatory changes in regards to fishing gear modifications or vessel operating procedures in critical whale habitat areas.
- Develop educational materials in support of humpback whale recovery plan objectives.
- Collaborate with other research, monitoring and outreach groups to combine efforts to protect the humpback whale.

Measurements of Success

SCDNR personnel will continue to serve on the ALWTRT in order to help develop and implement programs and activities designed to reduce humpback whale non-natural mortalities to insignificant levels approaching the Zero Mortality Rate Goal (ZMRG). The ZMRG (currently defined as 10 percent of PBR) for humpback whales is 0.13 animals. Success of any individual program will be measured according to its apparent contribution toward this goal. Additionally, information resulting from the YONAH study will serve a baseline against which to evaluate whether the population is increasing or decreasing over time.

Meadow Vole

Microtus pennsylvanicus

Contributors: Travis Perry and Mary Bunch

Description

Taxonomy and Basic Description

The meadow vole was originally described by George Ord in 1815 (*in* Guthrie 1815) from specimens collected “in meadows below Philadelphia” and was named *Microtus pennsylvanicus*

(Wilson and Reeder 1993).

The meadow vole is a small to medium sized rodent and is characterized by relatively small eyes, inconspicuous ears and a short tail. Meadow voles range in total length from 140 to 196 mm (5.5 to 7.7 inches) and in weight from 33 to 65 g (1.2 to 2.3 ounces) (Hall 1981; Tamarin 1999). The pelage is dark brown above and silvery gray beneath (Brown 1997). Meadow voles are best distinguished from South Carolina's other vole species, the pine or woodland vole (*Microtus pinetorum*) by four characteristics: (1) pine vole tails are barely longer than the hind foot whereas meadow vole tails are 2 to 3 times the length of the hind foot; (2) pine voles have elongate foreclaws relative to meadow voles; (3) pine voles (25 to 33g; 0.88 to 1.16 ounces) are typically much smaller than meadow voles; and (4) the second upper molar in pine voles has four dentine islands; there are five to six dentine islands in the meadow vole.

Status

The meadow vole is a globally secure species; however, the IUCN states that at least five of 26 subspecies are of conservation concern (MacDonald et al. 1998). The status of the subspecies found in South Carolina, *Microtus pennsylvanicus pennsylvanicus* is currently unknown but appears to be secure and is at the edge of its geographic range. An apparent isolated population of meadow voles in the Charleston area may be of particular concern.

Population Distribution and Size

Meadow voles purportedly range throughout the upper piedmont of South Carolina with an isolated population(s) in Charleston (Sanders 1978) and southern Georgetown County. Meadow vole populations fluctuate, sometimes dramatically from several to several hundred per hectare, with a period of 2 to 5 years (Krebs and Myers 1974).

Natural Community Requirements

Meadow voles depend on grassland habitat.

Apparently, density and height of grass cover are more important than food quality in determining the suitability of habitats in maintaining high, stable vole populations. In a 25-year study, Getz et al. (2001)

found that meadow vole populations exhibited the highest densities and lowest fluctuations in tall grass prairie habitats as compared to bluegrass and alfalfa habitats, which had successively lower cover and increased food quality.

Meadow voles coexist with numerous other small mammal species. In the southern Appalachians, meadow voles generally coexist with star-nosed moles (*Condylura cristata*), southern bog lemmings (*Synaptomys cooperi*) and meadow jumping mice (*Zapus hudsonius*). However, there is some evidence to suggest that meadow voles avoid areas where short-tailed shrews (*Blarina brevicauda*) are present (Fulk 1972) and previous studies indicate that there may be competitive avoidance between meadow voles and other vole species (Klatt 1986 and Blatzi et al. 1999). Evidence of this phenomenon has not been investigated in South Carolina meadow and woodland voles.



Meadow Vole Distribution

Challenges

The major challenge to meadow vole populations is most likely habitat loss. Dense grassland habitats are lost through at least three mechanisms: agricultural development, via cultivation or grazing, urban development and the natural process of community succession, whereby fields and meadows revert to pine or hardwood forest in the absence of disturbance such as fire. An additional problem may be displacement of native grasses by those favored for livestock production.

Conservation Accomplishments

To date, very little work has been done on the status or management of the meadow vole in South Carolina. However, from 2001 to 2003, researchers at Furman University worked closely with SCDNR biologists to assess the effects of vegetation type, fire and mowing on meadow vole populations in an old field on the Bunched Arrowhead Heritage Preserve in Greenville County. The results of these studies indicated that mowing is the preferred means of maintaining early successional habitats as voles moved back into mowed habitats sooner than burned habitats. Further, meadow voles preferred dense stands of planted switchgrass (*Panicum virgatum*) to naturally regenerated stands of broomsedge (*Andropogon virginicus*) and blackberry briar (*Rubus* spp.) or planted stands of deer tongue (*Panicum clandestinum*).

Conservation Recommendations

- Conduct a multi-year live-trapping survey of suitable habitats throughout the historical range. As meadow vole populations are known to fluctuate dramatically within periods of two to five years, areas will need to be surveyed over successive years to ensure that populations cycling through low density are not overlooked. Use Sherman live traps to survey known populations and suitable habitats annually during mid to late summer when densities should be highest. A standard trapping protocol should be used to enable reliable comparisons across years and sites. A trap density of 50 per 1/20 hectare (0.5 acre) in a grid formation should be sufficient.
- Investigate the apparently disjunct populations in the Charleston area with molecular techniques to determine if this isolate is unique and deserving of more serious independent conservation concern.
- Consider purchase of lands where meadow voles are documented on large areas of pasture or old-field habitat that can be easily maintained in an early succession grassland community.
- To the extent feasible, plant switchgrass (*P. virgatum*) and other tall, dense, native grassland species in open areas on existing SCDNR lands and mow on a two-year cycle to ensure tall dense stands and prevent conversion of grassland areas to brush and woodland.
- Partner with local colleges to complete initial survey work for meadow voles through educational field exercises.

Measures of Success

Surveys and monitoring will allow the re-evaluation of the status of the species in South Carolina. The molecular study of the coastal versus piedmont animals will allow researchers to discern appropriate taxonomic designation of the coastal animals.

Mink

Mustela vison

Contributors: Jay Butfiloski and Buddy Baker

Description

Taxonomy and Basic Description

Schreber first described the American mink, *Mustela vison*, in 1777. Mink are classified in the order Canivora, family Mustelidae and further categorized into the subfamily Mustelinae. Photo by Phillip Jones, SCDNR.

The mink, like other members of the weasel family, has short legs and a long cylindrical body. Body mass ranges from 0.55 to 1.25 kg (1.2 to 2.75 pounds.) and overall length is 470 to 700mm (18.5 to 27.5 inches.) Males are approximately 10 percent larger than females. Pelage is typically dark brown with white markings on the throat, chest and belly. The tip of the tail is markedly darker than the rest of the body (Jackson 1961).

Mink have two anal glands that produce a strong odor. When stressed, mink can release secretions from these glands, as a defense mechanism (Brinck et al. 1978). Feces are usually deposited in prominent places as territorial markers.

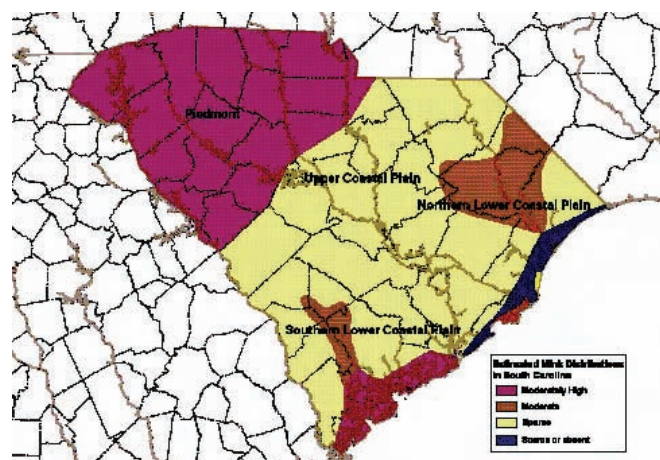
Mink are polygamous, and courtship and mating in mink can often be aggressive. Mating usually occurs from January through March and, because of delayed implantation, the gestation period ranges from 40 to 75 days. Birth of the young occurs 30 days after implantation. Young are typically born from April to June. Weaning occurs at eight to nine weeks, though the young may remain with the female as a family group until fall.

Status

Although no official status has been given to the mink, South Carolina's population is considered to be in decline statewide (Baker 1999).

Population Distribution and Size

The mink's range extends throughout Canada and much of the eastern United States. Historically, mink occurred throughout South Carolina in varying densities. The piedmont region and southern coastal marsh areas have had relatively abundant populations of mink. Much of the upper and lower coastal plain regions contain sparse densities, with moderately higher concentrations of mink in the Lynches/Pee Dee and Salkahatchie/Combahee river corridors. Mink are scarce or absent in the northern coastal marshes. Recent survey data indicates mink are essentially absent in the northern coastal marshes where population restoration by SCDNR has not taken place and are possibly declining throughout the remainder of the state (Baker 1999).



A recent ecological characterization of hammock islands in South Carolina's coastal zone suggests that these islands may provide denning habitat for coastal mink (Whitaker et al 2004). One researcher noted one diurnal sighting of mink as well as tracks on the islands. Additionally, he found many clusters of clapper rail feathers and a few piles of small mammal hair in grasslands on hammocks near salt shrub collars and logs on hammock uplands, suggesting mink use the islands for foraging and feeding (McCord, personal communication May 24, 2005).

Annual commercial fur harvest data indicated a 30-year average harvest of 108 animals per year by commercial trappers and hunters. However, this average does not adequately reveal the decline in harvest data over the last few years. From the 1975 season to 1989, the average mink harvest was 197 animals. Since the 1990 fur harvest season, the average take has been only 19 mink (SCDNR 2004 unpublished data).

A considerable amount of anecdotal information has been received from older trappers who report declining mink numbers. Numerous experienced mink trappers have noted that the species is rare or absent from areas of former abundance even though the habitat is seemingly intact. One trapper from Lancaster County reported that he had not caught a mink in over 20 years from a trap line that once produced as many as 30 mink per year. Furbearer biologists from the Georgia Department of Natural Resources and the North Carolina Wildlife Resources Commission reported similar comments from trappers about declines in mink numbers in their states (Greg Waters, GA DNR and Perry Sumner, NC Wildlife Resources Commission, personal communication).

In a mail survey of South Carolina sportsmen who caught mink during the 1988 trapping season, over 40 percent of the respondents perceived the mink population to be declining (SC Wildlife and Marine Resources Department, unpublished data).

Habitat and Natural Community Requirements

Mink are typically associated in habitats with some type of water component. These areas include swamps, rivers, streams, ponds and saltwater marshes. Mink typically live in dens located in rock piles, under tree roots, bridge crossings and stream bank holes. Mink in saltwater marsh habitat may rarely utilize dens because of tidal fluctuations.

Mink are carnivorous and their diet often reflects prey availability, opportunity and location. Statewide, fish may make up 40 percent of the mink's diet. However, mink will also consume small rodents, rabbits, muskrats, squirrels, crabs, crayfish, insects, snails, frogs, snakes and waterfowl (Baker 1999).

Challenges

Because of the lack of historic data on habitat conditions in South Carolina, it is difficult to quantitatively evaluate how mink habitat has changed over time. While the integrity of some streams has clearly been altered, others appear reasonably pristine. There has been no attempt to correlate mink densities with habitat alteration. Future studies should compare mink densities with existing habitat suitability index models.

While habitat alterations may be a contributing factor in South Carolina mink population declines, it is doubtful that habitat conditions alone are responsible. Elsewhere throughout the mink's range the species is reported to be adaptable in its use of habitats, tolerating both human activity and habitat changes (Allen 1984). Additionally, some of the areas in South Carolina where mink have declined are in stream drainages, which appear to be intact.

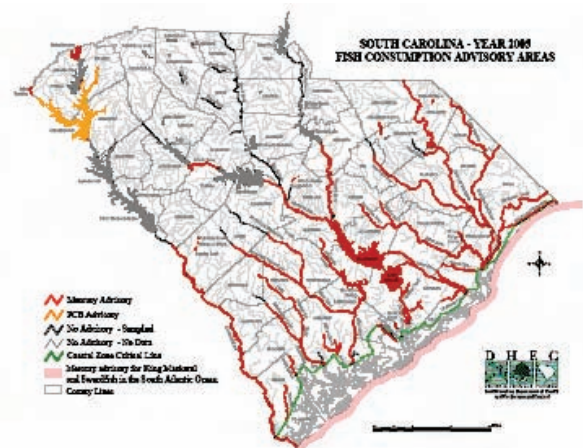
Environmental pollution has long been recognized as a biological hazard to wildlife. Industrial pollutants, pesticides and heavy metals are known to exhibit biomagnification as they pass up the food chain. The mink occupies a niche at or near the top of the food chain; therefore, this species would be especially vulnerable to environmental contaminants. Mink population decline in other regions of North America, most notably in the Great Lakes Region, have been associated with environmental contaminants. Numerous studies have demonstrated the mink's high level of sensitivity to pollutants, particularly organic mercury compounds (Aulerich et al. 1974; Woberser et al. 1976) and polychlorinated biphenyls (PCBs) (Platonow and Karastad 1973; O'Shea et al. 1981).

In 1987, the Furbearer Project initiated studies to evaluate contaminant levels in trapper harvested mink carcasses from South Carolina (Carmichael and Baker 1989). The University of Georgia Riverbend Research Center performed chemical analysis under contract to the SCDNR. Mink samples were screened for a total of 21 chlorinated hydrocarbon pesticides plus PCBs. Tests for ten heavy metals were also conducted. Residues of DDE, PCBs and mercury were detected in mink tissue samples from South Carolina. Residue levels were generally lower than those reported for other wild mustelid populations and did not approach levels published for mink that suffered mortality in laboratory studies. However, the effect of low levels of these contaminants on reproduction and survivability in wild mink remains uncertain. Ringer (1981) stated that reproduction in mink would normally not be impaired by chlorinated hydrocarbon pesticides such as DDT at levels typically encountered in the environment. However, small doses of PCBs and mercury, singly or in combination, are of concern. Fish in most rivers and lakes throughout the country are now contaminated with PCBs (Jacknow et al. 1986); dietary levels as low as 0.64 parts per million (ppm) have been shown to seriously impair reproduction (Platonow and Karastad 1973). Forty-three percent of the mink sampled in our studies had detectible residues of PCBs with a mean level of 0.56 ppm.

Additionally, mercury is widespread in the environment due both to human activities such as coal burning power generation as well as to naturally occurring mercury in the state's soils. One ppm mercury in the mink diet for as little as two months is known to be lethal (Kirk 1971). Smaller doses would likely have sublethal effects on reproduction and behavior of mink.

Health advisories posted by the South Carolina Department of Health and Environmental Control (SC DHEC) in January of 1995 indicated that mercury contamination of fish in 18 rivers and 9 lakes in South Carolina were high enough to prompt warnings about human consumption of fish. The advisory included all of the stream drainages of the coastal plain and reported mercury levels in many drainages that are above the levels known to be lethal to mink. Mercury levels for some fish species in the Black River and Pee Dee River were nearly three times higher than known lethal dietary levels for mink. The 2005 Health Advisories from DHEC show a worsening problem as now 26 rivers, 11 creeks or canals and 16 lakes or ponds have at least partial fish consumption advisories.

While the mean levels of mercury detected in mink from the piedmont region of South Carolina



(0.53 ppm) were below levels expected to cause direct mortality, a small sample of coastal plain mink (3) exhibited levels considered to be greater than normal background levels (6.01 ppm).

The current Environmental Protection Agency (EPA) limit for fish deemed safe to consume by humans is 2 ppm for PCBs and 1 ppm for mercury. Wild mink eating fish containing PCBs or mercury at these or lower levels are at risk. The situation becomes very complex when synergistic or combined effects of environmental contaminants are considered. Lab studies with mink have shown reduced survival in kits born to mink that received both PCBs and mercury simultaneously (Wren et al. 1987). Over 40 percent of mink sampled in South Carolina contained residues of both PCBs and mercury. If other negative impacts are present, such as food shortages, extreme climatic conditions (cold weather or drought) or parasite burdens, contaminant tolerance levels may be very low for a species like the mink (Wren et al. 1986; Wren et al. 1987).

In 1990 the Furbearer Project continued its investigations into the impact of environmental toxicants on mink by expanding the sample area in the coastal plain (Osowski et al. 1995). Samples from Georgia and North Carolina were included due to similar concerns about mink population declines by the wildlife agencies in those states. The Clemson University Institute of Wildlife and Environmental Toxicology conducted chemical analysis for the tri-state study.

Of the organochlorine pesticides tested, only dieldrin was detected at significantly higher levels in South Carolina's coastal plain than in the piedmont. Liver PCB concentrations were also found to be significantly higher than the piedmont reference group; many samples contained dieldrin in concentrations higher than those known to cause mink reproductive dysfunctions.

This study also revealed mercury concentrations from mink kidney tissue to be elevated in the Georgia, North Carolina, and South Carolina coastal plain compared to the piedmont reference. The concentrations detected were high enough, according to Wren et al. (1986), to cause sub-lethal effects on most physiological functions, including reproduction, growth and behavior. Of the three states, South Carolina had the highest mean level of detectable mercury (3.51 ppm).

Conservation Accomplishments

The Furbearer Project spent a number of years determining the status of mink populations in South Carolina and the causes of their decline. Research revealed that mink populations had been lost entirely in the tidal marshes from Charleston Harbor north to the South Carolina/North Carolina line. Beginning in 1999, the Furbearer project initiated restoration efforts with South Carolina's coastal mink population. Fortunately, mink remain abundant in the marshes along our state's southern coast. The marshes in the North Edisto River, the ACE Basin and in the vicinity of Hilton Head Island have served as mink population sources for capture efforts. The first restoration effort in the Cape Romain National Wildlife Refuge (NWR) in 1999 and 2000 was hugely successful, thanks in part to the hard work of then Clemson graduate student Jason Peeples and Dr. Tim Fendley of Clemson University. Based on the success of this effort in Cape Romain NWR, the mink restoration project moved up the coast in 2002.

The Furbearer Project has relied on many cooperators, including private citizens, landowners and property owner associations, as well as other governmental personnel to facilitate mink research and restoration efforts. Continued cooperation is envisioned in the future.

Mink restoration along the coast has been fairly well publicized. Several newspaper articles have been written about these efforts. An article has also appeared in the SCDNR's magazine, *South Carolina Wildlife*. SCDNR staff has provided information to residents during mink releases at

Deweese Island with the cooperation of Arla Jessen, education coordinator of Deweese Island. Any additional releases in the Murrell's Inlet area would likely involve Huntington Beach State Park personnel and visitors.

In 2002, the goal was to complete mink stocking at North Inlet in Georgetown County. Thanks to many cooperators, trapping efficiency was so effective in 2002 that stocking efforts in North Inlet were completed and efforts were focused on the next target area, Murrells Inlet. All totaled, 17 adults and 35 kits were stocked in North Inlet and 25 adults were stocked in Murrells Inlet.

In 2002 a new mink indexing technique was tested for measuring marsh mink populations. Lisa Vandiver a work-study student from the College of Charleston conducted this work. The Kiawah Island Natural Habitat Conservancy provided funding for the studies. The mink indexing research focused on testing a floating track board design. Overall, visitation rates by mink were 42 percent, indicating that this technique has significant value as a population-monitoring device. The current technique used for monitoring marsh mink involves spotlight flood tide surveys. The shortcoming of the flood tide surveys is that it can only be performed several days per season. This technique is also problematic as it must be conducted during flood tides when work should be concentrated on trapping mink. The track board technique will allow greater latitude in population monitoring.

Earlier research suggested that the decline in mink populations from South Carolina's northern coastal region was related to environmental contaminants. Therefore, investigations were initiated to determine if similar problems existed in mink populations of the southern coastal areas. SCDNR partnered with the Clemson University Department of Environmental Toxicology for these investigations. While this research did reveal concentrations of mercury, organochlorine pesticides, PCBs, dioxins and furans in tissues of mink at levels that may have some adverse effect on individual animals, the overall levels were not considered to be high enough to have adverse effects on the mink population.

Age structure work on ACE Basin mink suggests good survival rates and good recruitment rates within this population.

The Furbearer Project enlisted the assistance of SCDNR's Marine Division scientist David Knott to conduct food habits studies of mink in the ACE Basin. Marine organisms in mink scats and stomach contents collected throughout other studies were identified. This data will allow evaluation of prey abundance in prospective restoration sites. Further, environmental contaminant uptake in potential prey can be tested without sacrificing mink. Data from these food habit studies will also allow for better explain of mink population fluctuations, which may be tied to changes in food availability. Results of the studies revealed that mink are very opportunistic. Some general observations of the common food items in their diet include: small fish, blue crabs, fiddler crabs, insects, mud minnows, marsh hens and marsh rice rats.

During the May flood tides in 2003, follow-up surveys were conducted in North Inlet and Murrells Inlet to evaluate the success of 2002's mink stockings. Observations in North Inlet were very encouraging. In the course of a two-hour flood tide five adult mink were counted. Three of these were females with young. For mink to survive the stress of relocation and still be fit enough to reproduce the first year indicates good environmental conditions. Results from the Murrells Inlet surveys were disappointing. Two evening surveys were conducted; although no mink were detected, neither survey was considered a "complete" survey. Two incomplete surveys are not sufficient to demonstrate absence of mink. A mink sighting report from staff from Huntington

Beach State Park in the summer of 2004 provides encouragement that the released mink may still be present in the area.

Prerelease surveys in the vicinity of Dewees and Capers Islands support the belief that mink are absent in that area, the next restoration site. A total of 13 mink (1 unknown adult, 3 females with 9 young) were released into the marshes of Dewees Island during the June 2004 flood tides. One adult female was predated by a marsh hawk and witnessed by staff. The remaining 2 young were taken to a rehabilitator; one survived and was released later in 2004. The number of released animals at Murrells Inlet will be supplemented in the future unless additional surveys indicate that additional releases are not warranted.

Conservation Recommendations

- Encourage large-scale conservation easements and focus areas, such as those in the ACE Basin area, and consider purchase of important riparian properties to protect habitat for mink.
- Continue reintroduction efforts to restore mink populations in the northern coastal marshes.
- Conduct additional research to fully support the contention that environmental contaminants are associated with the decline in mink populations in South Carolina. From the results of the studies conducted thus far, the list of suspected contaminants can be narrowed to mercury, PCBs, DDE and dieldrin.
- Continue to assess and implement track board surveys and investigate their applicability to other areas of the state for mink survey need.

Measures of Success

Continue monitoring through the use of flood tide surveys and track board surveys to assess the success of current reintroduction projects in the northern coastal marshes of South Carolina. Additionally, continue to monitor commercial fur harvest of mink to look for long-term harvest increases as signs of successful conservation efforts.

Moles

Hairy-tailed Mole *Parascalops breweri*

Star-nosed Mole *Condylura cristata*

Contributors: Mary Bunch, Mark Ford and David Webster

Description

Taxonomy and Basic Description

Three species of moles occur in South Carolina. These include the eastern mole, (*Scalopus aquaticus*) which is widely distributed and common. The other two species, the star-nosed mole (*Condylura cristata*) and hairy-tailed mole (*Parascalops breweri*), are less commonly encountered in South Carolina. All three possess velvety fur; eyes that are small and concealed in the fur; and large well developed forelimbs with backward facing palms and long claws. They also lack external ear structures.

The star-nosed mole was first described by Linnaeus in 1758. Two subspecies are recognized for the star-nosed mole: *Condylura cristata cristata* and *Condylura cristata parva*. Star-nosed moles in South Carolina are considered to be *C. c. parva* (Peterson and Yates 1980). As the name

implies, the rostrum of the star-nosed mole is star-like and consists of 22 fleshy appendages. Total length of this species ranges from 153 to 238 mm (6.24 to 9.3 inches). The moderately haired tail is approximately one-third to one-half the body length. The fur is black or a black-brown on the back (Peterson and Yates 1980; Webster et al. 1985; Laerm et al. 2005a).

The hairy-tailed mole, first described by Bachman in 1842, is the smallest of South Carolina's moles, ranging from 139 to 174 mm (5.4 to 6.8 inches). The name suggests its identifying attribute, a densely furred tail. The tail is less than one-quarter of the body length. The fur is black to a gray-black on top and slightly paler underneath (Hallett 1978; Laerm et al. 2005b). Both mole species use their tail for fat storage; therefore, tail width varies with season and condition.

Status

Both species are of special concern in South Carolina. The state rank for the hairy-tailed mole is unknown (S?). The star-nose mole is ranked S3? or uncommon (mostly unknown). Both species have a global rank of secure (NatureServe 2004). The hairy-tailed mole is common in Pennsylvania (Merritt 1987) and appears to be secure in Virginia, Kentucky and North Carolina but is considered as vulnerable in Tennessee and critically imperiled in Georgia (Lamer et al. 2005b). The star-nosed mole, ranked as uncommon in South Carolina, is imperiled in Georgia and Tennessee and is considered secure in North Carolina and Virginia (Laerm et al. 2005a).

Population Size and Distribution

There are no population estimates available in the southern end of the range (southern Appalachians) for either the hairy-tailed or star-nosed moles. Laerm et al. (2005a, 2005b) reports both species as "uncommon" and the hairy-tailed mole as "rarely reported in appropriate habitat."

The hairy-tailed mole is restricted to the high elevation mountains of South Carolina within the southern Appalachian ecoregion. The range for hairy-tailed moles extends from the mountains in South Carolina northward into southern Maine and extreme southern Canada (Hallett 1978).

The star-nosed mole extends both into South Carolina's mountains and the outer and inner coastal plains and sandhills ecoregions. There appears to be a gap in the distribution of star-nosed moles in the piedmont of South Carolina and most of the piedmont of North Carolina (Beane 1995).

The North American distribution for the star-nosed mole extends from Canada, down to and across New England and the Great Lakes states, southward along the Appalachians into Georgia and South Carolina. Additionally, it is found coastally through Georgia and extreme northern Florida (Peterson and Yates 1980).



Hairy-tailed Mole Distribution



Star-nosed Mole Distribution

Habitat and Natural Community Requirements

Both the star-nosed and hairy-tailed moles are found in the southern Appalachian Mountains. Within that ecoregion, they show some overlap in habitat; both species use mesic mixed forest, mesic deciduous hardwood and bottomland or floodplain forests. The latter habitat is extremely uncommon in the mountain ecoregion in South Carolina (Griffith et al. 2002).

Hairy-tailed moles are usually found in areas with elevations above 427 m (1400 feet). Habitats for this species include fields and pastures, deciduous (including dry deciduous) needle-leaved evergreen forest and mixed evergreen-hardwood forest. Often the habitat includes loose, easily drained and excavated soil with cover. Soils are not typically wet or of high clay content. In the southern Appalachians, associated species that can occur in the same habitats as the hairy-tailed mole include several other South Carolina species of concern: the southern red-backed vole (*Clethrionomys gapperi*), woodland jumping mouse (*Napaeozapus insignis*), star-nosed mole (*Condylura cristata*) and masked shrew (*Sorex cinereus*).

Star-nosed moles in the southern Appalachian ecoregion tend to be found in wetter sites than hairy-tailed moles, often found in sites such as swamps, marshes and bogs. Star-nosed moles are the most aquatic of our moles and construct tunnels that sometimes lead into water (Webster et al. 1985). Forested floodplains, forested and early successional bottomland, mesic hardwood sites and streamside areas typify habitats used by this species in the mountains. Additionally, star-nosed moles are found in sites with dense leaf litter.

The coastal and sandhills habitats for star-nosed moles include pocosins, wetlands, saturated bottomlands and long-leaf pine habitat. Neither forest age nor successional stage has been reported as a critical factor determining habitat suitability for the star-nosed mole (Laerm et al. 2005a).

Both the star-nosed mole and the hairy-tailed mole burrow and will create both underground tunnels and surface tunnels. Nests are constructed underground. All moles are vulnerable to inundation; therefore, nests are built above the typical high water level.

Challenges

Scientists agree that additional surveys for star-nosed moles and hairy-tailed moles are necessary to better understand the distribution and abundance of these species. Additionally, in order to better understand the association with wet soils preferred by star-nosed moles, soil requirements should also be investigated for this species.

Cats, dogs, owls, foxes and snakes can all prey upon both species. Presumably, coyotes will also use star-nosed moles and hairy-tailed moles as a food source. Currently, none of these predators are reported to be major threats to the species' survival (Hallett 1978, Peterson and Yates 1980). Increased predation from cats and dogs is expected as residential development increases.

Increases in eradication from humans that view the species as nuisances can be expected. However, landscaping techniques exist that may reduce problems that result due to mole activity. One of these techniques is to limit the use of mulch. Mulch favors water retention, which, in turn, attracts soil invertebrates, the food source for moles. By removing the habitat of these invertebrates, the area becomes inhospitable to moles. Exclusion techniques, such as mole fences or underground barriers, may also limit mole damage (Henderson 1994).

As the urban interface grows, increased impacts from development will occur. Development

impacts can be measured by quantifying creation of impermeable surfaces, such as roads, buildings and parking lots (Laerm et al. 2005a). Direct loss of habitat is a threat, as are changes in hydrology associated with development. Laerm et al. (2005a) suggest that activities that permanently saturate the soil in sites occupied by star-nosed moles and hairy-tailed moles are detrimental. Neither the hairy-tailed nor star-nosed mole seems to be sensitive to seral stage; however, effects of timber harvests on localized, temporal water levels could cause nests to be flooded with ground water.

The recent range expansion of the nine-banded armadillo into the South Carolina coastal plains may represent a threat to the star-nosed mole by competition for food resources. Predation by feral hogs may also present a threat to moles throughout their range.

Conservation Accomplishments

In South Carolina, the Andrew Pickens Ranger District of the Sumter National Forest, several mountain Heritage Preserves, Jocassee Gorges, several state parks and some tracts owned or held in easement by various land trusts contain habitat for star-nosed moles and hairy-tailed moles. For example, over 30,000 acres of mountain land is under conservation easement held by The Nature Conservancy. None of those properties were purchased specifically to protect either the star-nosed or hairy-tailed moles; however, both benefit from these acquisitions and the protection offered for their habitat.

The South Carolina Department of Natural Resources (SCDNR) is in the process of creating new geology and soils maps for the northwestern corner of South Carolina. These new maps may prove useful in determining limiting factors for moles in the mountains of South Carolina.

Conservation Recommendations

- Discourage the construction of ponds in known star-nosed mole and hairy-tailed mole habitat and prevent increases in storm water run-off associated with development in all habitats.
- Re-examine current South Carolina state rankings for these mole species as required under the Nongame and Endangered Species Conservation Act, in Chapter 15 under Title 50 of the Code of Law of South Carolina.
- Conduct ecoregion-wide surveys for distribution and density of both the star-nosed mole and the hairy-tailed mole in order to better understand their conservation status. Survey techniques should be standardized throughout the southeast so that results and data are readily comparable. All capture data should be made available to the most current statewide Heritage Trust database. That information should also be shared with neighboring states.
- Complete a thorough identification of mountain bogs and seeps and their interface with upland sites to prioritize site surveys for the star-nosed mole and the hairy-tailed mole.
- Investigate specific limiting factors associated with habitats for both the star-nosed mole and the hairy-tailed mole.
- Investigate the effects of timber harvest on temporal water table levels and associated impacts to star-nosed mole distribution.
- Educate landowners and other members of the public about the ecological role and benefits of star-nosed moles and hairy-tailed moles.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs.

North Atlantic Right Whale

Eubalaena glacialis

Contributors: David Cupka and Margaret Murphy

Description

Taxonomy and Basic Description

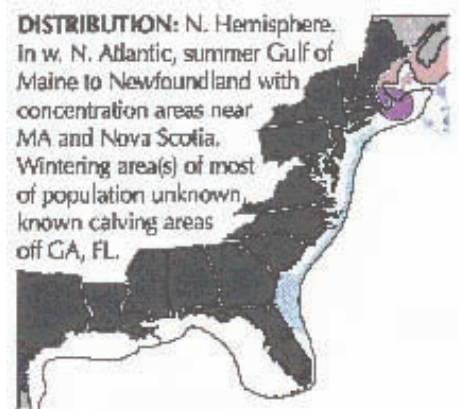
The North Atlantic right whale was first described by Müller (1776). Not built for speed, the northern right whale has a rotund body with a large head (one-third of its total body length) and a narrow, arching rostrum. Its baleen can reach up to 3 m (8 feet) with the fringe along the inside edge fine enough to allow right whales to filter very small food items from the water. Right whales have a broad smooth back absent a dorsal fin. Callus-like patches of skin are found on the rostrum, lower lip, and around the eyes. These patches are called callosities and offer a secure holding place for cyamids, (whale lice) which give the callosities an orange or whitish-yellow color. Right whales also have broad, paddle-like flippers and large flukes with smooth concave margins. These whales are predominately black in color, are often mottled and have a variable amount of white on the belly. Their spot is V-shaped. Adults reach 13 to 18 m (43 to 59 feet) in length and a weight of 55 metric tons (60 tons) (Wynne & Schwartz 1999). Illustration from Wynne & Schwartz, 1999.

Status

The North Atlantic right whale is federally listed as an endangered species. It is among the rarest of all large whale species and, indeed, of all marine mammal species. Population size is at a critical level with only about 300 animals remaining in western North Atlantic waters. The northern right whale is defined as “strategic” under the Marine Mammal Protection Act (MMPA) due to its endangered status and because the average annual fishery-related mortality and serious injury exceeds its Potential Biological Removal (PBR) level, which is zero.

Population Distribution and Size

The seasonal movements of the North Atlantic right whale are still poorly understood. Individuals in the western North Atlantic population range from winter calving and nursery areas off the southeastern United States to summer feeding grounds off New England and north to the Bay of Fundy and Scotian Shelf. These northern waters are also important mating and nursery habitats. Analyses based on both genetics and sighting histories of photographically identified individuals suggest that not all reproductively active females return to calving and nursery grounds each year (Waring et



Map from Wynne & Schwartz

al. 2004). In addition, other than calving females and a few juveniles that winter off the coasts of Georgia and Florida, the wintering location of the remaining individuals in the population is unknown. Therefore, it appears that one or more additional wintering and summering grounds may exist in unsurveyed locations. However, it is possible that the “missing” animals simply disperse over a wide area at these times (Waring et al. 2004).

The right whale was routinely harvested in U.S. waters from 1650 through 1924, with a peak in the early 1700s (Wynne & Schwartz 1999). An estimate of pre-exploitation population size is not available. Population trajectories, based on historical data and estimated present population size, indicate that there may have been 1,000 right whales in the population during the mid 1600s (Waring et al. 2004). During this time period, the population size has been greatly reduced to the point where today there are an estimated 300 animals remaining. It is currently unclear whether the population is stationary, undergoing modest growth or, as recent modeling exercises suggest, currently in decline. The size of this stock is considered to be extremely low relative to its Optimum Sustainable Population (OSP) level in the U.S. Atlantic Exclusive Economic Zone (EEZ).

Habitat and Natural Community Requirements

There are five well-known habitats used annually by western North Atlantic right whales:

1. coastal Florida and Georgia,
2. Great South Channel, east of Cape Cod,
3. Cape Cod and Massachusetts Bays,
4. the Bay of Fundy, and
5. Browns and Baccaro Banks south of Nova Scotia (NMFS 2003). Movements within and between these habitats are believed to be more extensive than originally considered (Waring et al. 2004).

Important feeding areas occur in the Bay of Fundy, Cape Cod Bay, Great South Channel and the Scotian Shelf. Right whales are frequently found in coastal and shelf waters and, for much of the year, their distribution is strongly correlated to the distribution of their prey, calanoid copepods (NMFS 2003). Individuals are generally found in Cape Cod Bay and adjacent waters from January through early May. In late spring, mothers with their newborn calves appear. In summer, right whales make their way northward to feeding grounds off Maine, New Brunswick and Nova Scotia. As mentioned earlier, these northern waters are also important mating and nursery habitats. In October, a portion of the population, mostly pregnant females, migrates southward to waters off southern Georgia and northern Florida to calve. At present, the southeastern United States is the only known calving ground for the western North Atlantic right whale.

Depending on the time of the year, right whales will spend much of their time near bays and peninsulas and in shallow, coastal waters. These areas provide shelter, food abundance, and security for females rearing young or avoiding the mating efforts of males. Four important habitat areas, used as both feeding and nursery grounds for northern right whales are the Browns-Baccaro Bank, Bay of Fundy, Great South Channel and the Cape Cod Bay. Each of these areas is distinguished by high densities of copepod populations. The first three have deep basins (150m) flanked by relatively shallow water. Copepods are concentrated here because of convergences and upwellings driven by tidal currents. This also occurs in the Cape Cod Bay even though a deep basin isn't present (Cummings 1985; Katona 1999). A fifth important habitat area is found off south Georgia and

north Florida in nearshore waters; this area serves as a nursery ground and is characterized by large shallow embayments that provide safe areas for females to calve in the winter.

Right whales are known to occur in waters off South Carolina during the winter but the duration of their residency and the extent to which they utilize this area of habitat is currently unknown. While no right whales have stranded in South Carolina in recent years, there have been strandings to the north of us in North Carolina and to the south in Florida (Wayne McFee, National Ocean Service, personal communication).

Three areas have been designated under the Endangered Species Act as critical habitat for this species (59 FR 28793, June 3, 1994). Two include feeding and nursery areas off the northeastern United States in Cape Cod/Massachusetts Bay and the Great South Channel; the third is the winter calving and nursery area in waters off the southeastern United States.

Challenges

The two most common anthropogenic causes of right whale mortalities in the western North Atlantic are ship strikes and entanglement in fishing gear. The greatest known cause of mortality is ship strikes, which accounted for approximately 35 percent of documented mortalities between 1970 and 1999 (NMFS 2003). The relatively low incidence of photographically identified whales showing scars/wounds attributed to ship propellers when compared to the high rate of such wounds on stranded carcasses indicates that a high proportion of ship/whale interactions are fatal to the whale (Kraus 1990). With improved reporting and more thorough necropsies performed in recent years, the rate of detection and confirmation of ship strike related deaths has most likely increased which may confound efforts to determine trends in the frequency of collisions. Ship speed has been argued as an important factor regarding the frequency of ship strike occurrence in large whale species including the right whale (Laist et al. 2001).

Gear entanglement was estimated to account for seven percent of the known mortality of North Atlantic right whales from 1970 to early 1993 (Kenney and Kraus 1993). At least two additional entanglement deaths occurred between late 1993 and 1999 (Knowlton and Kraus 2001). In the instances where mortality does not initially occur, such events probably weaken the entangled individuals making them more susceptible to other direct causes of mortality (Kenney and Kraus 1993). Entanglement-related stress may also decrease reproductive success or reduce the life span of an individual and may adversely affect the growth of the population. Fishing gear commonly implicated in right whale entanglements are gillnets, lobster pots, seine nets and fish weirs (NMFS 1991). Based on scarification, Hamilton et al. (1998) reported that 61.6 percent of the western North Atlantic population has been entangled in fishing gear. A subsequent study by Knowlton et al. (2001) estimated that between 10 and 28 percent of the population interacts with fishing gear every year.

Other potential challenges include habitat degradation, noise, contaminants and climate and ecosystem change (NMFS 2003). A continued impact to the coastal habitat of the right whale in the North Atlantic is the undersea exploration and extraction of mineral deposits, as well as dredging of major shipping channels. Offshore oil and gas drilling activities have been proposed off the coast of the mid- and south-Atlantic U.S. (NMFS 1991). Right whales also frequent coastal waters where dredging and its associated disposal operations occur on a regular basis, such as along the southeastern U.S. It is unknown to what extent mineral extraction and dredging activities may impact right whales.

Conservation Accomplishments

SCDNR and SAFMC (South Atlantic Fishery Management Council) personnel serve as members of the Atlantic Large Whale Take Reduction Team (ALWTRT) and on the Southeastern Right Whale Recovery Plan Implementation Team (SEIT). National Oceanic and Atmospheric Administration (NOAA) Fisheries established the ALWTRT, comprised of stakeholder groups, to determine ways to reduce serious injury and mortality of northern right, fin and humpback stocks that interact with Category I or II fisheries. Category I Fisheries are those that have a serious injury/mortality rate of 50 percent or more of a marine mammal stock's PBR. Category II Fisheries are those that are expected to have a serious injury/mortality rate of more than 1 percent but less than 50 percent of a marine mammal stock's PBR. The final plan was implemented in 1999; however, despite the measures put forth in the plan, annual mortalities and serious injury are still exceeding PBR for right whales (0.0 whales). Consequently, the ALWTRT is currently working with NOAA Fisheries to amend the Atlantic Large Whale Take Reduction Plan in order to meet the goals of the MMPA which mandate reducing incidental mortality or serious injury to below each stock's PBR level within six months of the plan's implementation. The long-term goal is to reduce serious injuries and mortality to an insignificant level approaching a Zero Mortality Rate Goal (ZMRG) in order that they can reach or maintain their optimum sustainable population size. To date, despite efforts of the plan to reduce large whale entanglements and other activities to reduce ship strikes, annual mortalities attributed to fishery interactions and ship strikes are still exceeding PBR for right whales (0.0 whales). SCDNR personnel will continue to serve on the ALWTRT and the SEIT in order to help develop and implement programs and activities designed to reduce North Atlantic right whale non-natural mortalities to insignificant levels approaching the ZMRG, which is 0.0 right whales.

Since its inception in August 1993, the SEIT has met regularly and has been active in a number of areas. Among other things, the SEIT has coordinated a number of efforts to educate mariners about the threat of ship strikes in right whale habitat. Particularly, the SEIT has been instrumental in developing a system of aircraft surveys and communication systems that alert mariners to the presence of right whales in the southeast U.S. on a real time basis. In addition, the team has addressed and/or provided recommendations to NOAA Fisheries regarding right whale research in the southeast U.S., additional measures to reduce the possibility of ship strikes, development of safe operating procedures for large vessels transiting right whale habitat, minimum vessel approach distances, and restrictions on hazardous fishing gear in right whale calving areas (NMFS 2003).

SCDNR has been conducting a marine mammals stranding program since 1991 in order to obtain data on marine mammals that strand along the South Carolina coast. In 2004, we applied for and obtained a Prescott Grant for \$87,000 to continue our stranding program. Data from the program are used to further our knowledge regarding these animals and the extent to which anthropogenic factors are responsible for or contribute to their stranding. We have recently been awarded a grant from the National Fish and Wildlife Foundation for \$353,000 to monitor the occurrence of right whales off the South Carolina and northern Georgia coast during the winter.

Conservation Recommendations

- Analyze available data and collect additional whale sighting data to assess expanding or modifying the critical habitat boundaries.

- Assess the utility and feasibility of voluntary and mandatory ship routing measures and vessel speed restrictions in right whale habitat.
- Develop and implement programs and regulations to incorporate gear modifications and fishing practices that reduce entanglements of right whales in South Carolina waters.
- Conduct studies of gear modifications that result in reduced right whale entanglements.
- Assess right whale population size, survival rate and trends on a regular basis. Determine right whale foraging ecology.
- Continue and expand annual winter surveys for right whales off the southeastern U.S. coast.
- Compile or collect relevant physical, chemical, biological, oceanographic, fishery, and other data to characterize features of important right whale habitats and potential sources of anthropogenic destruction and degradation of critical right whale habitats.
- Use acoustic detection technology to monitor right whale occurrence and distribution.
- Continue to maintain a database of right whale sightings and photo-identifications.
- Conduct studies to determine the direct and indirect effects of coastal development, mineral extraction and dredging activities on the distribution, behavior, and productivity of right whales.
- Continue and improve seasonal aircraft surveillance of right whale habitats and other elements of the “Sighting Advisory System.”
- Continue and improve the mandatory ship reporting system for right-whale sightings.
- Continue and improve the stranding network for right whales.
- Continue and expand efforts to educate mariners and the shipping industry, and fishermen and the fishing industry, about right whale vulnerability to ship strikes and fishing gear entanglements.
- Provide right whale sighting locations to mariners through broadcasts and other appropriate media.
- Encourage reports of right whale entanglements to the disentanglement network.

Measures of Success

SCDNR personnel will continue to serve on the ALWTRT and the SEIT in order to help develop and implement programs and activities designed to reduce North Atlantic right whale non-natural mortalities to insignificant levels approaching the ZMRG, which is 0.0 right whales.

Northern Yellow Bat

Lasiurus intermedius

Contributors: Mary Bunch, Wendy Hood, Susan Loeb, Mary K. Clark and David Webster

Description

Taxonomy and Basic Description

Northern yellow bats (*Lasiurus intermedius*) are foliage roosting bats, along with three other bat species in South Carolina: red (*Lasiurus borealis*), Seminole (*Lasiurus seminolus*) and hoary bats (*Lasiurus cinereus*) (Webster et al. 1985). Foliage roosting bats hang under leaves and branches,

or, in the case of northern yellow bats, often under Spanish moss (*Tillandsia usneoides*) (Barbour and Davis 1969). The yellow bat differs from the red, Seminole and hoary bats in that the tail membrane is not well furred entirely to the bottom and the ears are somewhat pointed, not rounded. These bats typically have two to four young in a single birth per year (Webster et al. 1980).

Northern yellow bats were once known as *Dasypterus floridanus*, but are currently accepted as *Lasiurus intermedius*, as described by H. Allen in 1862. The subspecies recognized in South Carolina is *Lasiurus intermedius floridanus* (Barbour and Davis 1969; Webster et al. 1980).

The second largest bat in South Carolina, the northern yellow bat weighs between 14 and 20 g (0.49 to 0.7 ounces) and has a total length of 127.6 mm (5 inches). The fur is a silky yellow-orange with a faint wash of brown or gray on the tips (Webster et al. 1985).

Status

The status of the northern yellow bat in North and South Carolina is unknown (S?). Georgia and Mississippi regard the species as imperiled. Alabama ranks the northern yellow bat as critically imperiled. The species has a global status of apparently secure (G4/G5) (NatureServe 2004). Because little information is available concerning the status of this species, South Carolina biologists rank this species of greatest conservation priority for terrestrial mammals.

Population Size and Distribution

The distribution of northern yellow bats is poorly known. They have been found in coastal New Jersey and Virginia, but the accepted range is typically farther south (Barbour and Davis 1969). They occur in the outer coastal plain of South Carolina and into the inner coastal plain along the Savannah River (Coleman 1948, Golley 1966; Menzel et al. 2003a). Northern yellow bats are also found southward in the coastal plain of Georgia and Alabama and into Florida (Barbour and Davis 1969; Webster et al. 1980; Menzel et al. 2003b).

Northern yellow bat density estimates are not available. In some locations in Florida, the northern yellow bat is the predominate bat species and feeding aggregations of more than 100 individuals, mostly females, have been reported in mid- to late summer. Males may congregate in the winter in Florida (Barbour and Davis 1969). The aggregation behavior of northern yellow bats in the Carolinas is unknown. The home range of a single bat in Georgia was reported as 10.5 ha (25.9 acres) in oak-dominated oak and pine habitat (Krishon et al. 1997). The species is not known to be migratory.



Yellow Bat Distribution

Habitat and Natural Community Requirements

The northern yellow bat occurs in the inner and outer coastal plain and coastal zone of South Carolina. Most information about this species has been discovered in Florida (Barbour and Davis 1969). These bats forage over open areas, such as fields, pastures, golf courses, marshes and along lake and forest edges. In the sandhills of Florida, roosting habitat includes oak forests and long-leaf pine (*Pinus palustris*) stands. Additionally, live oak (*Quercus virginiana*) hammocks also provide roosting habitat for northern yellow bats. Roosting sites are usually in clumps of Spanish moss or under old palm fronds (Mirowsky 1997).

Challenges

Northern yellow bats are one of the least known mammalian species in South Carolina. Without knowledge of the demographics or life history requirements for this species in this state's habitats, biologists can only base threats on those known in other parts of its range or threats to bats in general (Tuttle 2004a).

Loss of habitat represents the greatest challenge to this species. Lack of essential data on this species in the Carolinas and Georgia results in little information available to the public, land managers and decision-making processes, which influence the habitat of Northern yellow bats. Habitat loss is partially due to development as habitat is converted to urban uses. Additionally, roost sites are lost when old palm fronds are removed for cosmetic reasons and through Spanish moss harvests (Barbour and Davis 1969). Collisions with towers (Crawford 1981) and potential collisions with wind turbines (Erickson et al. 2002; Tuttle 2004b) also represent potential threats.

Conservation Accomplishments

No significant conservation accomplishments are known at this time.

Conservation Recommendations

- Retain Spanish moss and old palm fronds on public lands to preserve roosting habitat for northern yellow bats.
- Encourage retention of Spanish moss and old palm fronds on private lands to preserve roosting habitat for northern yellow bats.
- Conduct surveys to determine northern yellow bat distribution, roost sites and habitat requirements. Monitor populations, once identified.
- Conduct molecular research to determine the validity of northern yellow bat subspecies designation and the variation within the species across its known distribution.
- Determine if the northern yellow bat is threatened by pesticide and/or heavy metal contamination.
- Educate homeowners and landowners about the importance of northern yellow bats and other bats.
- Create demonstration areas on publicly owned site(s), leaving old fronds uncut on palms in a highly visible area with prominent signage explaining that old fronds provide important roosting habitat for northern yellow bats.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs. It is important to determine important roost site locations to provide long-term habitat for the species.

Shrews

Masked Shrew *Sorex cinereus*

Pygmy Shrew *Sorex hoyi*

Contributors: Mary Bunch and Mark Ford

Description

Taxonomy and Basic Description

All shrews have long pointed snouts, short dense fur and small eyes. The ears blend in well with the surrounding fur. The masked shrew was first named by Kerr in 1792 and the pygmy shrew by Baird in 1858. The pygmy shrew and the masked shrew closely resemble each other; both are small with gray-brown fur on the back and a more faded version underneath. Both have distinctly bicolored tails, dark above and pale underneath, that are more than half the head and body length (Webster et al. 1985). In the summer, the pygmy shrew has a reddish hue to its pelage, whereas the masked shrew has a brown hue.

Only one subspecies of masked shrew, *Sorex cinereus cinereus*, is found in South Carolina. The total length of this animal ranges from 80 to 111 mm (3.1 to 4.3 inches), including a tail of 34 to 48 mm (1.34 to 1.9 inches). Masked shrews weigh 3 to 5 g (0.10 to 0.17 ounces).

Pygmy shrews are the smallest mammal in South Carolina, weighing only 2 to 4 g (0.07 to 0.14 ounces), about the weight of a dime (Webster et al. 1985). They range in total length from 70 to 96 mm (2.7 to 3.8 inches) (Ford et al. 2004). Tail length is 25 to 34 mm (0.99 to 1.34 inches). The most reliable distinguishing feature is a third upper unicuspid tooth (one with only one point) that is reduced when compared to preceding unicuspids. In shrews found sympatrically with pygmy shrews, such as the masked shrew or the southeastern shrew (*Sorex longirostris*), the third upper unicuspid is similar in size to other unicuspids (Long 1974). *Sorex hoyi winnemana* is the only subspecies of pygmy shrew known from the extreme southern range, including its range within South Carolina (Diersing 1980). The pygmy shrew was originally classified as *Microsorex hoyi*. Diersing (1980) subsequently determined that the species was more appropriately classified in the genus *Sorex*; *microsorex* was reclassified to a subgenus.

Status

Both the masked shrew and the pygmy shrew have a global rank of secure or G5 (NatureServe 2004). The state rank for the masked shrew is unknown (S?) in South Carolina. This species is considered secure in the northern part of its range from Virginia north through the continental United States, through Canada and into Alaska. The masked shrew is apparently secure in North Carolina and Tennessee but is considered vulnerable in Kentucky and imperiled in Georgia (NatureServe 2004).

The pygmy shrew, ranked as S3/S4 (uncommon but believed to be secure) in South Carolina, is designated as apparently secure in Virginia and Tennessee and imperiled in Georgia and Tennessee; there is no ranking for the pygmy shrew in West Virginia (NatureServe 2004).

These species are considered of conservation concern in interest of maintaining the biological diversity of the state of South Carolina. Both species are indicative of habitats that are uncommon in the state and, therefore, provide an index of proper management of all habitats in this state.

Population Size and Distribution

South Carolina's mountains represent the southeastern most extent of masked shrew and pygmy shrew distribution. Distributions for both extend into Alaska and Canada, ranging into the Rocky Mountains and across much of the Great Lakes region, New England and down the Appalachians to northern Georgia and South Carolina.

Masked shrews are at the extreme edge of their range in Georgia and South Carolina. Here, they are uncommon and found only at high elevations or in sheltered coves (Ford et al. 1994; Laerm et al. 1995).

There are no population estimates available in the southern Appalachians for either the pygmy or masked shrew.

Habitat and Natural Community Requirements

Both the masked and pygmy shrews are restricted to the southern Appalachian ecoregion in South Carolina. Within that ecoregion, they show some overlap in habitat; both species use mesic mixed forest, mesic deciduous hardwood, dry deciduous forest and eastern hemlock ravine forests. Masked shrews are more selective in their southern habitats and tend to use more northern-type communities like high elevation sites. The pygmy shrew is rather prevalent throughout most mountain habitats (Ford et al. 2004; Laerm et al. 2005). Masked shrews use sites with thick understory, high soil moisture and high organic matter (Brannon 2000). Features like logs, stumps, rocks and dense leaf litter are often components of masked shrew habitat. Neither species is sensitive to timber harvest or prescribed burning in the central Appalachians (Ford et al. 2004; Laerm et al. 2005).

Shrews are beneficial mammals in that they eat many grubs and larvae, which are often pest species (Merritt 1987). Predators of the masked shrew and pygmy shrew include domestic and feral cats and dogs, hawks, owls, foxes, coyotes, weasels and snakes. None of these predators are currently reported to be major threats to the species' survival.

Challenges

In South Carolina, a large portion of the habitat in the Blue Ridge ecoregion that is appropriate for masked shrews and pygmy shrews is on public land, including National Forests, State Parks, Nature Conservancy properties and DNR managed properties. None of these properties were purchased specifically to protect these shrews; however, these species benefit from acquisition and protection of habitat. While these protected areas provide needed habitat, populations on private lands are still threatened by land conversion. Land development in the southern



Pygmy Shrew Distribution



Masked Shrew Distribution

Appalachians represents a major threat to the masked and pygmy shrews. Land use in this region is rapidly changing from rural/agricultural to urban. An unpublished study conducted by SCDNR showed a 4-fold increase in development to every one-fold increase in population between 1983 and 1998 (Richard Lacy, personal communication). Increased predation from domestic cats and dogs, direct displacement from development and limited movement across roads that form barriers are expected as development increases in the southern Blue Ridge Mountains.

Shrews and some other rodent species are readily found dead in discarded glass and plastic uncapped bottles; sometimes multiple animals are trapped in a single bottle. Therefore, unnecessary losses associated with refuse entrapment represents one of the challenges that litter poses to the ecosystem.

Destruction of hemlock forests by the exotic hemlock wooly adelgid (*Adelges tsugae*) may also impact local masked shrew populations (Laerm et al. 2004). It is important that entire hemlock-associate communities be sampled and monitored at permanent plots in order to measure effects of hemlock wooly adelgid infestations and to evaluate the effectiveness of recent releases of exotic predatory beetles to control the infestation (Conway and Culin 2004).

Conservation Accomplishments

In South Carolina, a large portion of the habitat in the Blue Ridge ecoregion that is appropriate for masked shrews and pygmy shrews is on public land, including National Forests, State Parks, Nature Conservancy properties and DNR managed properties.

Conservation Recommendations

- Re-examine current state rankings for masked shrews and pygmy shrews. Adjust those rankings based on any new surveys, as appropriate.
- Encourage various groups to increase litter removal.
- Conduct ecoregion-wide surveys to determine masked shrew and pygmy shrew distribution and density. All capture data should be shared with neighboring states.
- Consider partnerships that can help educate the public that litter can be extremely harmful to native wildlife.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide population estimations that will be used to more accurately rank the species and prioritize future management needs. The effectiveness of anti-litter campaigns can be readily verified by the amount of trash removed before and after the projects.

Sperm Whales

Pygmy sperm whale *Kogia breviceps*

Dwarf sperm whale *Kogia sima*

Contributor: Wayne McFee

Description

Taxonomy and Basic Description

The pygmy sperm whale was first described by de Blainville in 1838. The dwarf sperm whale was first described by Owen in 1866. Both were considered a single species until 1966. These are the only two species in the family Kogiidae. The species name for the dwarf sperm whale was changed in 1998 from '*simus*' to '*sima*.'

At sea, these two species are virtually indistinguishable. Both species are black dorsally with a white underside. They possess a shark-like head with a narrow under-slung lower jaw and a light colored "false gill" that runs between the eye and the flipper. Small flippers are positioned far forward on the body.

Pygmy sperm whales generally have between 12 and 16 (occasionally 10 to 11) pairs of needle-like teeth in the lower jaw. They can attain lengths up to 3.5 meters (11.5 feet) and weigh upwards of 410 kilograms (904 pounds). A diagnostic character of this species is the low, falcate dorsal fin (less than 5 percent of the body length) positioned behind the midpoint on the back.

Dwarf sperm whales generally have 8 to 11 (rarely up to 13) pairs of teeth in the lower jaw and can have up to 3 pairs of teeth in the upper jaw. They can attain lengths up to 2.7 meters (8.9 feet) and weigh upwards of 210 kilograms (463 pounds). A diagnostic character of this species is the high, dolphin-like dorsal fin (greater than 5 percent of the body length) positioned in the middle of the back. This species usually has a pair of short grooves on the throat.

Status

The status for both species is unknown; and neither is listed as threatened or endangered under the Endangered Species Act. The status for pygmy sperm whales is considered strategic by the National Marine Fisheries Service (NMFS) because of recent increased mortality events and fishery related mortalities exceeding Potential Biological Removal (PBR) as established by NMFS (Waring et al. 2002). An unusual mortality event (UME) of pygmy sperm whales in the southeastern United States was declared in 2003 by NMFS, prompting the need for more research on mortality of both species.

Population Distribution and Size

Both species appear to occur worldwide in tropical and temperate latitudes. They tend to occur over the continental slope with the pygmy sperm whale possibly venturing over the limits of the continental shelf more often than the dwarf sperm whale. Stable isotope research suggests that the species may be separated by vertical niche partitioning, occurring in similar locations (Barros et al. 1998).

Because of their shy behavior and avoidance of research vessels at sea, population estimates in the Western North Atlantic Ocean are unreliable. Nearly all the information obtained on either of these species is from stranded animals.

Habitat and Natural Community Requirements

Based largely on stomach content analyses from stranded specimens, pygmy and dwarf sperm whales live in deep water on the continental slope and occasionally continental shelf feeding on cephalopods (squid) and, less frequently, crustaceans and fish. The species of squid found in stomachs suggests that these animals require deep water up to 1,500 meters (4,921 feet). Benthic fish and crabs found in stomachs also suggest that these species forage on the ocean bottom (Reeves et al. 2002).

Challenges

The greatest challenge to both species appears to be marine debris (plastics, bags, balloons). Numerous stranded specimens have been documented with plastic bags and other marine debris in the stomachs. The reasons for this remain speculative but could be the result of mistaking a potential food source. NMFS observer programs have not documented any mortality in fisheries operations except for one take in the pelagic longline fishery in 2000 (Waring et al. 2002).

Cardiomyopathy (enlargement of the heart muscle) appears to be very common in pygmy sperm whales. The etiology of this disease to the heart is unknown, but is observed in nearly 50 percent of the stranded animals. Research on this disease is occurring at a few institutions in the southeastern US.

Conservation Accomplishments

A Prescott Grant through the NMFS to SCDNR has funded responses to marine mammal strandings, data collection, training of volunteers, and timely collection of tissues for research. These funds have allowed the recovery and collection of tissues by the National Ocean Services (NOS), Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) for research on pygmy and dwarf sperm whales. Additionally, a stranding brochure was developed by SCDNR and NOS/CCEHBR in 2003 to hand out to beachgoers at strandings.

Conservation Recommendations

- Continue monitoring sperm whale strandings to:
 - o develop predictive models of stranding rates, especially seasonally, to better prepare network volunteers for increased strandings of these species,
 - o increase information on mortality rates and cause of mortalities to obtain a better understanding on the stressors these species face, and
 - o develop a better understanding of the distribution of these species.
- Develop outreach material to educate the public about the harm plastics and other marine debris can cause to marine life.
- Conduct collaborative research with partners to determine the cause(s) of cardiomyopathy in sperm whales. Basic life history parameters such as age analysis using teeth and reproductive status are also essential in determining longevity, population status and fecundity.

Measures of Success

As more data are accumulated and a better understanding of the status and life history of the two sperm whale species emerges, further management recommendations will be developed. Reduction of marine debris could have a substantial impact on the survival of these species.

Southern Fox Squirrel

Sciurus niger niger

Contributors: David Guynn, John Edwards, Susan Guynn and Judy Barnes

Description

Taxonomy and Basic Description

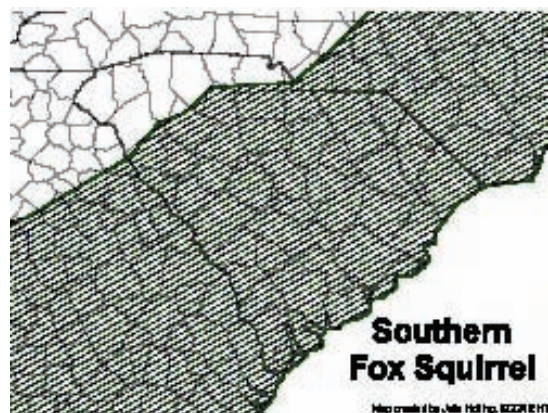
Fox squirrels (*Sciurus niger*) were first described by Linnaeus (1758); ten recognized subspecies exist throughout the United States. These arboreal mammals range in length from 450 to 698 mm (17 to 27.5 inches) and weigh 0.5 to 1.2 kg (17.6 to 42.3 ounces). Coloration varies greatly, both locally and regionally; this variation has resulted in subdivision into numerous subspecies (Hall 1981). Fox squirrel subspecies can be divided into two distinctive but intergrading coloration groups (Weigl et al. 1989). Six subspecies (*S. n. vulpinus*, *S. n. cinereus*, *S. n. niger*, *S. n. shermani*, *S. n. avicennia* and *S. n. bachmani*) have silver, gray, agouti (grizzled) and/or melanistic (black) pelage with tan, gold or reddish undersides. In this coloration group, animals have black head markings, white or gray noses, and white ears and feet. The other coloration group contains four subspecies (*S. n. vulpinus*, *S. n. subauratus*, *S. n. ludovicianus*, and *S. n. limitis*) that are characterized by a distinctly reddish, orange, or tan agouti (grizzled) pelage, a grizzled or black nose, and no white markings on the head or feet. Melanism is common in the southern portions of the range (Lowery 1974; Kiltie 1989; Roe 1994). However, Turner and Laerm (1993) concluded that pelage characteristics are too varied and subjective to permit consistent determination of subspecies in the southeastern portions of the range. The fox squirrel is readily distinguished from the smaller gray squirrel (*S. carolinensis*) by its larger size and presence of only a single pair of premolars in the upper and lower jaws.

Status

The eastern fox squirrel has state rank of S4, apparently secure, in South Carolina and a global rank of G5, secure (NatureServe 2004). However, it is listed as vulnerable in North Carolina, as vulnerable/apparently secure in Alabama, as apparently secure in Arkansas, South Carolina, and Virginia, and as secure in Florida, Georgia, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas. The Delmarva Peninsula fox squirrel (*S. n. cinereus*) is federally listed as endangered (US Department of Interior 2003). The fox squirrel is considered a game animal and its harvest seasons are regulated in all states in the southeast (Edwards et al. 2003). Concerns for the conservation status of the southern fox squirrel are due to the lack of information on the distribution, abundance and ecology of the species.

Population Distribution and Size

The southern fox squirrel (*Sciurus niger niger*) is the only fox squirrel native to South Carolina (Edwards et al. 2003). Populations are scattered across the South Carolina Coastal Plain, occur less often in the piedmont (Wood and Davis 1981; Harrigal 1993) and are rare to absent in the Blue Ridge (Harrigal 1993). In Georgia the species is most common in the coastal plain and piedmont and rare to absent in the Blue Ridge (Hilliard 1979; Turner 1988; Turner and Laerm 1993). Fox squirrels in North Carolina are restricted to the southeastern coastal plain south of the Pamlico River (Weigl 1987); although historical records indicate its former occurrence in the piedmont and Blue Ridge (Lee et al. 1982), the fox squirrel is now rare to absent (Weigl 1987).



Fox squirrel populations east of the Appalachians and along the eastern Gulf Coast have been declining dramatically over the past 100 years (Doutt et al. 1977; Webster et al. 1985; Loeb and Lennartz 1989; Weigl et al. 1989; Humphrey and Jodice 1992, Loeb and Moncrief 1993; Conner et al. 1999). Density estimates in the southeast range from 0.1 to 75 per square km (0.2 to 185 per square acre) (Moore 1957; Hilliard 1979; Humphrey et al. 1985; Weigl et al. 1989; Tappe 1991; Tappe et al. 1993; Lee 1999).

Habitat and Natural Community Requirements

Southeastern fox squirrels select more pine-dominated habitats compared to the deciduous habitats selected by the midwestern subspecies (Weigl et al. 1989). In southern Florida, they occur in cypress swamps, tropical hardwood forests, live oak (*Q. virginiana*) forests and mangrove forests (Humphrey and Jodice 1992). Throughout the lower coastal plain, fox squirrels occur in fire-maintained longleaf pine (*P. palustris*) turkey oak (*Q. laevis*) sand hills, pine flatwoods and associated bottomland habitat (Moore 1957; Williams and Humphrey 1979; Kantola 1992; Wooding 1997; Conner et al. 1999). The preferred habitat of fox squirrels in the sandhills and piedmont of the Carolinas, Georgia and elsewhere is mixed stands of longleaf, loblolly (*P. taeda*) and shortleaf pine (*P. echinata*), hardwoods and bottomlands (Taylor 1973; Hilliard 1979; Dueser et al. 1988; Edwards et al. 1989; Loeb and Lennartz 1989; Weigl et al. 1989; Loeb and Moncrief 1993). Throughout its range, parks, golf courses and residential areas may support substantial fox squirrel populations (Jodice and Humphrey 1992).

Fox squirrels use tree cavities and leaf nests both as refugia and for rearing young. Leaf nests occur in a variety of tree species including both hardwoods and pines. Fox squirrels use cavities in a variety of tree species. Cavity use is greatest during winter and spring (Nixon and Hansen 1987; Edwards et al. 1989; Edwards and Guynn 1995). Hilliard (1979) and Weigl et al. (1989) suggested that the absence of suitable cavity trees might be a critical factor in litter survival and subsequent recruitment of fox squirrels in Georgia and North Carolina. However, others have found no evidence that an absence of cavities was limiting fox squirrels in Florida or Georgia (Kantola 1986; Edwards and Guynn 1995).

Throughout their range, fox squirrels produce two litters per year; breeding is concentrated in late winter/early spring and, to a lesser extent, in summer (Moore 1957; Hoffman and Kirkpatrick 1959; Harnishfeger et al. 1978; Weigl et al. 1989; Larson 1990). Reproductive success is highly variable and dependent on demographic and environmental factors such as availability and timing of food sources, availability of cavities and weather (Nixon and McClain 1969).

The diet of the fox squirrel is diverse and varies seasonally and by region (Flyger and Gates 1982). Nuts, seeds, buds and flowers of pines (*Pinus* spp.), oaks (*Quercus* spp.), hickories (*Carya* spp.), beech (*Fagus grandifolia*), walnut (*Juglans* spp.) and other available hardwood species like dogwood (*Cornus* spp.) and maple (*Acer* spp.) are major components of the squirrel's diet. Soft mast, such as grape (*Vitis* spp.), persimmon (*Diospyros virginiana*) and cherry (*Prunus* spp.), various fruits, fungi, and insects are also eaten.

Challenges

The widespread loss of preferred habitat, including mature, open pine-oak forests and associated bottomland and swamps is detrimental to fox squirrels throughout the southeast. Practices that have contributed to habitat loss include large-scale monocultural replacement of longleaf pine by loblolly pine, shortened stand rotation, loss of hardwoods and fire suppression (Weigl 1987; Loeb

and Lennartz 1989; Weigl et al. 1989; Dueser and Handley 1991; Humphrey and Jodice 1992; Kantola 1992).

Habitat improvement practices for fox squirrels generally target forest structure and tree species composition. Changes in forest structure affect overstory and understory densities and tree cavity availability. Tree species composition markedly affects mast production. Specific management practices vary among regions. The primary factor in maintaining fox squirrel populations in forest stands after harvest is sustaining adequate levels of winter-storable tree seeds (Nixon et al. 1975). Chamberlain et al. (1999) and Yarrow and Yarrow (1999) provide management guidelines specific to Mississippi and Alabama, respectively. Streamside management zones offer an option for providing high-quality habitat and travel corridors for fox squirrels in areas affected by even-aged forest management. Studies in the southeast suggest that forest management practices that reduce dense understory vegetation and promote retention of mature mast-producing hardwood will benefit fox squirrels. Such practices include use of prescribed fire, mowing and retention of hardwood stringers in pine-dominated habitats (Kantola 1986; Edwards et al. 1989; Lee 1999; Chamberlain et al. 1999; Conner et al. 1999).

Fox squirrels also benefit from promotion and retention of cavity trees. Although cavity trees benefit both fox and gray squirrels, cavities are a more important habitat component for gray squirrels (Sanderson et al. 1980; Flyger and Gates 1982; Edwards and Guynn 1995).

The fox squirrel is a popular small game animal. Hunting mortality is considered compensatory to some extent, and is generally not thought of as a major factor controlling squirrel populations (Conner 2001). However, intensively hunted populations may be particularly vulnerable to overharvest depending on their level of isolation and potential for recolonization from nearby refuges or other lightly hunted areas (Allen 1943; Nixon et al. 1974; Herkert et al. 1992). In South Carolina, no distinction is made between hunting regulations for fox and gray squirrels on private lands, which contain the bulk of suitable fox squirrel habitats. Tappe and Guynn (1998) suggested that it might be more appropriate to manage southern fox squirrels differently than the gray squirrel because the former requires large home ranges and has a low reproductive rate. Hunting fox squirrels is prohibited on many wildlife management areas in South Carolina.

Conservation Accomplishments

Fox squirrels have been protected from hunting mortality on 22 of 36 (61 percent) Wildlife Management Areas within South Carolina. Additionally, a sighting survey to determine fox squirrel distribution in South Carolina was performed in 1989 and became a biennial event beginning in 1994. County distribution of fox squirrels appears to be stable. The data are not appropriate for estimating abundance as the number of personnel and sighting effort vary greatly between survey periods. A restoration project on St. Phillips and Hall Islands, South Carolina suggests translocation of fox squirrels may be a useful tool in restoring and augmenting fox squirrel populations throughout the southeast (Senecal 2001). Fifty-two fox squirrels were released on the islands in 1999 and 2000. Annual survival of translocated fox squirrels was similar to reported rates in native populations and reproduction was documented.

Conservation Recommendations

- Consider southern fox squirrel habitat requirements when managing for red-cockaded woodpeckers (*Picoides borealis*) as these two species often occur sympatrically.
- Consider southern fox squirrel habitat when restoring longleaf pine/wiregrass ecosystems.

- Encourage landowners and developers to consider southern fox squirrels when planning and constructing developed areas such as golf courses, parks and residential communities.
- Encourage maintenance of mature (greater than 50 years) loblolly and longleaf pine stands that have open canopies and sparse midstories. When possible, encourage landowners to create mature stands on their properties.
- Use prescribed burning to maintain sparse midstories in pine and mixed pine/hardwood stands on SCDNR properties. Encourage other landowners to also use prescribed burning to provide habitat for southern fox squirrels.
- Consider establishing separate hunting regulations for gray and fox squirrels, especially regarding bag limits on SCDNR owned wildlife management areas (WMAs).
- Develop a restoration program to enhance fox squirrel populations in the piedmont.
- Document the distribution and population status of southern fox squirrels in South Carolina, particularly in the piedmont.
- Conduct studies of dispersal patterns, feeding habits, translocation success, hunting mortality and population dynamics for southern fox squirrels.
- Conduct landscape-scale research studies to determine the effects of anthropogenic-induced habitat fragmentation and loss.
- Establish a survey protocol to periodically monitor southern fox squirrel population trends on WMAs and large SCDNR land holdings.
- Estimate harvest of fox squirrels on game harvest surveys.
- Continue the biennial fox squirrel sighting survey.

Measurements of Success

The ongoing biennial survey has shown population fluctuations from year to year. At this point, there are not enough data to determine if this is a cyclical pattern of a stable population. Over time, biologists hope that the population in South Carolina can be stabilized or increased. As research and management needs are identified, projects will be initiated to address those needs.

Swamp Rabbit

Sylvilagus aquaticus

Contributors: Mary Bunch, Steven G. Platt and Stanlee Miller

Description

Taxonomy and Basic Description

The swamp rabbit, *Sylvilagus aquaticus*, was first described by Bachman in 1837. Swamp rabbits, or cane-cutters, are the largest species of rabbit in the southeastern United States. These rabbits range in total length from 452 to 552 mm (17.8 to 21.7 inches) and range from 1900 to 2700 g (4.5 to 6 pounds) in weight (Chapman and Feldhamer 1981; Webster et al. 1985). Weights of South Carolina specimens in the Campbell Museum of Natural History at Clemson University range from 1700 to 2300 g (3.74 to 5.07 pounds).

The fur of swamp rabbits is rusty-brown with black hairs, giving the animals a grizzled appearance. Similar to the eastern cottontail (*Sylvilagus floridanus*) and the Appalachian cottontail (*Sylvilagus obscurus*), the underside of the tail is white. This differs from the bluish gray tail of the marsh rabbit (*Sylvilagus palustris*).

There are two recognized subspecies of swamp rabbit: *Sylvilagus aquaticus aquaticus* and *Sylvilagus aquaticus littoralis*. The former is the only subspecies found in South Carolina and the latter is restricted to the Gulf Coast (Hall and Kelson 1959; Chapman and Feldhamer 1981).

Status

In South Carolina, these rabbits are considered rare or imperiled (S2/S3) due to habitat loss and limited habitat availability. In Alabama and neighboring Georgia, the swamp rabbit is ranked as secure, while in Tennessee the species is apparently secure. The Global Heritage Rank is secure or G5 (NatureServe 2004), yet data from several states, including Arkansas, Missouri and Kentucky, indicate populations are imperiled due to loss of habitat (Platt and Bunch 2000) and range shrinkage (Sealander and Heidt 1990; Schwartz and Schwartz 1981; Sole 1994).

Population Size and Distribution

Swamp rabbits are distributed from the Gulf of Mexico, northward along the Mississippi River to Illinois and Indiana, eastward to the western piedmont of South Carolina and westward to east Texas and Oklahoma (Chapman and Feldhamer 1981). In South Carolina, most occurrences are in Anderson, Oconee and Pickens Counties in the Savannah River drainage of the western piedmont region. A few isolated records have been reported from McCormick County, York County and Richland County (Platt and Bunch 2000). It is unclear whether these disjunct records represent naturally occurring populations or are the result of translocations by hunters. Unverified reports of swamp rabbits exist for Greenville, Kershaw, Chesterfield and Marlboro Counties (Golley 1966).



Swamp Rabbit Distribution
Noncontiguous sites are marked with (*)

Swamp rabbit population size and density estimates are unavailable for South Carolina. In a Georgia floodplain, swamp rabbits had an average maximum home range of 7.6 hectares (18.9 acres) and a density of 0.14 animals per hectare (0.05 animals per acre) (Lowe 1958). Home ranges in Missouri average 1.82 to 2.43 hectares (4.5 to 6 acres) (Schwartz and Schwartz 1981).

Habitat and Natural Community Requirements

As indicated by their common name, swamp rabbits tend to be found in close proximity to water. The home range of swamp rabbits in Indiana is limited to within two kilometers (1.24 miles) of water (Terrel 1972); this is likely to hold true throughout the entire range for this species. In South Carolina, habitat varies from swamps and wet scrub/shrub land to forested bottomlands. Swamp rabbits are often associated with, but not restricted to canebrakes dominated by switchcane (*Arundinaria gigantea*) (Platt et al. 2001).

Korte and Fredrickson (1977) reported that viable swamp rabbit populations require contiguous habitat in areas exceeding 100 ha (247.1 acres); however, Sole (1994) suggests that this figure needs to be re-evaluated. Sole found that in Kentucky, about one third of the occupied habitat was in woodlots less than 100 ha in size that were sometimes isolated or connected by narrow bands to other suitable habitat.

Logs, stumps and tree falls are an important component of swamp rabbit habitat. These structures are used for latrine sites, resting cover and nesting (Zollner et al. 2000a; Platt and Rainwater 2001). Like all of South Carolina's rabbits, swamp rabbits prefer dense thickets that provide suitable cover.

Challenges

Hydrologic changes that result from flooding associated with dam construction and filling, channelization, ditching and draining of wetlands are well-recognized challenges to swamp rabbit populations throughout their range. In South Carolina, a significant portion of swamp rabbit habitat was inundated by the construction of Lake Hartwell. Habitat is also lost as a result of pond construction, urban development, road construction and land clearing for agricultural activities. Two sites reported by Platt and Bunch (2000) along US 123 have since been destroyed by urban development.

Because swamp rabbits inhabit floodplains and wetlands, they are vulnerable to flooding. Floods during the breeding season can be especially deleterious to populations. Although flooding is a natural phenomenon, urban development tends to alter natural floodplains, resulting in more frequent and, often, more severe flooding than is usually expected (C. Gawne and Lee Mitchell, Personal Communication, 2004). As stated above, hydrologic changes will result from urban development. An unpublished study conducted by SCDNR demonstrated a four-fold increase in development for every one-fold increase in population between 1983-1998 (Richard Lacy, personal communication, 2004). For this study, development was measured by impermeable surfaces such as pavement and buildings. This increase in flow to rivers and streams often results in erosion of streambeds. Once this erosion begins, the streams and rivers become vulnerable to flash flooding.

The impact of hunting on swamp rabbits has not been determined. Swamp rabbit populations on small tracts of land and those isolated by development or well-traveled roads tend to preclude the use of hunting dogs, thereby reducing the threat of hunting. Current data collected from rabbit hunting does not require hunters to distinguish the rabbit species that was taken.

Most of the suitable swamp rabbit habitat in South Carolina is on private land. Therefore, the future of the species in South Carolina and throughout much of its range (Sole 1994) largely depends on the stewardship of private lands. It is important that the landscape and local flooding history be a consideration in site protection design (Zollner et al. 2000b).

Conservation Accomplishments

The U.S. Army Corps of Engineers designed and constructed Lake Hartwell. Because their boundary line follows the approximate 204 m (670 foot) contour around Lake Hartwell, some swamp rabbit habitat along creeks and rivers flowing into the lake was protected during development of the lake. Other public lands that offer protection for the swamp rabbit include SCDNR and Clemson University properties.

Conservation Recommendations

- Partner with private and public landowners to maintain swamp rabbit habitat via whatever means are available, including but not limited to acquisitions, conservation easements, designations of green spaces and encouragement of stewardship by private landowners.
- Partner with federal agencies, such as the Army Corps of Engineers, the Natural Resources Conservation Service and the US Fish and Wildlife Service, to protect more wetland habitat.
- Evaluate the impact of hunting on swamp rabbit populations and improve collection of harvest data from rabbit hunters.
- Partner with hunters to collect habitat information for the swamp rabbit.
- Estimate the amount of habitat necessary to sustain a viable population of swamp rabbits.
- Conduct ecoregion-wide surveys of suitable habitat; those sites with previously unconfirmed records should be given priority.
- Revisit sites previously documented as occupied by swamp rabbits to verify if populations remain extant.
- Determine swamp rabbit density within selected study populations and determine population size estimates based on available habitat.
- Re-examine current state rankings for swamp rabbits and adjust those rankings based on new survey data, if appropriate.
- Monitor suitable swamp rabbit habitat by aerial photography over regular intervals.
- Produce brochures and web links to better educate South Carolinians on this unique species of rabbit.
- Where possible, restore wetlands that exist within the range of the swamp rabbit. The restoration work could be used for public outreach, giving school groups or community organizations hands-on experience in wetland restoration. The Natural Resource Conservation Service and US Army Corps of Engineers would be important partners in these efforts.

Measures of Success

Surveys and monitoring will allow the re-evaluation of the status of the species in South Carolina. Density estimates, paired with habitat information, will allow evaluation of the amount of potential habitat and remote assessment of habitat levels. The effectiveness of partnerships protecting wetlands and other properties that contain swamp rabbits can be assessed when paired with the monitoring of those populations.

Woodland Jumping Mouse

Napaeozapus insignis

Contributors: Mary Bunch, Travis Perry, Edward Pivorun and Stan Miller

Description

Taxonomy and Basic Description

The woodland jumping mouse (*Napaeozapus insignis*) is monotypic and was first named by

Miller in 1891. The subspecies recognized in the southern Appalachians, based entirely on morphometric measurements, is *Napaeozapus insignis roanensis* (Whitaker and Wrigley 1972). Adults of this subspecies are 204 to 256 mm (8.0 to 10.1 inches) long, including the tail. The tail, which is longer than the body, is often white-tipped and bicolored; it is brown-gray on the top and whitish underneath and ranges in length from 115 to 160 mm (4.5 to 6.3 inches). Woodland jumping mice have large hind feet, 28 to 34 mm (1.1 to 1.3 inches), which are appropriate for jumping. The woodland jumping mouse is a colorful mammal: the fur on the sides a yellow-orange and a dark wide stripe down the back in a red-orange-brown hue. The belly is white. Adults weigh 15 to 30 g (0.53 to 1.06 ounces) (Whitaker and Wrigley 1972; Webster et al. 1985).

Status

Woodland jumping mice are “apparently secure” in North and South Carolina, Tennessee and Kentucky (S4 or S4?) and are “rare or vulnerable” (S3) in Georgia. Their global rank is G5 or “secure” (NatureServe 2004). They are not listed on the IUCN Red list (Hafner et al. 1988). This species is included as a species of concern due to the relatedness of these populations to those in neighboring states.

Population Size, Distribution, and Trends

Woodland jumping mice range from New Brunswick, Canada, southeastward through Ontario, Quebec, Nova Scotia and New Brunswick, south through Michigan, the New England states and Pennsylvania. As the range extends southward, it narrows to the confines of the Appalachian Mountains, ending in Georgia and South Carolina (Linzey 1995; Whitaker and Wrigley 1972; Webster et al. 1985).

Density estimates from the north vary from 0.64, 5.2 and 6.7 animals per hectare (0.26, 2.7, and 5.2 per acre) and home ranges are about 0.4 to 3.6 hectares (1 to 9 acres) (Whitaker and Wrigley 1972). It is not considered abnormal to have widely varying densities due to short life expectancies, high reproductive outputs and a life cycle prone to fluctuation with seasons, weather and predation cycles. No density estimates are available for the Southeast.



Woodland Jumping Mouse Distribution

Habitat and Natural Community Requirements

Within the Southern Appalachian Ecoregion, woodland jumping mice are restricted to high elevation sites in cool moist habitats such as hemlock stands, sheltered cove hardwood stands with northern species and Rhododendron draped streamside zones (Ford et al. 1994). In South Carolina, these animals have been found at elevations of 427 m (1,400 feet) and above. Woodland jumping mice are true hibernators in the north (Merritt 1987); however, this behavior has not been studied or confirmed in the southeast. Hibernation requires reliably cold temperatures; this fact might explain their range restriction in the southeast.

The effects of logging or canopy removal on habitat selection by woodland jumping mice is not clearly understood, but there are indications that these mice prefer moist habitats with abundant

herbaceous cover rather than thick woody regeneration (Ford et al. 2000). South Carolina priority listed species that are sometimes associated with these same habitat characteristics in the southern Appalachians, include the southern red-backed vole (*Clethrionomys gapperi*), pygmy shrew (*Sorex hoyi*), star-nosed mole (*Condylura cristata*) and masked shrew (*Sorex cinereus*).

Woodland jumping mice have a varying diet of fungi, insect larvae, berries, seeds, nuts and vegetation (Whitaker and Wrigley 1972). Studies indicate that woodland jumping mice consume significant amounts of the *Endogone* spp. and *Glomus* spp. fungi in both mixed mesic forest and eastern hemlock habitats (Williams and Finney 1964, Orrock et al. 2003). The presence or abundance of deer mice (*Peromyscus maniculatus*) is negatively correlated with consumption of the *Endogone* spp. fungi; in those situations the jumping mice consume other fungal species (Orrock et al. 2003).

Challenges

Challenges to the woodland jumping mouse include habitat fragmentation due to development and barriers created by associated structures such as 4-lane divided highways (NatureServe 2004). Additionally Hemlock wooly adelgids (*Adelgas tsugae*), an invasive pest, may threaten some suitable habitat sites if the hemlocks and associated fungi are killed or reduced (Evans 2004). Finally, global warming could shift suitable habitat farther north and into higher elevations not found in South Carolina (W. Mark Ford, pers. comm.).

Conservation Accomplishments

Some woodland jumping mouse habitat is protected on public lands such as the Jocassee Gorges and Caesars Head State Park.

Conservation Recommendations

- Consider land acquisitions or conservation easements that provide linkage of appropriate habitat within the southern Appalachian ecoregion. Investigate the possibility of promoting or participating in regional efforts to establish such linkages.
- Encourage land managers to avoid canopy removal of mesic, high elevation sites and provide corridors linking appropriate habitat.
- Estimate woodland jumping mouse density for habitats in the southern part of the species' range.
- Conduct genetic research to determine if southern woodland jumping mice are distinct from northern animals.
- Designate permanent monitoring sites on public land including a high elevation hardwood cove and a hemlock site.
- Work with partners to make information about the woodland jumping mouse available to the general public.

Measures of Success

As research and management needs are identified, projects should be proposed and prioritized for the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs. Analysis of DNA and mtDNA will reveal the relatedness and genetic diversity of the northern versus southern woodland jumping mice.

CHAPTER 2: BIRDS

American Oystercatcher

Haematopus palliatus

Contributors: Felicia Sanders and Thomas Murphy

Description

Taxonomy and Basic Description

The American oystercatcher (*Haematopus palliatus*) is a large shorebird, weighing approximately 590grams (20.8 ounces). Five races are distributed in North, Central and South America on the Atlantic, Pacific and Gulf coasts (Nol and Humphrey 1994). On the Atlantic coast of the United States, the eastern race of the American oystercatcher (*Haematopus palliatus palliatus*) breeds from Massachusetts to Florida, with highest concentrations from Virginia to Georgia (Humphrey 1990).

Oystercatchers have a long orange bill, specialized for prying open bivalves (oysters, mussels, clams, etc.) Yellow eyes and an orange eye ring contrast with a black head and dark brown back and wings. The abdomen and portions of the wings and tail are white while the legs are light pink. The juvenile oystercatcher's head and back are speckled brown and the tip of its bill is brown.

Status

The eastern race of the American oystercatcher has been identified as an extremely high priority shorebird on the U.S. Shorebird Conservation Plan (Brown et al. 2001). The rationale for this designation is based on population estimates that total less than 25,000 birds and on threats to the race posed by the degradation of beach nesting habitat. The American oystercatcher is considered stable globally (G5) and is not ranked in South Carolina (NatureServe 2005).

Population Distribution and Size

Although population estimates of the eastern race of the American oystercatcher have been assembled from censuses of breeding pairs (1,624 pairs), large wintering flocks suggest these estimates are low (Nol et al. 2000; Davis et al. 2001). South Carolina supports just over one third (3,536) of the estimated oystercatcher population that winters on the Atlantic and Gulf coasts of the United States (approximately 10,000; Sanders et al. 2004; Brown et al. 2003). Statewide surveys by SCDNR in 2002 and 2003 averaged 394 breeding pairs.

The Cape Romain Region of the South Carolina coast includes the Cape Romain National Wildlife Refuge (CRNWR) south to Dewees Inlet. Between 50 and 60 percent of South Carolina's wintering oystercatchers are in this region. Censuses in the winter of 1988 and 1989 and again in 2001, suggest a 21 percent decline in oystercatchers in the Cape Romain region over 14 years (Marsh and Wilkinson 1991; Sanders et al. 2004).

In 2002, SCDNR estimated immature to adult ratios at all oystercatcher roost sites in South Carolina. Nine percent of birds examined had immature bill coloration. This suggests that breeding success may not be sufficient to maintain the population.

Habitat and Natural Community Requirements

Oystercatchers nest in coastal habitats with little vegetative cover. They lay their eggs in a shallow depression on sandy beaches, shell mounds and spoil islands. Oystercatchers are territorial and solitary or semi-colonial nesters. Nesting territory size is variable but frequently only a few pairs will occupy a mile of beach or shell rake. Therefore, extensive coastal habitat is required to maintain the present nesting population.

Oystercatchers feed on oyster bars, intertidal mud flats and sandbars. Large winter flocks feed primarily on oysters, mussels, clams and other invertebrates found on oyster bars. During the nesting season they utilize a more diverse range of bivalves, mollusks and other invertebrates near their nest site.

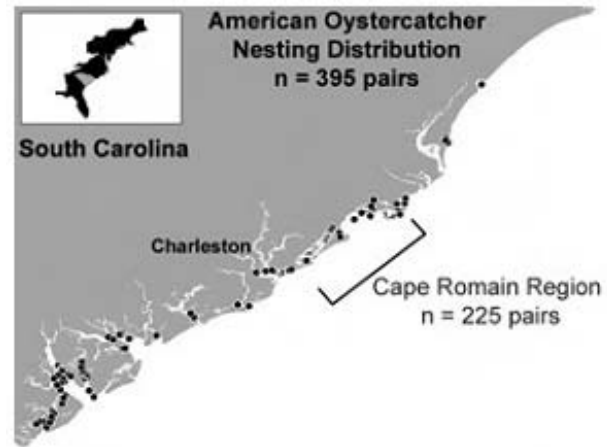
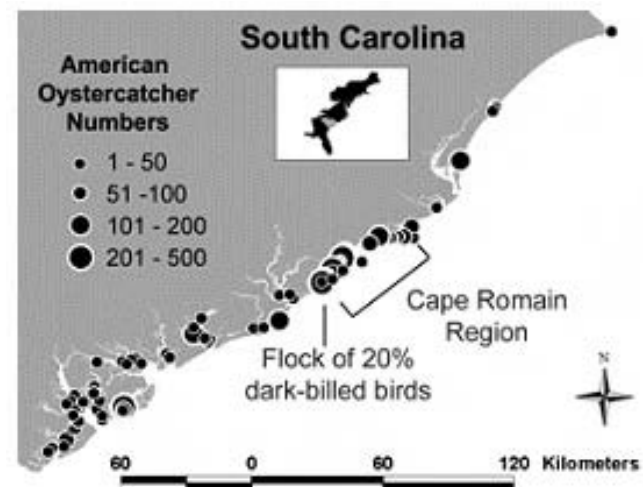
Challenges

Oystercatchers in South Carolina concentrate for both breeding and wintering and are susceptible to catastrophic events such as hurricanes, oil spills and harmful algal blooms.

Increased development of the South Carolina coast continues to reduce suitable oystercatcher nesting habitat and may force breeding pairs into less suitable sites. Although actual nesting sites are rarely destroyed, suitability of the sites is greatly reduced when nearby development increases disturbance of nesting birds. Disturbance from sources such as humans, dogs and boats negatively affects reproductive success by causing threatened oystercatchers to leave eggs and/or chicks unattended.

Oystercatcher nests are also at risk from native avian and mammalian predators. Human disturbance increases vulnerability to predation. Nests can also be destroyed by high tides and boat wakes. Studies in South Carolina and North Carolina report low chick production suggesting this species may be in peril.

In South Carolina, most wintering oystercatchers roost in flocks of over 100 birds on shell rakes along heavily traveled waterways. In the Cape Romain Region, 75 percent of the wintering birds roost along the Atlantic Intracoastal Waterway. Increased boat traffic will increase the frequency at which birds are flushed from roost sites.



Distribution of wintering American oystercatchers for 2002

Because oystercatchers feed primarily on shellfish, degradation of this resource through either disease or over-harvesting negatively affects oystercatchers. Unsustainable harvest of oysters, the oystercatcher's principal food item in South Carolina, can reduce the available prey base and may contribute to the decline of this species.

Conservation Accomplishments

South Carolina over-winters the largest concentration of oystercatchers on the Atlantic coast of the United States. The winter population includes resident breeding birds as well as a large number of migratory oystercatchers from all areas north. South Carolina averages 3,536 oystercatchers during the winter. Statewide winter censuses have provided data on the abundance, age class partitioning and distribution of oystercatchers. Multiyear breeding season censuses provided data on abundance of nesting pairs and identified important nesting habitats. An American oystercatcher working group has been formed to coordinate banding and survey efforts, prioritize conservation needs and communicate evolving research techniques. Important nesting areas, primarily on federal and state lands, have been closed to the public and signs posted. Adult survival rates, migratory patterns and nest site fidelity have begun to be documented from the color-banding project. Finally, an oystercatcher web site has been developed with information on the status, management and natural history of oystercatchers in South Carolina.

Conservation Recommendations

- Protect American oystercatchers during the nesting season, concentrating on public land. Adequate and timely posting and law enforcement may be required.
- Identify and protect important roost sites statewide. Identify important sites for protection during the permit review process.
- Continue cooperative efforts with the USFWS to census and manage nesting sites within Cape Romain National Wildlife Refuge (CRNWR). Control predators on important nesting areas and prioritize beaches that will benefit both sea turtles and shorebirds.
- Cannon net wintering oystercatchers at high tide roosts in order to document the natal source of wintering birds and to color band resident breeding birds.
- Capture breeding adult oystercatchers at their nest sites to increase the number of banded breeding adults.
- Document adult mortality rates by annually monitoring color-banded adults on breeding territories. Adult mortality rates are required to evaluate the status of the species.
- Color-band pre-flight chicks and monitor non-natal banded juveniles to determine movement and survivorship of juvenile oystercatchers.
- Continue regionwide cooperative studies such as banding of wintering birds and resighting of color marked migratory birds.
- Develop standardized techniques to document nesting success and annual chick production because current estimates suggest that low reproductive success may be a limiting factor.
- Develop techniques to enhance chick production such as elevating nests to protect from over-wash and artificial incubation of eggs and fostering chicks back to breeding adults.
- Document important foraging areas and nocturnal roost locations using radio instrumented oystercatchers. Protect these identified sites from disturbance.

- Evaluate possible state listing of the species to provide additional legal protection.
- Update and maintain the SCDNR oystercatcher web page to educate the public on the importance and management needs of the species.
- Support conservation efforts to maintain a healthy marine environment, free of pollutants, and maintain or enhance shellfish populations.
- Conduct low tide observations of foraging oystercatchers to identify and quantify prey items taken during the nesting season and during the winter.

Measures of Success

As research and management needs are identified, we will initiate projects to address those needs. Factors leading to declines in oystercatcher populations are poorly understood and the rate of decline is poorly documented. As current population trends are documented and limiting factors are identified, appropriate research and management actions will be initiated.

American Woodcock

Scolopax minor

Contributor: Billy Dukes

Description

Taxonomy and Basic Description

The commonly accepted scientific name of the American woodcock is *Scolopax minor* (ITIS 2001) as described by Gmelin in 1789. Common names for woodcock include timberdoodle, bogsucker and wood snipe. They are alternately characterized as marsh birds, shore birds or upland ground birds.

The woodcock is a mottled brown bird, weighing from 125 to 240 grams (4.4 to 8.5 oz.) (Owen and Krohn 1973) and averaging approximately 28 cm (11 inches) in total length (eNature 2004). The unusual physical appearance of the woodcock is characterized by the bird's buff-colored body, long beak, bulging eyes, and short wings. The diet of woodcock consists primarily of earthworms, although other invertebrates and some vegetative matter are also consumed. Woodcock foraging for earthworms is aided by a prehensile beak, which allows woodcock to grasp earthworms and extract them from below the soil surface (Krementz and Jackson 1999).

Status

The U.S. Shorebird Conservation Plan (USSCP) lists woodcock as a Species of High Concern and as a species known or thought to be declining (Brown et al. 2004). Woodcock are listed by the U.S. Fish and Wildlife Service as a Game Bird Below Desired Condition (USFWS 2004). They are listed on the Audubon Watchlist "yellow list" of those species that are in slow decline and of national conservation concern (National Audubon Society 2004). Woodcock are identified as secure (G5) globally and apparently secure (S4) in South Carolina (NatureServe 2005).

Population Distribution and Size

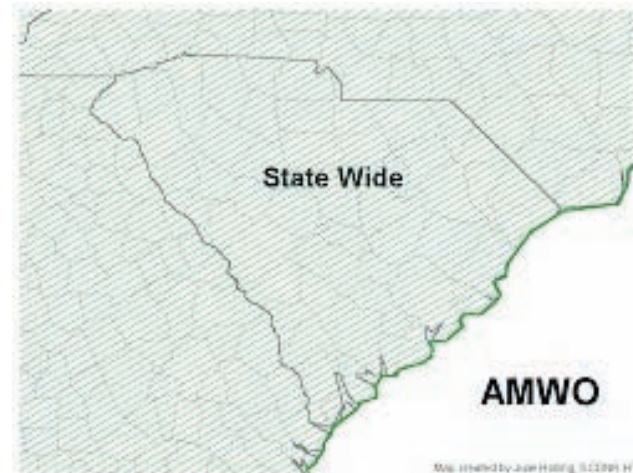
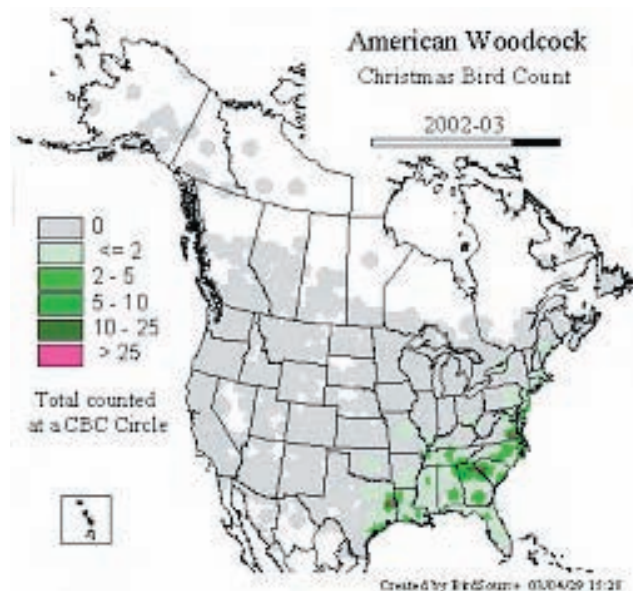
Woodcock are managed on the basis of two regions or populations, eastern and central, as recommended by Owen et al. (1977). Singing ground surveys from the U.S. Fish and Wildlife Service indicate a significant long-term decline of 2.1 percent annually for woodcock in the eastern region (Kelley 2004).

The range of American woodcock extends from the Maritime Provinces in southern Canada westward to southeastern Manitoba and southward into eastern Texas. All states east of this line are within the species' range. The principal breeding range includes New England and the Lake States, although limited breeding occurs throughout almost the entire range (Roberts 1989). The estimated population of woodcock in North America is approximately 5 million individuals (Brown et al. 2004). North American Breeding Bird Survey (BBS) data indicate a 6.8 percent annual declining trend in the U.S. between the years 1980 and 2003 (Sauer et al. 2004). Christmas Bird Count data indicate no significant declining trend for South Carolina and North America (National Audubon Society 2004a). Christmas Bird Count data also reveal higher wintering populations of woodcock in the lower coastal plain and piedmont than in the upper coastal plain of the state. Wintering woodcock numbers peak between mid-December and mid-February in South Carolina coastal plain habitats (Pace and Wood 1979).

Habitat and Natural Community Requirements

Unlike most other shorebirds and marsh birds, woodcock are a forest-dwelling species. Woodcock are often associated with forested wetlands. In the southeast, alluvial floodplains with a brushy forest understory are apparently a preferred habitat type. Swamp privet (*Forestiera acuminata*), holly (*Ilex* spp.), switch cane (*Arundinaria gigantea*), honeysuckle (*Lonicera japonica*), peppervine (*Ampelopsis arborea*), trumpet creeper (*Campsis radicans*), greenbriar (*Smilax* spp.) and grapes (*Vitis* spp.) have been identified as important understory species (Owen et al. 1977; Roberts 1989). The composition of the tree overstory appears unimportant (Owen et al. 1977).

Old fields, croplands, pasturelands, wet seeps and damp thickets also provide important habitat for woodcock on wintering grounds. Old fields and other early successional habitat types are often used as nocturnal habitat, and should be located within 230 m (251 yards) of diurnal habitats (Berdeen and Krementz 1998). While a high density of plant stems is preferred by woodcock, open ground underneath the canopy is a necessity to provide easy access to worms and other invertebrates in the ground litter (Roberts 1989; Krementz and Jackson 1999).



Challenges

Declines in woodcock populations are currently unexplained, but may be linked to natural forest succession within the breeding range of the species. Bottomland hardwood loss due to reservoir construction, drainage and clearing for agricultural uses and urbanization has negatively impacted the availability of winter habitat for woodcock in the southeast (Straw et al. 1994; Krementz and Jackson 1999).

Conservation Accomplishments

Although little research on woodcock has been conducted in the past 20 years in South Carolina, research projects have been completed on woodcock habitat selection, food habitat and migration chronology. Woodcock hunter surveys were conducted in 1983 and 1985 to provide information on hunter effort, harvest and woodcock age ratios. The Harvest Information Program (HIP) has been fully implemented nationwide and allows a better assessment of woodcock hunter numbers and harvest in South Carolina. Comprehensive hunter harvest surveys were conducted for all species in South Carolina, including woodcock, in 2000 and 2003. Since 1997, woodcock flushing rates and harvest by South Carolina quail hunters have been tracked through annual quail and rabbit hunter surveys.

Forestry Best Management Practices (BMPs) now strongly encourage the conservation of Streamside Management Zones (SMZs), which persist as woodcock wintering habitat following logging operations. Additionally, recent land acquisitions, notably Wee Tee State Forest and Bonneau Ferry Wildlife Management Area, have preserved significant acreages of prime woodcock wintering areas in South Carolina. Finally, an American Woodcock Management Plan was completed by the U.S. Fish and Wildlife Service in 1990, and a revision is due in the near future.

Conservation Recommendations

- Focus habitat protection efforts (acquisition and easements) on significant tracts of bottomland hardwoods and isolated forested wetlands to preserve woodcock wintering areas in South Carolina.
- Implement management practices that promote habitat diversity, like timber harvest and prescribed burning on SCDNR lands with high potential to provide wintering habitat for woodcock.
- Maintain early successional upland habitat associated with wetlands conservation efforts (acquisition, easements) to provide roosting habitat for woodcock. Early successional habitats can be maintained through prescribed burning.
- Using remote imagery, identify potential areas of woodcock wintering habitat to guide habitat conservation efforts.
- Identify winter microhabitat requirements for woodcock in South Carolina.
- Assess population densities of woodcock on wintering grounds in South Carolina and the state's contribution to range-wide wintering populations.
- Increase the number of yearly Christmas Bird Count (CBC) routes.
- Monitor habitat loss through mapping of landscape-level habitat changes.
- Continue hunter surveys as an assessment of woodcock hunting effort and harvest.

- Insure that upland buffers are included in the Wetlands Reserve Program (WRP) and similar programs, and that proper management practices are recommended and implemented to provide quality woodcock habitat.
- Provide woodcock habitat recommendations to natural resource agencies with management responsibility for extensive acreages of woodcock habitat.
- Provide woodcock habitat recommendations to private landowners through on-site technical assistance, fact sheets and management bulletins.
- Work with USFWS to identify woodcock hunters in South Carolina and increase hunter participation in the woodcock parts collection survey.
- Partner with other agencies and organizations such as the US Forest Service, US Fish and Wildlife Service, Clemson University and National Audubon Society (South Carolina Chapter) in order to survey for woodcock

Measures of Success

Following identification of woodcock winter habitat requirements in South Carolina, experimental habitat manipulations should be conducted to test habitat models. Woodcock flushing rates by rabbit hunters and quail hunters should continue to be monitored through the statewide Rabbit Hunter Survey and Quail Hunter Survey. Christmas Bird Count data should be utilized as a statewide index of wintering woodcock populations and trends evaluated periodically to determine changes in winter population status. As opportunities arise, directed research should examine changes in wintering woodcock densities, which occur as a result of incidental or intentional habitat manipulation. Woodcock winter habitat changes should be monitored through remote imagery and mapping.

Bald Eagle

Haliaeetus leucocephalus

Contributors: Thomas Murphy and Charlotte Hope

Description

Taxonomy and Basic Description

The family *Accipitridae* contains 59 species of eagles worldwide (Grossman and Hamlet 1964). Sea and fish eagles account for 11 species comprising three genera, of which eight are in the genus *Haliaeetus*. The bald eagle is the only species of sea eagle to regularly occur on the North American continent. Two subspecies of *leucocephalus* are described based on size and weight. These are of questionable merit because of a continuous gradient in size from north to south throughout the range; therefore, the subspecies *leucocephalus* and *alascanus* are not recognized in this report.

Adult bald eagles are large raptors with a distinctive white head and tail that contrasts with the dark brown body. They also possess a bright yellow bill and feet with unfeathered lower legs. Eyes are large and yellow. Juveniles have a dark head and tail in addition to the dark body. Eyes and bill are dark but the feet and legs are like adults. As the juvenile ages, its body plumage becomes mottled with white and in 3-4 years will reach adult plumage.

Bald eagles in South Carolina are smaller than their northern counterparts with a mean wingspan of 188 cm (6 feet 2 inches) and a mean weight of 3.27 kg (7.14 pounds). Eagles from the

northern portion of their range can be twice as heavy. Eagle chicks are full grown when they leave the nest and frequently weigh more than adults.

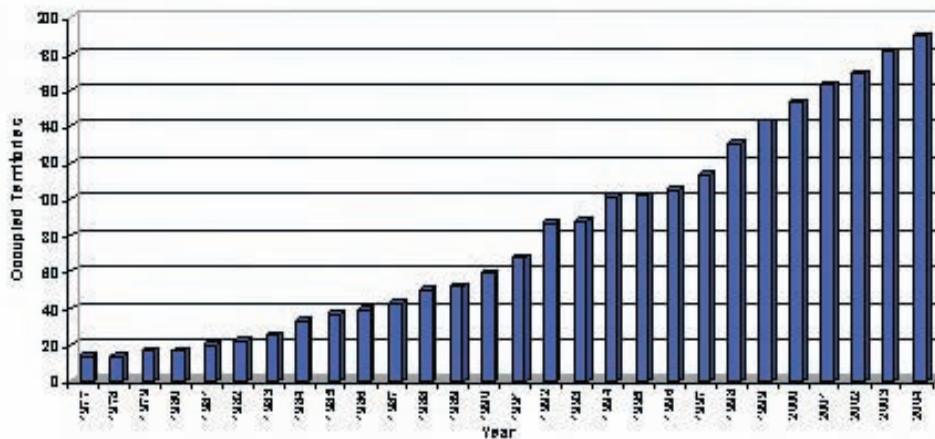
Status

Bald eagles (*Haliaeetus leucocephalus*) are protected under the Eagle Protection Act (16 U.S.C. 668-668d) as of June 8, 1940, as amended on October 23, 1972. Bald eagles below the 40th parallel were listed as endangered on March 11, 1967 and subsequently received protection under the Endangered Species Act of 1973 (16 U.S.C.1531-1543). On February 14, 1978, listing status was changed to endangered throughout the conterminous United States except for Washington, Oregon, Minnesota, Wisconsin and Michigan, where the bald eagle was designated as threatened. Bald eagles were reclassified as threatened in all lower 48 states on July 12, 1995 (50CGR Part17) and are currently being considered for delisting. The bald eagle continues to receive protection under the South Carolina Nongame and Endangered Species Conservation Act as a state endangered species. In South Carolina, the bald eagle is considered an imperiled species (S2) (NatureServe 2005).

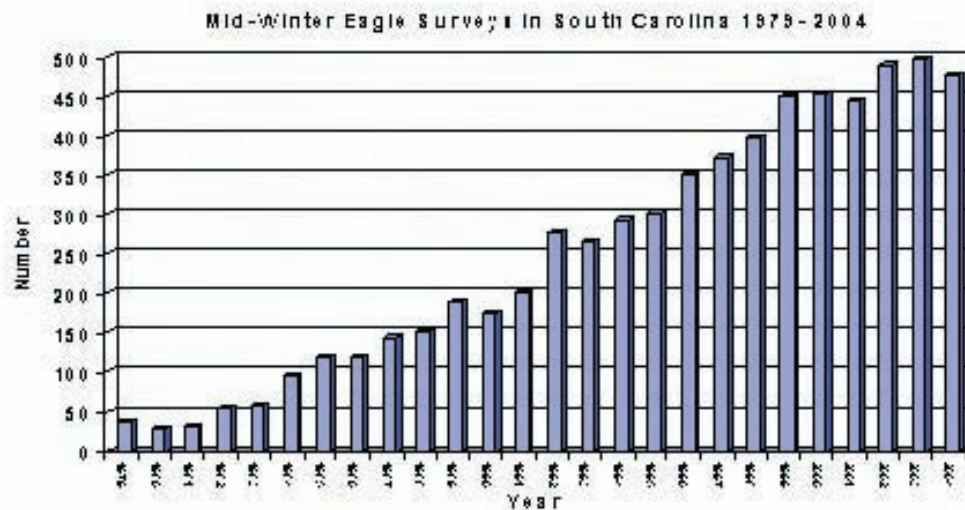
Population Distribution and Size

During the early 1960s, the nesting eagle population was estimated at about 412 pairs in the 48 contiguous states (Sprunt and Ligas 1963). In 1982, the number of nesting pairs was up to 1,482 (Green 1985). Based on the most recent data, there are 7,066 nesting pairs of bald eagles in the lower 48 states. Eagles nest in every state except Hawaii and Vermont. South Carolina ranks twelfth in the nation in terms of the numbers of nesting bald eagle pairs. In 1977, there were 13 occupied nesting territories in South Carolina and by 2004 the state's population increased to 190 pairs (see graph below).

South Carolina Bald Eagle Statewide Nesting 1977-2004



Since 1979, mid winter surveys of adult and juvenile eagles in South Carolina have been conducted as part of a national effort. The 2004 survey resulted in 481 eagles counted during mid-winter (see graph below), up from 36 during the first survey.



Habitat and Natural Community Requirements

Eagles require large trees with an open limb structure for nesting and are usually located on the forest/marsh ecotone within one km (0.62 miles) of open water. Large trees allow for large nests that can support nesting for many years without falling. The large size may also reduce fratricide or premature fledging. The open limb structure provides easy access and a clear view of foraging habitat. Nesting habitats initially selected by eagles usually have limited disturbance, although eagles are showing remarkable adaptability when confronted with moderate habitat alterations, often due to development in established territories. Trees suitable for perching and future nesting sites are also important components of stable nesting territories.

Fresh, brackish and marine habitats provide suitable foraging sites and include open water, marsh and riverine types. Prime habitats are characterized by having shallow, slow moving water with abundant fish and bird prey. Preferred sites have suitable perch and roost sites with minimal disturbance. Large manmade reservoirs in South Carolina have provided 240,000 ha (592,800 acres) of new inland eagle foraging habitat. Concentrations of eagles may be found below hydroelectric dams where they forage on injured fish. Impounded marsh managed for waterfowl is preferred foraging and nesting habitat.

Challenges

Shooting has historically been the most significant cause of mortality in eagles. Between 1961 and 1965, 62 percent of eagles found dead were shot. More recently, the percentage of eagles that died as a result of illegal shooting has declined to under 20 percent. This is undoubtedly one major reason for eagle recovery. Delisting the bald eagle may mislead the public by inferring that eagles are no longer protected and could result in increased shooting mortality. Additionally, when eagles lose protection under the Endangered Species Act, they may lose much of the habitat protection currently afforded to the species. This may lead to habitat degradation that can make current and future nesting habitat unsuitable.

Chemical contamination of eagle habitat has long been a problem for this top carnivore. Eagles have been shown to be sensitive to a variety of toxins, particularly persistent organo-chlorine pesticides, such as DDT. Pesticide poisoning has been greatly reduced and is another reason for recovery of the species. However, even with many new products on the market, the problem persists. In addition, lead poisoning in eagles has also been identified as a significant problem (Pattee 1981). There is a chronic problem with barbiturate poisoning of eagles at landfills where eagles feed on animals that have been euthanized. Deposition of mercury in eagle foraging habitat poses a potential threat to the health of bald eagle populations.

Currently there are two emerging diseases affecting eagles. West Nile virus (WNV) and Avian Vacuolar Myelinopathy (AVM) have both been identified as new sources of eagle mortality. Recovery of the bald eagle population will result in larger concentrations of eagles and less fit individuals as a result of competition. This may lead to an increased risk of disease.

Finally, other significant sources of mortality in eagles include electrocution at power lines and collision trauma.

Conservation Accomplishments

Conservation accomplishments directly and indirectly affecting this species are varied. Through public education and effective law enforcement, shooting mortality has declined from 62 percent (Mulhern 1970) to less than 20 percent of diagnosed mortalities (Locke 1982). A ban on widespread use of DDT was implemented in 1972. Since then, an array of effective pesticides has been developed that have limited impacts on non-target species. Bald eagle management guidelines for nesting territories have been developed and implemented and non-toxic shot has been required for waterfowl hunting. Finally, a variety of raptor safe power line configurations have been developed and implemented.

Reproductive effort of South Carolina nesting eagles has been documented on an annual basis for 28 years. Additionally, fledging success of South Carolina nesting eagles has been documented each year for 28 years. Adult mortality rates of 12 percent per year have been calculated based on banded eagles at nesting territories.

Conservation Recommendations

- Determine the etiology of Avian Vacuolar Meilinopathy (AVM), document the current extent of the disease, evaluate the potential for future disease and develop management strategies to minimize impacts.
- Continue to evaluate the effects of habitat alterations on the long-term viability of eagle nesting territories.
- Continue monitoring the level of shooting mortality and react with increased active and proactive law enforcement in the event of an increase.
- Continue to implement raptor safe power-line configurations with a variety of power companies and cooperatives.
- Continue to work with DHEC, veterinarians and landfill operators to eliminate barbiturate poisonings of eagles at landfills.
- Work with Clemson Institute of Environmental Toxicology, Southeastern Cooperative Wildlife Study group (UGA) and the USFWS Wildlife Health Laboratory to monitor contaminants in eagles

- Conduct standardized monitoring of nesting eagles prior to delisting to serve as baseline information to evaluate the effects of delisting.
- Monitor the causes of injury and mortality of eagles before and after delisting to document effects of delisting.
- Conduct post mortem examination of fresh dead eagles to evaluate impacts of AVM and WNV.
- Conduct active surveillance of known and potential AVM disease.
- Continue to monitor banded breeding adult to refine adult mortality rates.
- Continue to partner with the International Center for Birds of Prey to provide public education, raptor rehabilitation and to document the causes of injury and death of eagles.
- Continue to participate in the Southeastern Bald Eagle Working Group.

Measures of Success

The bald eagle is a species with deferred maturity, low annual reproductive potential, and is sensitive to environmental contaminants. Therefore, utilizing adaptive management to implement conservation actions is important. Indicators of success include high annual survivorship. Maintaining annual survivorship greater than 85% can best be accomplished by minimizing anthropogenic sources of mortality such as shooting, barbiturate poisoning and AVM disease. Management of nesting territories should maintain 1.0 young per occupied territory by minimizing human disturbance and providing adequate perch and nest trees. Eagle mortality and impairment of reproduction by contaminants should be prevented by reducing current and future environmental contamination of territories and important prey base species.

Bay Ducks

Canvasback *Aythya valisineria*

Greater Scaup *Aythya marila*

Lesser Scaup *Aythya affinis*

Redhead *Aythya americana*

Ring-necked Duck *Aythya collaris*

Contributor: Walt Rhodes

Description

Taxonomy and Basic Description

Members of this group of ducks are classified in family Anatidae, subfamily Anatinae and tribe Aythyini. Members of the tribe Aythyini are referred to as bay ducks or pochards. These five species are the members commonly found in North America and belong to one genus, *Aythya* (Bellrose 1980). The bay ducks are very similar in size and, in some species, plumage. Canvasbacks are the largest species, weighing about 0.99 kg (2.7 pounds). Greater scaup and redheads each weigh about 0.83 kg (2.3 pounds), while lesser scaup and ring-necked ducks each average about 0.40 kg (1.5 pounds).

In addition to being the largest of the bay ducks, canvasbacks are probably the easiest to recognize. Males feature a chestnut-red head, charcoal black breast and rump, a white body and a smooth sloping black bill. Females feature the same distinctive head profile but have a buffy brown head

and neck and pale brown body. Immatures of both sexes have plumage similar to adults by their first winter. The species gets its name from the fine vermiculations on its scapulars (Mowbray 2002).

Although having a somewhat similar plumage to canvasbacks, redheads differ by profile and smaller body size. Redheads have a rounder head. Males have a brighter red head, and both sexes have a grayish-blue bill that is tipped with black. Males feature a black breast and rump, similar to canvasbacks, but their gray body contrasts greatly with a canvasback's white body. Females appear tawnier than female canvasbacks (Woodin and Michot 2002).

Greater and lesser scaup are two of the more difficult species to separate. The greater scaup has a more rounded, larger, green-tinted head that contrasts with the blacker, more purplish, smaller head of the lesser scaup. In hand, both sexes of greater scaup have a broader bill with a wider nail and white coloration that extends out onto the primaries (Kessel et al. 2002). On the lesser scaup this same white coloration normally remains only on the secondaries. Females of both species are brownish and feature a distinct white patch behind the base of the bill (Austin et al. 1998).

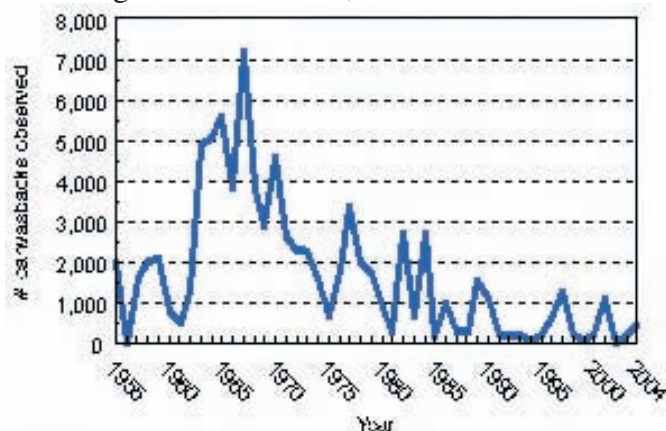
Ring-necked ducks are often confused with scaup. However, both sexes of the ring-neck feature a distinctive, compact peaked head profile. Further, there is a white triangle or "spur" on the breast sides that is plainly visible in males and faint in females. Both sexes of ring-necks also feature grayer wing bars and their blacker backs of males and darker backs of females contrast to the grayer backs of scaup. Male ring-necked ducks feature a colorful bill of contrasting blue that is outlined in white with a black nail. Female ring-necked ducks resemble female redheads but are much smaller. Ring-necked ducks are named for the faint chestnut-brown ring around a male's neck (Hohman and Eberhardt 1998).

Status

All five species of bay ducks occur throughout South Carolina. In most cases, their numbers place a degree of responsibility on this state for conservation efforts during wintering. The North American Waterfowl Management Plan (NAWMP) ranks canvasbacks as of moderate continental priority with high priority placed on nonbreeding populations in the coastal zone. Ringneck ducks are described as increasing and of moderate continental priority with conservation need moderately high in the coastal plain and piedmont ecoregions. As of the 2004 NAWMP, the redhead is considered to be stable and of moderately high continental priority with populations in the coastal plain and zone needing moderately high conservation priority. Greater scaups are considered to be stable and of moderate continental priority with populations in the piedmont and coastal plain of moderately high to high conservation need. Lesser scaup are considered to be a high continental priority with populations decreasing. Across the state, conservation need for lesser scaup in the upstate, piedmont and coastal plain are of moderate, high and highest priorities, respectively (NAWMP 2004). Bay ducks are not listed species but are protected under the Migratory Bird Treaty Act.

Population Distribution and Size

Continentially, the bay duck group is doing well. Most species that are monitored by the Waterfowl Breeding Population and



Habitat Survey are at or near their long-term averages (1955 to 2004) with the exception of the scaup species. Lesser and greater scaup are not differentiated during the breeding survey since it is difficult to identify the species from fixed-winged aircraft. However, it is known that lesser scaup are the more abundant species (Austin et al. 1999). The scaup species are currently 27 percent below their long-term average and at 3.81 million birds, remain well below the North American Waterfowl Management Plan (NAWMP 2004) goal of 6.30 million.

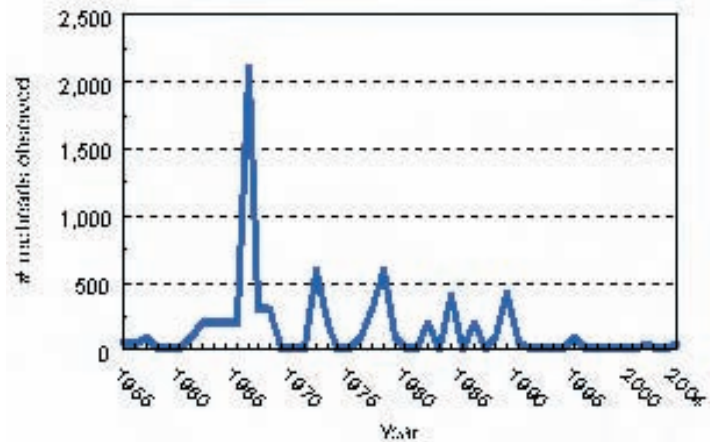
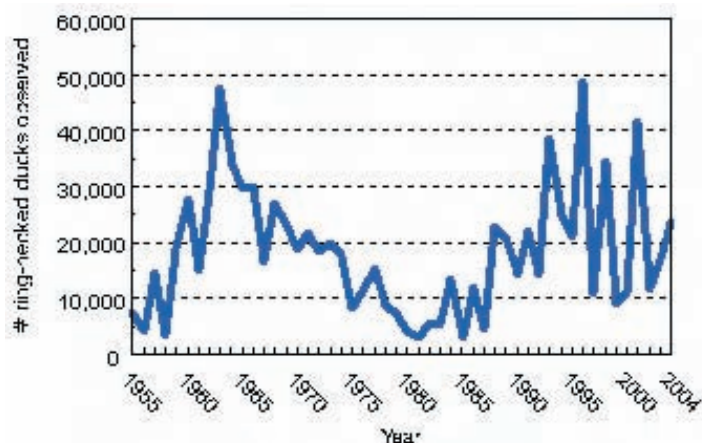
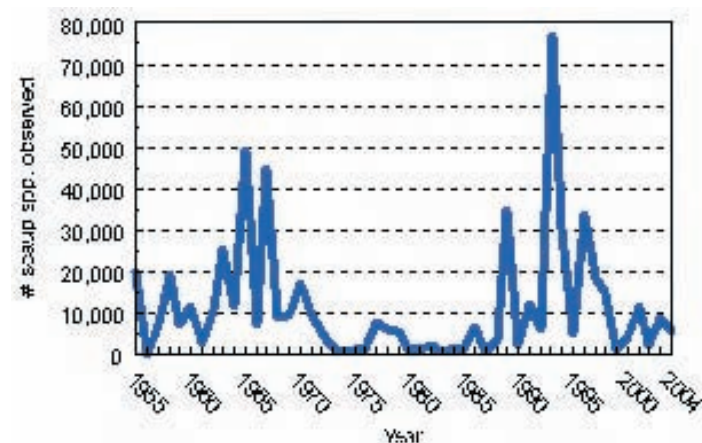
With an average breeding population of slightly more than 500,000 individuals, canvasbacks are historically the least numerous of the bay ducks in North America. Canvasback populations have shown no trend over the long term, and the recent breeding population estimate of 617,000 puts the species 10 percent over its long-term average (Serie and Raftovich 2004).

Redheads are the second least populous species of the bay ducks. Their long-term breeding population estimate is only 100,000 more than canvasbacks. Currently, redheads are only five percent below their long-term breeding population estimate and NAWMP goal.

Ring-necked populations have shown a significant increase over the long-term and the breeding population is currently estimated at over 1.2 million birds. Ring-necked ducks are the

most common species but substantial numbers of scaup, and nearly all lesser scaup, have been sighted in Charleston Harbor, Bulls Island and the nearshore waters of the Atlantic Ocean. Post and Gauthreaux (1989) listed ring-necked ducks and lesser scaup as very common, redheads and canvasbacks as fairly common and greater scaup as a rare winter visitor.

Midwinter waterfowl survey (MWS) and harvest estimates the number of wintering ring-necked ducks averages about 20,000 birds, which is second only to the number found wintering in Florida. The number of scaup species observed during the MWS is highly variable but averages



about 10,000 ducks. Although never very high relative to wintering populations found elsewhere in the Atlantic flyway, canvasback populations wintering in South Carolina have declined, and number less than 1,000 ducks. The wintering redhead population in South Carolina was never large either but this species has declined as well, and less than 100 birds are observed annually. Christmas bird count data indicates similar trends as the MWS.

The harvest of ring-necked ducks has increased in South Carolina over the long-term and the recent annual harvest is 15,000 to 20,000 ducks (Serie and Raftovich 2002, 2004). Scaup are differentiated in the harvest survey. Lesser scaup harvest varies with the wintering population size and averages 2,500 to 5,000 birds; however harvest had quadrupled this estimate in some years. Typically, more than 500 greater scaup are harvested in the state. Average redhead and canvasback harvest estimates are small (less than 1,000 birds) and reached their peaks during the cold winters of the late 1970's.

Habitat and Natural Community Requirements

All five bay duck species occur primarily on fresh or brackish water habitats across the state. Most species are associated with large inland reservoirs, such as Lake Murray, the Santee Cooper lakes and the Savannah River lakes, and managed wetlands along the coast. Lesser scaup are known to use tidal, estuarine and nearshore ocean habitats. Ring-necked ducks have the widest distribution across the state, occurring on reservoirs, Carolina bays and coastal managed wetlands. Historically, rafts of canvasbacks were known to use the lower reaches of Winyah Bay, which was probably part of the large flock that utilized Middleton Pond, a diked tidal creek located east of Georgetown (Cely 1979). Currently, canvasbacks do not use Winyah Bay, very few are observed on Middleton Pond, and the birds that formerly wintered in Charleston Harbor no longer do so. The largest known concentration that occurs with any regularity is on Bulls Island, located within Cape Romain National Wildlife Refuge. Because greater scaup and redhead numbers are so low in the state, little is known about them. However, both species are found in brackish to saline habitats elsewhere in the Atlantic flyway. Greater scaup feed on benthic organisms and redheads are primarily vegetarian (Stewart 1962; Quay and Critcher 1962; Perry and Uhler 1982).

Some research has been conducted on food habits of bay ducks in South Carolina. Working in various fresh to brackish water coastal habitats, Kerwin and Webb (1971) found that watershield (*Brasenia schreberi*) was the most important food item by volume for 78 ring-neck ducks followed by saltmarsh bulrush (*Scirpus robustus*). Panicgrasses (*Panicum* spp.), smartweeds (*Polygonum* spp.) and spikerushes (*Eleocharis* spp.) were the most important food items for 15 scaup collected. Landers and others (1976) collected ducks from managed wetlands in the ACE Basin and reported smartweed, panicgrass and saltmarsh bulrush were favored by ring-necked ducks while saltmarsh bulrush and widgeongrass (*Ruppia maritima*) were common in lesser scaup. Perry and Uhler (1982) found that widgeongrass was the predominant food in 17 lesser scaup from South Carolina but animal food accounted for 56 percent of the total volume consumed. Animal food consisted of lobed moon shell (*Polinices duplicatus*), dwarf surf clam (*Mulina lateralis*) and recurved mussel (*Brachidontes recurvus*). One ring-necked duck was reported to feed mainly on widgeongrass seeds. Perry and Uhler (1982) found plants formed 100 percent of the food items from three canvasbacks collected on Andersonville Pond in South Carolina. Sago pondweed (*Potamogeton pectinatus*), slender pondweed (*Potamogeton pusillus*) and banana waterlily (*Nymphaea mexicana*) were the major plants. Cely (1979) estimated that 37 percent of the estimated 2,000 canvasbacks wintering in South Carolina in 1977 were feeding

on banana waterlily. R. A. Kennamer (unpublished data) stated that lesser scaup wintering at Savannah River Site fed dominantly on an animal diet composed mainly of mollusks with Asiatic clams (*Corbicula fluminea*) the preferred species. He found that ring-necked ducks were generalists, feeding on waterlily (*Nyphaea* spp.), spikerush seeds, freshwater snails, Asiatic clams and dragonfly nymphs. Working on the same area, Bergan and Smith (1989) found that ring-necked ducks used more shallow habitats (emergent and floating-leaved vegetation) while lesser scaup preferred submergent vegetation and open water sites. Emergent and floating-leaved habitats were characterized by waterlily, watershield, spikerush and bulrush while submergent habitats consisted of American wild celery (*Vallisneria americana*), spiked watermilfoil (*Myriophyllum spicatum*) and floating bladderwort (*Utricularia inflata*).

Challenges

Like other migratory birds wintering in South Carolina, the bay ducks are subject to problems outside of the state that can affect their numbers locally. Within South Carolina, they face additional challenges, mostly habitat related. The majority of the bay ducks wintering in South Carolina use coastal managed wetlands. These are dynamic systems that require a substantial amount of financial resources to maintain and manage for the benefit of waterfowl. Several thousand acres are protected on state and federal properties, but private holdings could be subject to habitat degradation. Many birds also winter on Carolina bays or similar sized depressional wetlands, which are especially susceptible to altered hydrology.

Disturbance and habitat degradation associated with shipping traffic and offshore sand mining activates (for beach renourishment) may negatively affect lesser scaup. Since South Carolina supports one of the highest numbers of registered boats in the country, all bay duck species wintering on tidal waters or inland reservoirs could be subject to substantial disturbance from recreational boat traffic.

Hunting pressure does not currently appear to negatively affect these bay ducks. Very few greater scaup, canvasbacks and redheads (less than 1,000 annually for each species) are reported in the state's harvest. Seasons for canvasbacks and redheads are typically restrictive, given the birds' historically low populations continentally. Lesser scaup harvests have been low in the state as well. However, the birds have recently started using coastal managed wetlands more frequently. This could predispose them to higher harvest. Ring-necked duck harvest in South Carolina has been increasing as the wintering population size increases. Currently, the harvest level (greater than 15,000 annually) has not appeared to affect wintering numbers.

Conservation Accomplishments

Aerial and ground surveys conducted as part of the Atlantic flyway midwinter waterfowl survey have recorded the presence of bay ducks wintering in South Carolina. However, the surveys do not allow sufficient monitoring of greater scaup since these birds cannot be differentiated from fixed-winged aircraft. Land-based Christmas bird counts have documented the occurrence of bay ducks in the state. Past research has provided some insight into food habits, and thus, habitat associations of some species of bay ducks.

Conservation Recommendations

- Implement more comprehensive surveys to monitor bay duck population numbers.
- Participate in research to determine the cause of continental declines in bay duck numbers.

If causes of decline are associated with South Carolina wintering grounds, implement conservation actions to mitigate impacts.

- Establish more frequent winter surveys to document bay duck numbers and distribution.
- Monitor water quality and benthic organisms in offshore habitats used by scaup species.
- Maintain a rapid response procedure to oil spills.
- Ensure adequate safeguards and regulations are in place to protect offshore habitats utilized by bay duck species.
- Maintain winter banding of bay duck species to document timing and location of migration, harvest areas and survival rates.

Measures of Success

An increase in the number of bay ducks that winter in South Carolina is an appropriate measure of success of conservation actions implemented for these species.

Black-throated Green Warbler (Wayne's race)

Dendroica virens waynei

Contributor: John Cely

Description

Taxonomy and Basic Description

Considered a subspecies of the more widespread nominate race described by Gmelin in 1789, the “Wayne’s” black-throated green warbler is slightly smaller with a smaller bill. Male Wayne’s black-throated green warblers also have slightly less extensive black bibs (Dias, pers. comm.). The coloration is olive on the back and crown with yellow on the head (Sauer et al. 2000). Black streaks are present on the sides while the wings have white bars (Sauer et al. 2000). The male has an additional black throat patch (Sauer et al. 2000). The breeding range, separated from the nominate race by more than 321.8 km (200 miles) and a 609.6 m (2,000 feet) elevational difference, consists of a narrow band of Atlantic white cedar (*Chamaecyparis thyoides*) stands, cypress (*Taxodium*) swamps, and other forested wetlands of the outer coastal plain from southern Virginia to South Carolina.

Watts and Paxton (2002) noted that peak singing activity is around the end of April with a notable decrease after mid-May. This corresponds to its early spring arrival, usually the last 7 to 10 days of March in South Carolina.

Status

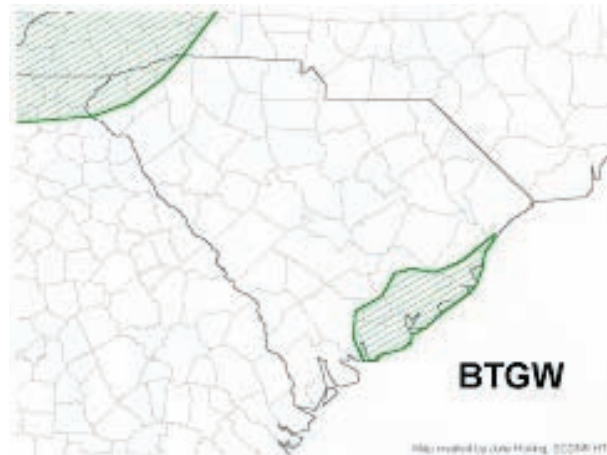
The black-throated green warbler (Wayne’s race) is listed as a “species of special concern” by the South Carolina Department of Natural Resources (SCDNR); it is considered a high priority landbird by Partners in Flight (PIF). It is locally distributed within a narrow belt of forested wetlands of the outer Coastal plain from southern Virginia to the Edisto River in South Carolina. Even within this narrow range, it is absent from some areas. The South Carolina Heritage Trust Program identifies this warbler as apparently secure (S4) in South Carolina and secure (G5) globally. However, this ranking may need to be re-evaluated to consider the coastal population.

Populations of the black-throated green warbler are declining in South Carolina (Dias pers.

comm.). The second-largest colony in this state has dwindled to a few sporadic sightings. Other colonies have disappeared entirely since the mid-to-late 1990's (Dias, pers. comm.). Population levels in the Francis Marion National Forest and other areas that received heavy damage from Hurricane Hugo did not begin a steep or noticeable decline until the mid to late 1990's. For example, the population in the drainage between the Wambaw Wilderness and the Little Wambaw Wilderness was South Carolina's second-largest population until 2000. Point counts conducted from mid-March to April of 1998 consistently yielded multiple singing males with a low count of 5 and a high count of 10. Over the past three years, a maximum of one or two singing males have been counted; many surveys failed to identify any birds (Dias pers. comm.).

Population Distribution and Size

This species has one of the most restricted breeding distributions of any warbler in South Carolina or the southeastern United States. It is rarely found further than 40 to 48 km (25 to 30 miles) inland from the coast. Prior to Hurricane Hugo, the habitat of the Francis Marion National Forest (FMNF) in Berkeley and Charleston Counties could have supported the largest population in South Carolina (Cely, pers. obs.). Even there, it was probably not common, based on 82-point counts conducted in the late 1970's. In these counts, black-throated green warblers ranked eighth out of 12 breeding warblers (Hamel 1981). The black-throated green warbler (Wayne's race) has a spotty and, perhaps clumped, distribution within its limited range in the state. It is not known to occur in Horry County and much of northern Georgetown County.



A population of unknown size and status occurs southwest of Charleston extending up, but not within, the Edisto River floodplain. Black-throated green warblers are not known to occur within the ACE Basin west of the Edisto. Population size and trends are unknown, although it is suspected of disappearing or declining from southeastern Virginia and parts of North Carolina (Watts and Paxton 2002) as well as areas devastated by Hurricane Hugo in South Carolina in 1989 (Cely pers. obs.).

Habitat and Natural Community Requirements

In coastal South Carolina, black-throated green warblers avoid the big blackwater rivers, except for a stretch of Wambaw Creek near the South Santee River. They remain in areas around the slow-moving headwaters of blackwater creeks and the swamps and swamp borders that feed blackwater rivers and their tributaries. South Carolina colonies sometimes occur in isolated Cypress-Tupelo swamps amidst drier pine-hardwoods habitat.

In southern Virginia and coastal North Carolina, black-throated green warblers are closely associated with Atlantic white cedar. Where cedar is scarce or absent, such as coastal South Carolina, these birds are found primarily in non-alluvial forested wetlands or transitional zones between upland and wetland, where, as a canopy or subcanopy species, it uses blackgum (*Nyssa sylvatica*), laurel oak (*Quercus laurifolia*), sweetgum (*Liquidambar styraciflua*), bald cypress (*T. distichum*) "wet" loblolly pine (*Pinus taeda*) and red maple (*Acer rubrum*). It is rare to see

this species without the presence of pond cypress, sweet gum and black gum and that they are almost always located near water tupelo (*Nyssa aquatica*) (N. Dias, pers. comm.). Black-throated green warblers are sometimes found in small or headwater riparian forests, but most observers suggest an association with forest stands growing in non-alluvial muck swamp. In Virginia and North Carolina, Watts and Paxton (2002) found higher than expected warbler use in survey plots containing loblolly pine, Atlantic white cedar and bald cypress and less than expected use in those plots with pond pine (*P. serotina*) and hardwoods. This may help to explain the bird's absence in pond pine-dominated Carolina bays in Horry County. Black-throated green warblers are not known to occur in large and medium outer coastal plain floodplain forests such as those associated with the Waccamaw, Great Pee Dee, Black and Santee Rivers.

At the Francis Marion National Forest, Hamel (1981) noted most foraging and behavioral observations occurred between 10 and 17 m (32.8 and 55.7 feet), similar to that of the pine warbler (*D. pinus*) and yellow-throated warbler (*D. dominica*). More than 50 percent of behavioral observations were made in laurel oak, blackgum, sweetgum and water oak (*Q. nigra*). Red maple was used sparingly and a subjective impression was that the species was found in forest stands with a high site index (Hamel 1981). Male Wayne's black-throated green warblers favor sweet gum trees for singing perches, even with taller cypress or tupelo trees nearby (Dias pers comm.).

Challenges

Based on its very restricted breeding range and apparent decline in parts of this range, and the fact that almost nothing is known about its breeding biology, status and habitat use, the black-throated green warbler should be considered a high priority landbird species for research and survey efforts in South Carolina.

As a canopy/subcanopy species, short timber rotations may negatively affect the species (Cely pers. obs.; Sprunt 1953). Alterations of hydrology and wetland drainage also pose potential problems. Additionally, Hurricane Hugo opened up many habitats to brown-headed cowbirds. The I'On Swamp Road in the Francis Marion National Forest used to have breeding Wayne's warblers without sightings of brown-headed cowbirds. Currently, the opposite is true – brown-headed cowbirds are often seen while very few Wayne's warblers are noted. However, effects of nest predation have not been studied in depth.

Like most Neotropical migrants, the black-throated green is probably area-sensitive and may require thousands of acres of suitable habitat in large blocks to sustain long-term population viability. No information is available on the location(s) of the wintering grounds and habitat use, but it could possibly differ from that of the nominate race.

Conservation Accomplishments

Current surveys for the black-throated green warbler are being coordinated through the Cape Romain Bird Observatory (CRBO) (Dias pers. comm.). These studies have confirmed that Wayne's black-throated green warbler is declining precipitously in South Carolina. Researchers are plotting all known present breeding locations while developing a plant index at each site. The location of suitable habitat on private lands, especially plantations, is being determined. Partnerships with private landowners and managers are being developed to increase surveyed acreage.

Some private lands, especially those with easements or long timber rotations, may offer some protection as well. The protected Francis Marion National Forest probably has the main concentration of the species in South Carolina.

Conservation Recommendations

- Investigate the possible benefits of Streamside Management Zones (SMZs) and buffers to black-throated green warblers, with particular attention to characterization of width, extent and configuration.
- Complete intensive surveys to locate as many potential breeding populations of black-throated green warblers within the state as possible.
- Support adoption of brown-headed cowbird control measures near identified breeding locations of black-throated green warblers in partnership with CRBO and other identified cooperators.
- Conduct in-depth investigations of black-throated green warbler breeding biology and habitat use once breeding populations have been identified. Locate nests and determine nesting success and nesting habitat, site fidelity, foraging behavior and habitat use. At least two such study areas should be established, if possible, for comparative purposes.
- Develop a statistically valid monitoring protocol for black-throated green warblers.
- Determine wintering locations, migration corridors and stopover sites for black-throated green warblers.
- Issue news releases and information to the general public, constituent groups and conservation organizations. Biologists and researchers should work closely with landowners and the forest products industry to provide management data as it becomes available.
- Establish habitat protection measures for the black-throated green warbler, including easements, Best Management Practices and acquisition where feasible.

Measures of Success

After determining habitat use, management guidelines should be provided for landowners and agencies. Use adaptive management where opportunities arise. The development of a valid monitoring protocol will facilitate the periodic evaluation of population health and allow for appropriate corrective measures when declines occur.

Colonial Nesting Seabird Guild

Sandwich Tern *Thalasseus sandvicensis*

Least Tern *Sterna albifrons*

Royal Tern *Thalasseus maximus*

Common Tern *Sterna hirundo*

Eastern Brown Pelican *Pelecanus occidentalis*

Forster's Tern *Sterna forsteri*

Gull-billed Tern *Gelochelidon nilotica*

Black Skimmer *Rynchops nigra*

Willet *Catoptrophorus semipalmatus*

Wilson's Plover *Charadrius wilsonia*

Contributors: Thomas M. Murphy, Sally R. Murphy and DuBose Griffin

Description

Taxonomy and Basic Description

This guild ranges from the diminutive least tern (wing span of 50.8 cm or 20 inches) to the sizeable pelican (wing span of 228.6 cm or 90 inches). Members represent four families, but are grouped into a guild because they nest on small coastal islands in mixed colonies. The three families are: Pelecanidae (pelicans), Rynchopidae (skimmers) and Laridae (gulls and terns).

Smallest of North American terns, the least tern measures 21 to 23 cm (8.3 to 9.1 inches). This tern has a black cap with a white forehead. Least terns are grey above and white below with two black outer primaries. The bill is yellow or orange with a dark tip (Thompson et al. 1997).

The sandwich tern is intermediate in size between the royal and common tern but with a much different body shape than either. Sandwich terns are sized 34 to 45 cm (13.4 to 17.7 inches) and weigh between 180 and 300 g (6.3 to 10.6 oz.). This tern is the only crested tern with a black bill, the tip of which is yellow. They are uniformly gray above, darker on their outer primaries, with a white rump and tail. Underneath, sandwich terns are white with dark grayish edges under the primaries. The cap is entirely black with a spiky crest (Shealer 1999).

The gull-billed tern is another medium sized tern measuring 33 to 38 cm (13 to 15 inches) (Parnell et al. 1995). The gull-billed tern has a black bill and is similar in size to the sandwich but has a stockier, gull-like build, longer legs and a thicker, shorter bill. The upper wing of the gull-billed tern is uniform with a black line on the edge of the primaries, a gray rump and a similar tail. Gull-billed terns have black ear patches (Shealer 1999).

Common terns are medium terns with a length of 31 to 35 cm (12.2 to 13.8 inches), including elongated outer tail feathers forming a 6 to 9 cm (2.4 to 3.5 inches) fork. These terns weigh between 110 and 145 g (43 to 57 ounces). Adult breeding common terns are light gray above and below with a black cap, orange-red legs and an orange-red bill with black tip. There is extensive black on outer primaries that is very obvious on the closed wing (Nisbet 2002)

Forster's terns are typically 33 to 36 cm (13 to 14 in.) long and weigh 130 to 190 g (4.6 to 7.0 ounces). Both sexes are mostly white during breeding season with mostly white plumage and a black cap, pale gray wings and a deeply forked tail. These terns have orange legs and variably black-tipped orange bills (McNicholl et al. 2001).

The royal tern is the largest crested tern with a length of 45 to 50 cm (18 to 20 inches) and a weight of 350 to 450 g (12 to 16 ounces). Both sexes of the royal tern have long orange bills and forked tails. The breeding plumage of the royal tern is gray above and white below with a full black cap and shaggy crest. The rump is very pale gray with a white tail. The legs and feet are black and the eyes dark brown (Buckley and Buckley 2002).

The black skimmer is a slim bird with a black back and white belly. Males and females vary greatly in size with lengths between 40 and 50 cm (16 to 20 inches). Weight for females averages 265 g (9.3 ounces) and for males weight averages 365 g (12.9 ounces). The bill of the black skimmer is unique, half red and half black, long and laterally flattened (Gochfield and Burger 1994).

The brown pelican is one of two North American pelicans and is easily distinguished from its counterpart, the white pelican. White pelicans are larger with white bodies and black primaries. Brown pelicans are gray to gray-brown with a black-brown belly. This coastal seabird is very large measuring 100 to 137 cm (3.3 to 4.5 feet) with a long bill (25 to 38 cm, 9.8 to 14.9 inches) and extensible gular pouch (Shields 2002).

The willet is a large sandpiper, colored gray to brown with a white rump and black and white wing pattern. Willets measure 33 to 41 cm (13 to 16 inches) in length and 200 to 330 g (7 to 12 ounces) (Lowther et al. 2001).

The Wilson's plover is a medium sized, ringed plover found strictly in coastal habitats. Wilson's plovers measure 165 to 200 mm (6.5 to 7.9 inches) and weigh between 55 and 70 g (1.9 to 2.5

ounces). These birds have large, heavy black bills with gray to gray-brown upperparts and white underparts and a black to brown breast-band (Corbat and Bergstrom 2000).

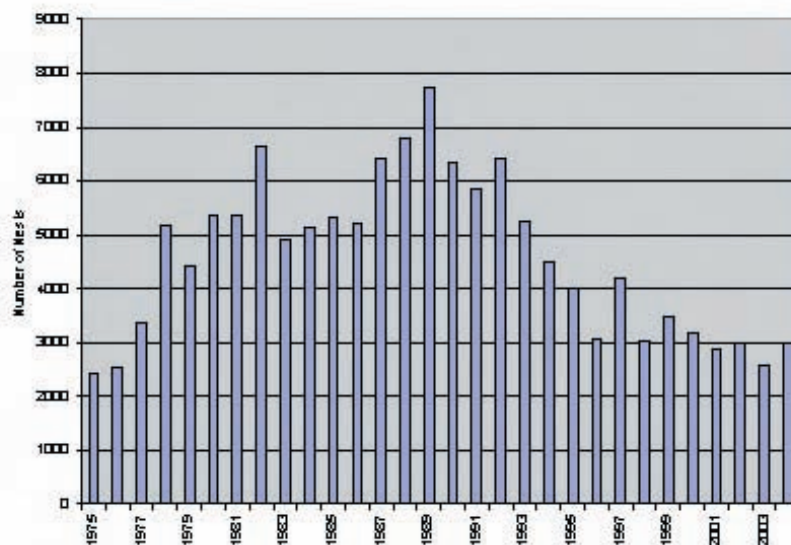
Status

Least terns are listed as state threatened, but coastal populations have no official federal designation since they are most abundant along the Gulf and Atlantic coasts. Nevertheless, least terns are classified threatened, endangered or species of concern for most states because of loss of nesting habitat (Thompson et al 1997).

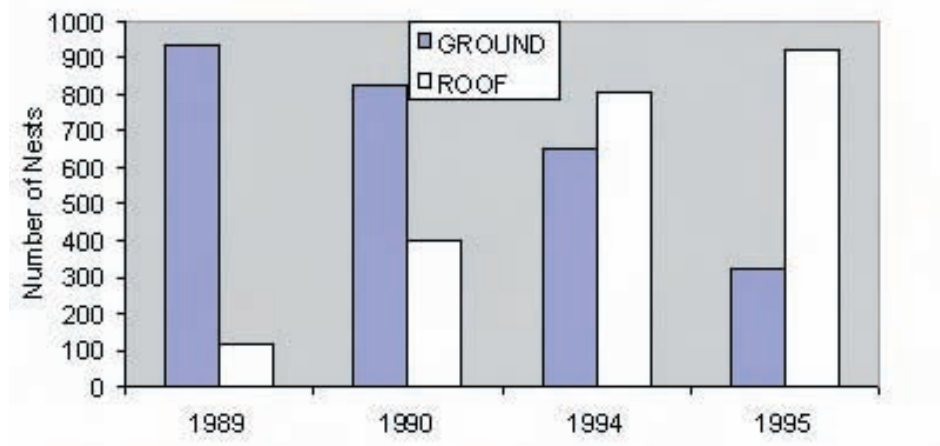
Eastern brown pelicans were formally listed as endangered, but the east coast population was removed from the list in 1985 as both numbers and reproductive success recovered. The South Carolina Department of Natural Resources (SCDNR) Heritage Trust Program lists the pelican as imperiled (S1/S2) statewide and restricted (G3) globally. The royal and gull-billed terns are currently under U.S. FWS status review. Gull-billed terns and black skimmers are listed as state species of concern.

Population Distribution and Size

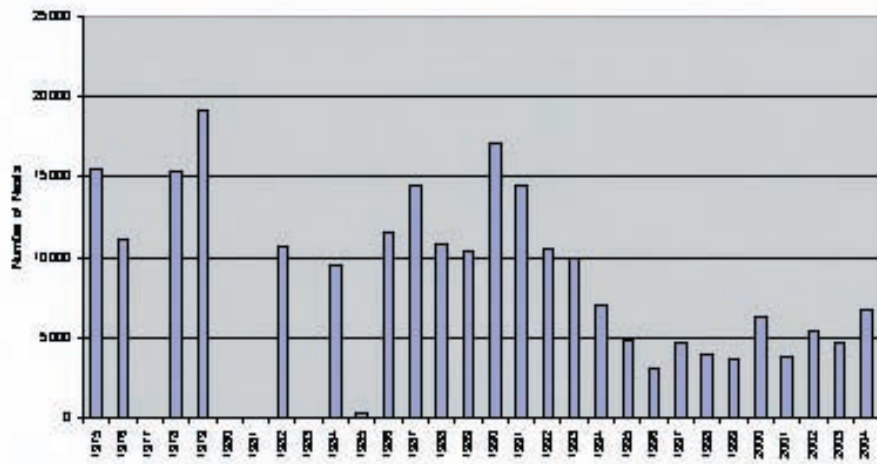
This guild of birds supports populations with thousands of nesting pairs, but most are in decline. All of the birds are subject to loss of suitable nesting habitat, which can cause abrupt changes in numbers. Members of this guild have been in decline in recent years, excluding the laughing gull, which has increased dramatically. Common and Forster's terns are peripheral and occur in low numbers. A more detailed status review through 1996 can be found in Wilkinson (1997).



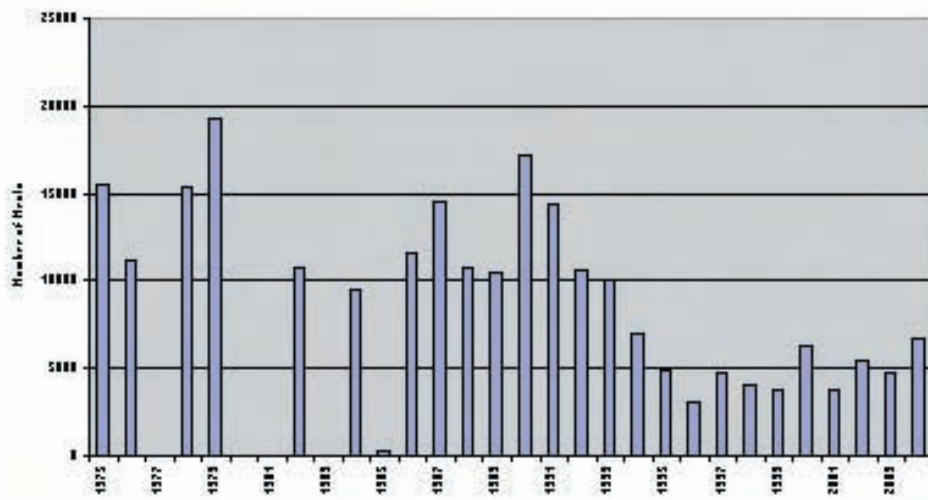
Eastern brown pelican nesting showed a strong recovery following the ban on DDT in 1973. Numbers peaked in 1989 and have declined since that time.



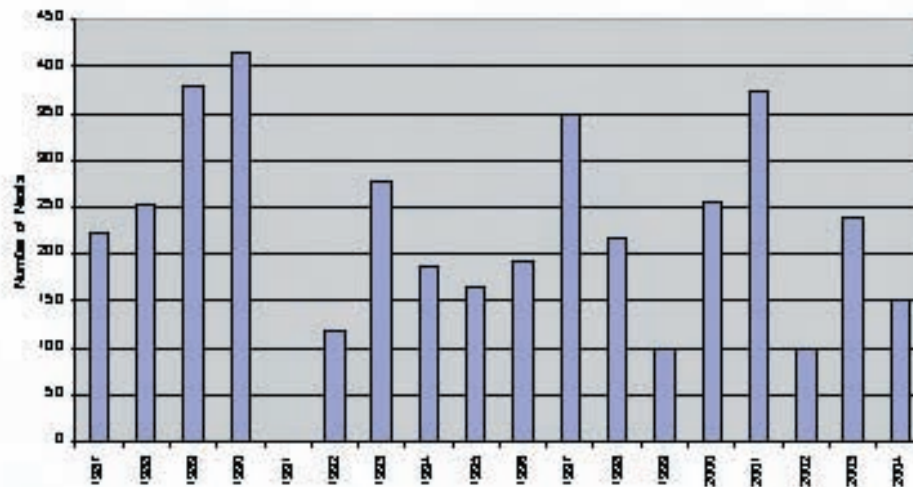
Beginning in 1975, least terns began moving from natural beach sites to roofs of buildings. By 1995, more than 70% of nesting was on roofs. The overall population has remained stable.



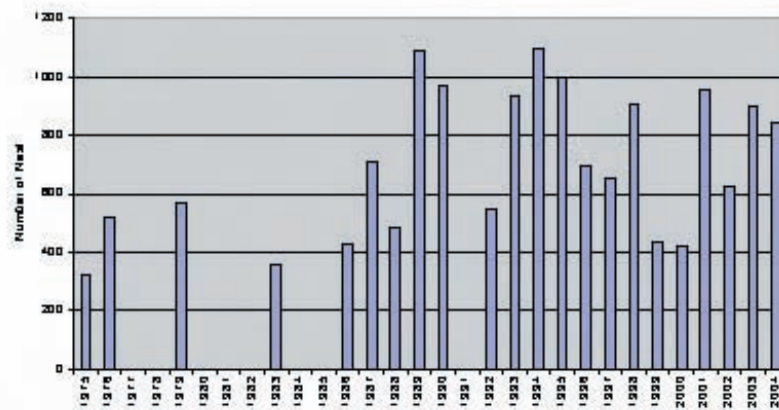
Royal tern nests averaged 15,000 nests per year in the late 1970's. Numbers have declined precipitously to 5,000 nests in recent years.



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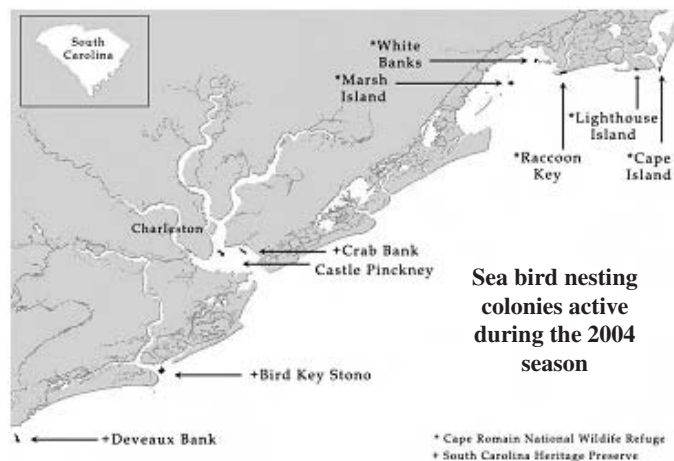
The Gull-billed tern population is difficult to monitor because of asynchronous nesting; it appears to be relatively stable but in low numbers.



Because colonies are subject to overwash, the number of black skimmer nests counted varies between years largely due to survey efficiency. Overall, the population appears stable.

Habitat and Natural Community Requirements

Seabirds usually nest on isolated coastal islands that are high enough to prevent over-washing and too small to support mammalian predators. Nesting sites that were previously used in St. Helena Sound, Port Royal Sound and at the mouth of the Savannah River have eroded away. There are nine remaining active nesting sites in the state; all are located in Charleston County. Colony sites with multiple species require habitats ranging from bare sand or shell to low grass or



shrub vegetation. The ends of larger islands are used by several species. Nesting colonies serve as information exchange centers to facilitate location of prey that has a patchy and changing distribution. In addition, least terns began nesting on roofs in 1975. Currently approximately 70 percent of nesting occurs on roofs and requires an innovative management approach.

This guild is principally picivorous and feeds in nearshore and estuarine waters of the state. During the nesting season, foraging is limited to areas within 10 to 15 miles of nesting sites. Terns typically plunge dive for food, while pelicans and skimmers have specialized foraging strategies. This guild also utilizes shrimp trawler bycatch.

Challenges

Members of this guild share both nesting and foraging sites and are usually impacted by the following factors: loss of suitable nesting habitat; disturbance at nest sites; soft tick infestation; loss of suitable roof nesting sites; oil spills; and loss of prey base.

Seabirds nest at sites that are prone to sudden and dramatic changes. Storms and hurricanes can alter or destroy nesting islands at any time. Loss of a single colony site can result in major lasting impacts to statewide populations. Many of the islands currently in use by seabird colonies are owned by state or federal government agencies.

With ever increasing coastal development and associated boat use, protection of seabird colonies has become increasingly difficult. During the nesting season, several thousand nests can be negatively impacted by a single disturbance event such as a person entering a nesting colony during the heat of the day. Egg temperatures are significantly altered when the brooding parent is forced from the nest. The boating public frequently uses seabird nesting islands as public recreation areas. Dogs that often accompany their owners are a particular problem as they run through the colonies destroying eggs, killing or injuring chicks and leaving unattended chicks vulnerable to aerial predators.

Nest abandonment associated with tick infestations has frequently affected pelican rookeries in the state and may be contributing to recent declines in nesting pairs. These ticks (*Ornithodoros* spp.) feed mostly at night and complete a blood meal in a matter of hours; therefore, they are infrequently seen on the birds. Close examination of nests is required to detect the presence of ticks except when they are present at high densities. Infestations can involve thousands of ticks per nest and result in nest abandonment.

Least terns have been able to maintain their nesting population by utilizing roofs with a pea-gravel substrate for nesting. A large proportion of the current population was hatched and has nested exclusively on roofs. During Hurricane Hugo, the fact that the pea-gravel can become ballistic in high winds was discovered and is now only rarely used on roofs; this resulted in fewer suitable roofs available for tern nesting. Further, although roof nesting sites can be productive, they frequently flood during thunderstorms, lack perimeter barriers to prevent chicks from falling and may receive excessive disturbance.

Conservation Accomplishments

Nesting areas are posted and closed on an annual basis. In addition, three nesting islands have been protected as State Heritage Sites. Long-term complete annual census data are available for most species and extensive banding has been conducted on several of the guild members. Experimental spraying of ticks has been conducted to evaluate its effectiveness in protecting offspring. Finally, one nesting island has been constructed for use by nesting seabirds.

Conservation Recommendations

- Protect birds during the nesting season; adequate and timely posting and effective law enforcement is required.
- Establish or maintain suitable nesting islands at 48 km (30 mile) intervals along the coast to maximize use of foraging habitat during the nesting season.
- Evaluate management actions and determine population trends using annual monitoring with complete ground counts.
- Continue cooperative efforts with U.S. Fish and Wildlife Service to census and manage nesting sites within Cape Romain National Wildlife Refuge.
- Document impacts of soft tick infestations and provide suitable treatment as needed.
- Conduct cooperative projects with U.S. Army Corps of Engineers to construct and maintain seabird-nesting sites under the authority of Section 204 of the Water Resources Development Act of 1992.
- Develop public education program by creating and maintaining a web site with information on the status, management and natural history of seabirds in South Carolina.
- Develop oil spill contingency plans to protect nesting sites and provide rehabilitation of oiled birds.
- Maintain fish prey base for long-term success of these species.

Measures of Success

This guild of birds is subject to rapid shifts in distribution and abundance and will require adaptive management to respond to these changes. Attaining performance goals in nesting pairs will represent a measure of success.

Colonial Nesting Wading Birds

Black-crowned Night-Heron *Nycticorax nycticorax*

Glossy Ibis *Plegadis falcinellus*

Great Blue Heron *Ardea herodias*

Great Egret *Casmerodius albus*

Green Heron *Butorides virescens*

Little Blue Heron *Egretta caerulea*

Snowy Egret *Egretta thula*

Tricolored Heron *Egretta tricolor*

White Ibis *Eudocimus albus*

Yellow-crowned Night-Heron *Nyctanassa violacea*

Contributors: Elizabeth A. Ciuzio and Thomas M. Murphy

Description

Taxonomy and Basic Description

Colonial nesting wading birds are a taxonomically diverse group composed of several different genera. Members of this guild belong to two families: Ardeidae (herons and egrets) and Plataleidae (ibises). Colonial nesting wading birds are medium to large birds that have long legs,

necks and bills; these features are specially adapted for capturing prey while wading in shallow water. The glossy and white ibises have long, narrow bills that enable sub-surface, tactile feeding.

Colonial wading birds are among the most striking birds in North America. The white ibis, great and snowy egrets are white birds; however the white ibis has black primaries, visible during flight. These three species are easily distinguished from each other by size or color of the bill or legs: the white ibis has a scarlet bill and legs; the snowy egret has yellow feet; and the great egret is tall with a yellow bill and black legs. Juvenile little blue herons are also white. On the other extreme, the glossy ibis appears as an all dark bird from a distance. Upon closer inspection, the glossy ibis is actually a glossy chestnut color.

Little blue, great blue and tricolored herons as well as the night-herons appear as their names suggest. The little blue heron is a darker blue and considerably smaller than the great blue heron. The great blue has white on the crown, cheeks and a stripe down the neck. The tricolored heron is slate blue above and on the neck, with a white abdomen and white strip on the front of the neck. The yellow-crowned night-heron is overall a grayish bird with yellow on the crown and white on its head and cheeks. The black-crowned night-heron is also a grayish bird with black on its crown and down its back. The belly of this bird is white. The green heron is stocky with relatively shorter legs, a dark bill, rust colored neck, black cap and back, and grey underparts.

Status

Members of this guild are of conservation concern because their reproductive strategy leaves them especially vulnerable to habitat degradation. As the name suggests, colonial wading birds nest in large colonies; hundreds of birds can nest in one tree. Although this strategy affords benefits in terms of predator avoidance, it also makes them especially vulnerable to habitat loss because impacts to a small area (colony) can affect hundreds of breeding pairs of several different species.

In addition to this vulnerability to habitat alterations, several members of this guild are of special concern due to declining population trends (Sauer et al. 2004). With the exception of the great blue heron, all of these colonial wading bird species have been in decline in recent years in South Carolina. The little blue heron and white ibis are listed as Birds of Conservation Concern (USFWS 2002).

Population Distribution and Size

All of the colonial nesting wading birds can be found in the coastal zone of South Carolina. The glossy ibis, tricolored heron and snowy egret are restricted to the coastal zone, while the great egret, little blue heron and white ibis can range into the coastal plain. The yellow-crowned night heron is an uncommon breeder in the piedmont (Post and Gauthreaux 1989). The black-crowned night heron is a coastal breeder, is uncommon in the coastal plain away from coast and is not found in sandhills, piedmont or mountains. The great blue heron can be found through out the state.

Complete ground censuses of wading bird nesting colonies were conducted in 1988, 1989, 1994 and 1996. Counts of the total number of wading bird nests fluctuated between years, but high counts of 59,483 and 52,587 in 1989 and 1996 were representative of the population (Dodd and Murphy 1997). The fluctuations were primarily a result of one species: white ibis. Nesting populations of members of this guild appeared to be stable during this period.

Since that time, aerial estimates indicate that most species have declined precipitously. This was particularly apparent during years of extended drought from 1999 through 2003. Although rainfall has returned to near normal levels, there has not been a return to historic nest numbers.

Habitat and Natural Community Requirements

Nesting sites are found in a variety of habitats. Colony sites for most guild members are found on islands in fresh and brackish water ponds. Water surrounding a nesting site deters mammalian predators and alligators frequently provide an additional deterrent. When suitable island sites are lacking, guild members may use vegetation around the edge of a pond for nesting. These sites are generally unsuccessful as a result of predation except for ponds in residential areas that are not affected by predators. Colonies are also sustained on estuarine islands that are free of mammalian predators. While most species in this guild prefer snags and mature trees with large lateral limb structures, yellow-crowned night-herons, little blue herons, tricolored herons and snowy egrets nest lower and prefer shrubby habitat.

Great blue herons nest in mature pines on hammocks islands, along the marsh-upland ecotone or in riparian swamps. Further away from the coast, they nest on islands or along the riparian zone of rivers and man-made water bodies, such as reservoirs.

Colonial nesting wading birds can be found feeding in a wide variety of aquatic habitats. The glossy and white ibis can use their long bills to probe the soil for invertebrates in moist soil and shallow water. The great blue heron, tricolored heron, snowy egret, green heron, great egret, little blue heron, black-crowned and yellow-crowned night herons all feed in shallow water, with the great blue heron and great egret being able to tolerate deeper water owing to their long legs. Colonial wading birds feed primarily on fish, crabs, crayfish and amphibians. The great blue heron will also feed opportunistically on small birds and mammals. Each bird has its own feeding style. Snowy egrets are very active feeders and pursue their prey while great egrets and great blue herons are 'lie-in-wait' predators.

Challenges

Loss of feeding, roosting and breeding habitat is the biggest problem for colonial wading birds (Dodd and Murphy 1998). Suitable nesting and roosting habitat is reduced by removal of vegetation during timber harvest and residential and commercial development. Shrub-type nesting and roosting habitat is lost through removal of vegetation, mainly for aesthetic reasons, along the edge of ponds and impoundments.

While South Carolina has been relatively successful in protecting its wetland resources that represent important foraging habitat for wading birds, significant losses have occurred in freshwater non-tidal wetlands. The amount and quality of foraging habitat will ultimately determine the status of colonial wading bird populations.

Human disturbance is a problem for nesting colonial wading birds. Short-term disturbances such as airplanes, boats, vehicles and human presence may cause the birds to fly from their nests, which can result in nest abandonment. Docks result in disturbance to feeding birds because of the increased boat traffic. The docks themselves are frequently used by the birds for foraging because fish concentrate in the shade of the docks.

Several types of environmental contaminants are problems for colonial wading birds. Petroleum from oil spills damages bird feathers and causes mortality. Chemicals such as DDT and PCBs are not currently widespread; however they do cause reduced reproductive success. Metals such as mercury and lead can concentrate and lead to reduced survivorship and reproductive success. Environmental contaminants also reduce availability of prey items. Nonpoint sources of pollution can reduce productivity of coastal marshes.

Diseases such as cholera and botulism are particularly problematic for colonial wading birds. In the event of an outbreak of these diseases, they spread easily because the birds nest in such high densities.

Other human-related causes of mortality include collisions with power lines and entanglement in fishing line, gill nets, drift nets and various forms of plastics (Dodd and Murphy 1998).

Competition with cattle egrets (*Bubulcus ibis*) and double-crested cormorants (*Phalacrocorax auritus*) for food resources and nesting sites can reduce nesting success for guild members (USFWS 2003).

Conservation Accomplishments

The Lacey Act of 1900 was the first major step toward protecting wading birds. The Lacey Act was passed, in part, in response to the millinery trade to regulate interstate and international trade of bird parts. Hundreds of thousands of herons and egrets, among other birds, were killed for their nuptial plumes, used in ladies hats and fashionable clothing (Ogden 1978).

The Migratory Bird Treaty Act of 1918 made it illegal for a person to possess any migratory bird or part, with the exception of game birds during the proper season, as well as the possession of nests and eggs. Prior to these Acts, market hunting was responsible for population declines in many bird species.

The South Carolina Department of Natural Resources (SCDNR) collected baseline data during statewide ground census counts were 1988, 1989, 1994 and 1996. Statewide aerial surveys have been conducted annually since 1988.

Conservation Recommendations

- Protect and manage nesting colonies through acquisition, technical guidance or construction of new sites.
- Develop best management practices for colony sites.
- Integrate management for colonial wading birds into traditional waterfowl management of currently impounded wetlands by timing draw downs during key feeding periods (post fledging).
- Partner with industry and permitting agencies to deter development of important wading bird breeding, feeding and roosting sites.
- Partner with timber industry to develop best management techniques for important wading bird breeding and roosting sites.
- Establish buffer zones to protect tree and shrub nesting colonies during the nesting season.
- Establish a buffer zone of 30 m along (94 feet) the marsh/upland interface of shorelines to protect roosting and foraging sites. Mature trees, snags and shrubs should be maintained within this zone.
- Partner with local communities to minimize boat traffic in small creeks, mudflats and formerly impounded rice fields to reduce disturbance of foraging birds.
- Partner with permitting agencies and local communities to restrict the development of new docks to wide channels and bay shoreline and/or encourage the use of community docks, as opposed to single-dwelling docks.

- Partner with industry to encourage the inclusion of island habitat suitable for nesting wading birds in new pond construction. Islands should be located near the pond center to discourage mammalian predators.
- Partner with permitting agencies and industry to place landfills, power lines and towers away from colonies and wetland areas.
- Partner with the appropriate agency to restrict development of small marsh islands or hammocks of less than 12 acres (4.9 hectares).
- Complete a statewide ground census of nesting wading birds for two consecutive years at least every ten years.
- Annually survey colonies containing federally endangered birds.
- Provide permitting agencies with current information on known nesting wading bird colonies by updating distribution maps every year.
- Partner with appropriate permitting agency to reduce input of chemical contaminants into marine and aquatic systems.
- Encourage the use of Best Management Practices in residential and commercial development activities.
- Create an educational program for homeowners emphasizing the importance of including vegetation around ponds and lakes for bank stabilization and wildlife habitat.
- Partner with law enforcement to reduce littering in aquatic and marine systems.
- Educate the public about the harmful effects of plastic litter and abandoned nets on birds and other marine and aquatic species.
- Decrease the potential for disease organisms by discouraging activities such as depositing raw or partially treated wastewater into wetlands.
- Determine the current population status of colonial nesting wading birds and document the reasons for declines.
- Document water quality issues at colony sites.
- Determine best management practices for multi-species management of impounded marsh habitat.
- Determine the effects of human activity on wading bird foraging efficiencies.
- Determine the importance of roost sites and their relationship to available foraging habitat.

Measures of Success

Protecting important habitat as outlined above should provide stable resources and enable populations to rebound. The ultimate measure of success would be to document stable to increasing population trends of colonial wading birds. Colonial wading bird nesting should total 50,000 pairs distributed widely across coastal plain counties.

Deciduous Forest Interior Birds

Wood Thrush *Hylocichla mustelina*

Eastern Wood Pewee *Contopus virens*

Black-throated Blue Warbler *Dendroica caerulescens*

Worm-eating Warbler *Helmitheros vermivorus*

Scarlet Tanager *Piranga olivacea*

Contributor: Anna Huckabee Smith

Description

Taxonomy and Basic Description

The species described in this report are in the perching bird order, Passeriformes, and represent four families: Parulidae (warblers), Turdidae (thrushes), Thraupidae (tanagers), and Fluvicolinae (pewees). Currently accepted names for the wood thrush, worm-eating warbler and scarlet tanager are from Gmelin (1789) and the eastern wood pewee was first described by Linnaeus in 1766. Two subspecies have been described for the black-throated blue warbler: *Dendroica caerulescens caerulescens* (Gmelin, 1789), which ranges from Pennsylvania into Canada, and *Dendroica caerulescens cairnsi* (unverified), which ranges from West Virginia south to Georgia (Holmes 1994; ITIS 2004).

Eastern wood pewees are medium sized flycatchers. Both sexes are grayish-olive with white wing bars and a bi-colored mandible; the lower mandible is yellow. Wood pewees are 13.3 cm (5.25 inches) long and weigh 14 g (0.49 ounces) (McCarty 1996).

Basic coloration of the wood thrush is rusty brown with white underparts punctuated by brown spots. A white eye ring is also present. The wood thrush is 17.8 cm (7 inches) in length and weighs 40 to 50 g (1.4 to 1.8 ounces) (Roth et al. 1996).

Worm-eating warblers are olive-brown with bold black and buff head stripes. Pink legs are another feature of this species. The worm-eating warbler is 11.4 cm (4.5 inches) in length. The male and female of this species are identical in appearance (Hanners and Patton 1998).

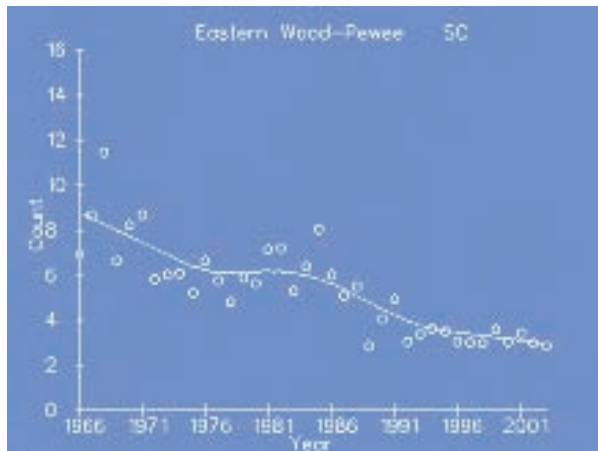
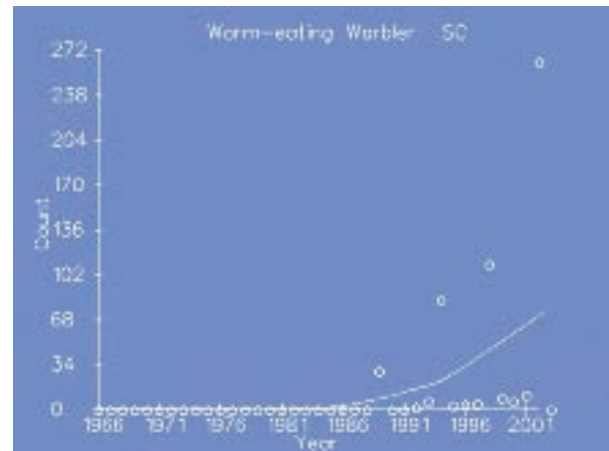
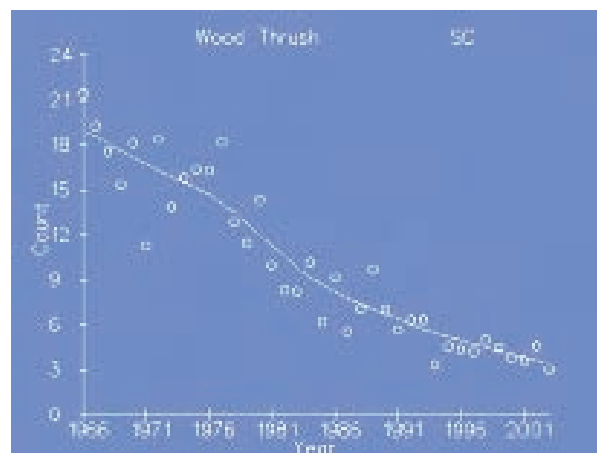
In the black-throated blue warbler and scarlet tanager, the sexes differ greatly. In fact, the female black-throated blue warbler was once mistaken for a separate species, the “pine swamp warbler” by Audubon in 1841. The male black-throated blue warbler has a black face and dark blue crown and back. The female is yellowish-white above with gray on the cheek. A white wing patch is visible on both sexes. Black-throated blue warblers measure 11.4 cm (4.5 inches) in length and weigh 9 to 10 grams (0.32 to 0.35 ounces) (Holmes 1994).

Scarlet tanager males take on scarlet red body plumage with black wings and tail in the breeding season. Females are olive colored above and yellow underneath with gray wings and tail. This species is 16.5 cm (6.5 inches) long (Mowbray 1999).

Status

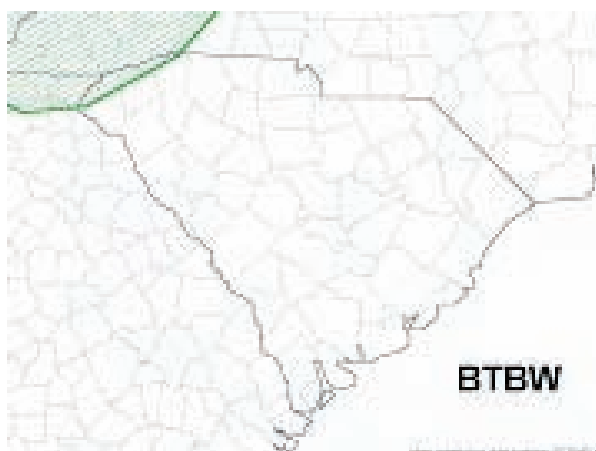
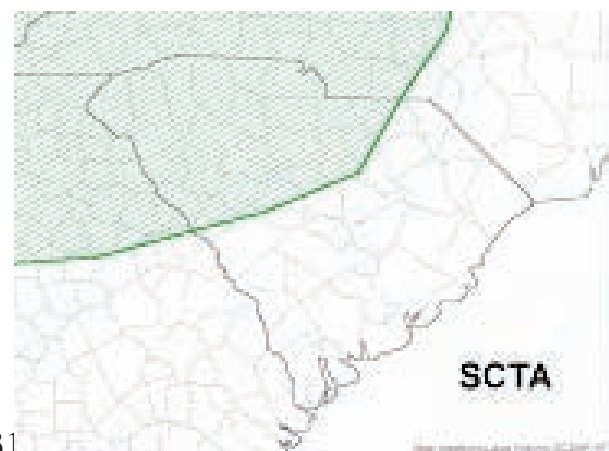
All species in this group are Neotropical migrants of regional importance (Rosenberg 2004) and are considered priority species because of trends showing present population declines or potential declines in the near future due to threats to their habitat.

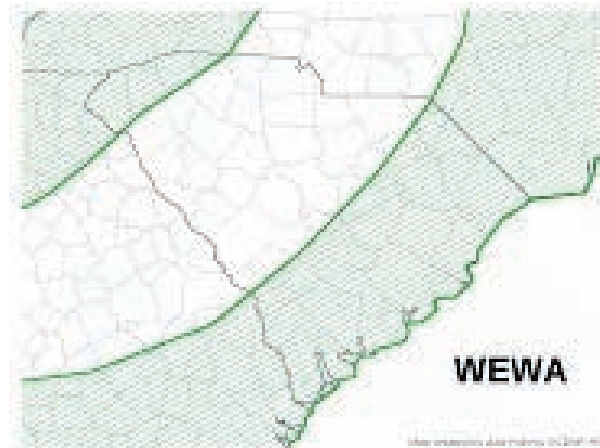
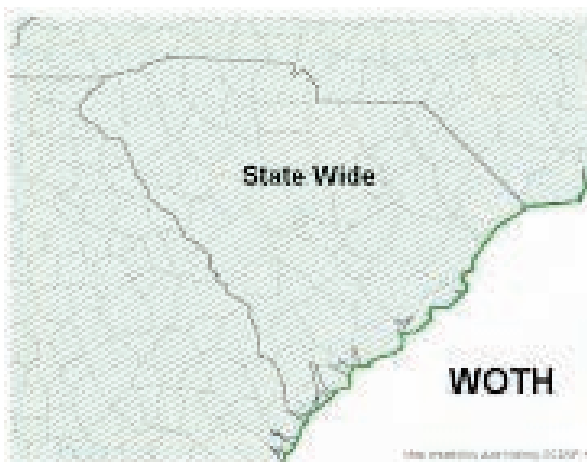
The Breeding Bird Survey (BBS) indicates a 3.4 percent rate of decline per year for the eastern wood pewee in South Carolina while the wood thrush has undergone more drastic reductions in its population at 5.0 percent per year (Cely 2003). The worm-eating warbler has gained a slight increase in population numbers in South Carolina in recent years, possibly due to a range expansion into the inner and outer coastal plains (Cely 2003). Scarlet tanager and black-throated blue warbler populations in South Carolina appear to be stable; however, these peripheral species have not been studied in depth in the southern Appalachians of South Carolina (Huckabee 2001).



Population Distribution and Size

The black-throated blue warbler and scarlet tanager range into the Southern Appalachian Ecoregion. However, the scarlet tanager may be experiencing a range expansion into the Piedmont Ecoregion (Cely 2003; Mowbray 1999).





The eastern wood pewee, worm-eating warbler and wood thrush are found in the Southern Appalachians, but often range into the piedmont. The eastern wood pewee can be found statewide, although the densest populations are in upstate areas. The worm-eating warbler does occur in the eastern portion of the coastal plain (inner and outer) while the wood thrush, another coastal plain inhabitant, is less common in the outer coastal plain.

Population size estimates and goals derived by Rosenberg (2004) from the Partner's In Flight North American Landbird Conservation Plan are outlined below.

Population estimates for species in South Carolina (Rosenberg 2004).

* In individual numbers of birds

Species	SC Population Estimate*	Target Population Estimate*
Wood Thrush	360,000	540,000
Eastern Wood-Pewee	140,000	210,000
Black-throated Blue Warbler	N/A	N/A
Worm-eating Warbler	6400	6400
Scarlet Tanager	2800	2800

Habitat and Natural Community Requirements

Since forest birds tend to cue in on forest age, size and overall structure more than plant composition (Hanners and Patton 1998; Rosenberg et al. 2003), these birds appear to prefer blocks of deciduous forest (Rosenberg et al. 1999). These birds benefit most from landscapes that are 50 to 70 percent forested (Rosenberg et al. 1999) with patches no less than 80 ha (200 acres). Blocks that are 3,000 ha

(7,500 acres) in size provide the greatest benefits to all of these forest bird species, especially since some require larger territories as habitat quality changes (Rosenberg et al. 1999; Rosenberg et al. 2003). The shape of the management blocks should be circular to minimize edge effects, which can extend 45 to 90 m (150 to 300 feet) into the forest interior (Rosenberg et al. 2003).

The forest cover type these species of birds utilize is “deciduous forest,” characterized by Northern red oak (*Quercus rubra*), chestnut oak (*Q. prinus*), hickory (*Carya* spp.), red maple (*Acer rubrum*) and a variable shrub layer (depending on soil moisture conditions and elevation). This cover type is comparable to the “Appalachian oak” (Hunter et al. 1999) and “Oak-hickory” (Hamel 1992) complexes. These forests often grade into “coves,” which are characterized by the addition of such species as eastern hemlock (*Tsuga canadensis*), yellow poplar (*Liriodendron tulipifera*), and an understory of rhododendron (*Rhododendron* spp.) (Hamel 1992; Hunter et al. 1999). The wood thrush and eastern wood pewee can also be found in mixed pine-hardwood forests and in edge habitats. The wood thrush may even move from interior to second-growth woodlands after the breeding season and before migration (Roth et al. 1996). The wood thrush often uses small deciduous forest corridors on the coast (Forsyth pers. comm.).

All of the bird species in this grouping share the same basic habitat requirements such as forest interior (greater than 70 percent cover) (Hunter et al. 1999), a partially to completely closed canopy and patch sizes of at least 80 ha (200 acres) due to area sensitivity (Rosenberg et al. 2003). The exception is the eastern wood pewee, which can tolerate smaller woodlots and an open canopy. However, as with most species in this group, nesting success declines in such areas. All members of this group require some understory cover, but certain species, such as black-throated blue warblers, require a higher density of shrubs (viburnums) for nesting. Natural disturbances throughout a forest often creates vertical and horizontal vegetative structure. Those typical of the canopy are the scarlet tanager and eastern wood pewee. Understory and ground users are the worm-eating warbler, wood thrush and black-throated blue warbler. All five of these species typically require breeding territories of approximately 5 ha (12.3 acres) about 250 m (820 feet) in diameter (NatureServe 2004).

Other species that may benefit from the maintenance of deciduous forests of this age and structure include, but are not limited to, the following: hooded warbler (*Wilsonia citrina*), ovenbird (*Seiurus aurocapilla*), black-throated green warbler (*Dendroica virens*), red-eyed vireo (*Vireo olivaceus*), black-and-white warbler (*Mniotilta varia*), Louisiana waterthrush (*Seiurus motacilla*) and Kentucky warbler (*Oporornis formosus*) (Rosenberg et al. 1999; Huckabee 2001).

Challenges

Forest fragmentation is the biggest problem for deciduous forest interior birds. Roads into forests bring native and non-native predators such as rodents and feral cats. Nest parasites, such as the brown-headed cowbird (*Molothrus ater*) can also move into the forest interior. As forest habitat shrinks, bird species that are area-sensitive may abandon smaller woodlots altogether.

Communication towers are a significant source of mortality for migratory birds. 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 the species comprising this deciduous forest group.

Additionally, an over-population of white-tailed deer can be detrimental to bird habitat. In areas

of high densities (greater than 7.9 deer/km²), herbivores browse the understory such that nesting and foraging substrates are greatly reduced (NatureServe 2004).

Although not a problem specific to South Carolina, habitat destruction on the birds' wintering grounds (Central and South America and the Caribbean) is causing a decline in populations. For example, the black-throated blue warbler exhibits site tenacity at wintering grounds. This factor makes it vulnerable to changes in that habitat (Holmes 1994).

Introduced diseases that affect the birds' habitat can be detrimental. Sudden oak death (*Phytophthora ramorum*) is a fungus that has entered South Carolina and other southeastern states via nursery stock. It affects red oaks, black oak and Northern pin oak. Although not an immediate problem at this time, the disease, if not contained, has the potential to decimate the deciduous forests of South Carolina, not unlike the chestnut blight (*Cryphonectria parasitica*) in the earlier part of this century. In addition to introduced diseases, there are exotic insect outbreaks of concern. Because the black-throated blue warbler also utilizes coves where hemlocks are a major canopy species, the hemlock woolly adelgid (*Adelges tsugae* Annand) may impact the bird's habitat.

Although not as common in the mountains of South Carolina, continued acidic precipitation may lead to the leaching of calcium from the soil. This is a major requirement of snails, earthworms (*Sparganophilus pearsei*) and pillbugs (*Isopoda* spp.), which are all food for leaf litter foraging worm-eating warblers and wood thrushes. Finally, it has been suggested that precipitation changes as a result of global warming may impact the habitat of the black-throated blue warbler (Holmes 1994).

Conservation Accomplishments

Purchase and protection of the Jocassee Gorges in 1997 resulted in habitat protection for these species. The Jocassee Gorges includes at least 1,200 acres of forest 60 years and older; some patches are older than 80 years (M. Hall, SCDNR, pers. comm.). Most, however, is still maturing. Completion of PIF plans for Physiographic Area #03: South Atlantic Coastal Plain and Physiographic Area #23: Southern Blue Ridge serve as good sources of continued management interaction. Finally, preliminary (Huckabee 2001) and continued (Boyle et al. 2003) research on forest interior species in the Jocassee Gorges and surrounds have provided and will continue to provide important information for these species.

Conservation Recommendations

- Identify and protect forest interior and unbroken large tracts of deciduous forest habitat. Determine the best sites for conservation and/or restoration projects by conducting a landscape level spatial analysis and utilize GIS based models as a basis for land acquisition and delivery of private lands programs in order to locate areas where opportunities for conservation are the greatest.
- Maintain migratory stopover habitat in coastal areas and river bottoms for wood thrush, worm-eating warbler and other Neotropical migrants.
- Develop corridors to link forested tracts.
- Continue to promote partnerships to implement forest health measures to prevent, detect and suppress outbreaks of SOD and hemlock woolly adelgid on public and private lands.
- If disturbances are unavoidable, they should be concentrated near edges. Although some

tracts should be allowed to return to old-growth forest, other areas can be selectively thinned to mimic natural disturbances.

- Private landowners should be encouraged to protect contiguous tracts of high-quality deciduous forest. In addition, the consolidation of land ownership to expand existing forests already under protection should be continued.
- Reduce communication tower collisions. The following recommendations set forth by Shire (2000) may assist in that effort:
 - o No aviation lights should be placed on towers that are less than 199 ft. tall.
 - o Remove old towers that are no longer in operation. Recycle old communication towers for additional purposes instead of building new ones.
 - o Environmental Assessments should be conducted to determine the impact a new tower's construction will have on birds if built in a migratory route.
- If found to be causing an impact in certain areas, the removal of feral cats (*Felis catus*) from public lands through live trapping should be implemented.
- Conduct studies to determine the minimum area requirements for forest birds.
- Investigate coastal nesting and general habitat use in the coastal plain for worm-eating warblers.
- Initiate site fidelity and dispersal studies for the scarlet tanager.
- Investigate the effects of deer on breeding bird habitat.
- Develop and implement monitoring programs to better assess breeding, migrating and wintering bird population sizes. Management and surveillance monitoring techniques will need to be assessed to quantify short and long-term population responses in order to answer specific monitoring questions. Measures will need to be developed to integrate state monitoring results into regional and national level databases.
- Breeding Bird Survey routes should continue annually; increase the number of routes in under-sampled areas of South Carolina.
- Radar ornithology should be continued in order to monitor bird-habitat associations at migration stopover sites.
- The public should be educated on the plight of Neotropical migrants and those species that specifically utilize deciduous forest interiors. Interpretive trails can be created within Jocassee, possibly utilizing the existing Foothills Trail.
- Partner with other states and countries to gather data on migratory stop-over sites, wintering ground usage and the threats faced at each.
- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels. Promote the development of a piedmont bird conservation region initiative.
- Continue participation in Partner's In Flight, NABCI and other bird initiatives.
- Promote existing and develop new partnerships to facilitate increased land acquisition.
- Promote the participation of volunteers and agency personnel to collect survey and monitoring data.

Measures of Success

Habitat improvement and restoration projects should result in higher BBS survey counts and nesting success rates. One obvious measure of success is to support population sizes similar to the goals outlined here (Rosenberg 2004).

Early Succession Bird Group

Chestnut-sided Warbler *Dendroica pensylvanica*

Prairie Warbler *Dendroica discolor*

Bewick's Wren *Thryomanes bewickii*

Contributor: Elizabeth Ciuzio

Description

Taxonomy and Basic Description

The chestnut-sided and prairie warblers are in the taxonomic order Passeriformes (perching birds) in the family Parulidae (the wood warblers). The Bewick's wren is also in the perching bird order, but is in the wren family, Troglodytidae. All three are small birds and can be distinguished by song, appearance and habitat preference.

The chestnut-sided warbler appears as its name suggests; both males and females have a chestnut colored streak down the sides of their bodies. Adult birds have a yellow crown, white check patches and belly, and a lemonish-green back with black stripes. Males are colored more brightly than females. Juveniles are colored much differently, but can be identified as a chestnut-sided warbler by its white belly, lemonish-green back, and two pale yellow wingbars (Peterson and Peterson 2002).

Male and female prairie warblers also look very much alike. This bird has yellow underparts, black stripes on the sides of its body, a brownish-green back, and two black face marks. Males can be distinguished from females by darker coloration and the presence of chestnut colored streaks on its back. This species can also be identified by its propensity to bob its tail. Juvenile birds appear quite differently, but also bob their tails (Peterson and Peterson 2002).

Like most wrens, male and female Bewick's wrens look alike and cannot be distinguished from one another. Wrens are small, active birds with decurved bills and cocked tails. The Bewick's wren is a brown bird with a white eye stripe and black barring on its tail feathers (Peterson and Peterson 2002).

Status

Disturbance dependent birds, as are the birds in this report, are experiencing precipitous population declines (Askins 2000 and 2001; Hunter et al. 2001). Furthermore, all three species are listed as birds of conservation concern by the United States Fish and Wildlife Service (USFWS 2002).

Population Distribution and Size

The chestnut-sided warbler is a northern breeding bird found in southern Canada, the northeastern United States, and the Appalachian mountains (Richardson and Brauning 1995). South Carolina is at the southern most end of this bird's breeding range and its distribution in the state is restricted to the Appalachian Mountains. The chestnut-sided warbler winters in Central

America. This warbler has been experiencing long-term (1966 through 2004) population declines of 0.6 percent per year in the eastern Breeding Bird Survey (BBS) region (Sauer et al. 2004).

The prairie warbler is a common breeding bird in eastern North America and ranges from the northern border of the United States to northern Florida and winters in central and southern Florida, eastern Central America and the Caribbean (Nolan et al 1999). In South Carolina, the prairie warbler is most common in the piedmont and coastal plain ecoregions.

The prairie warbler has been experiencing long term (1966 through 2004) population declines of 2.3 percent in South Carolina with the steepest declines (6.3 percent) occurring from 1966 through 1979 (Sauer et al. 2004). Recently (1980 through 2004), population trends have stabilized; however populations are still below objectives.

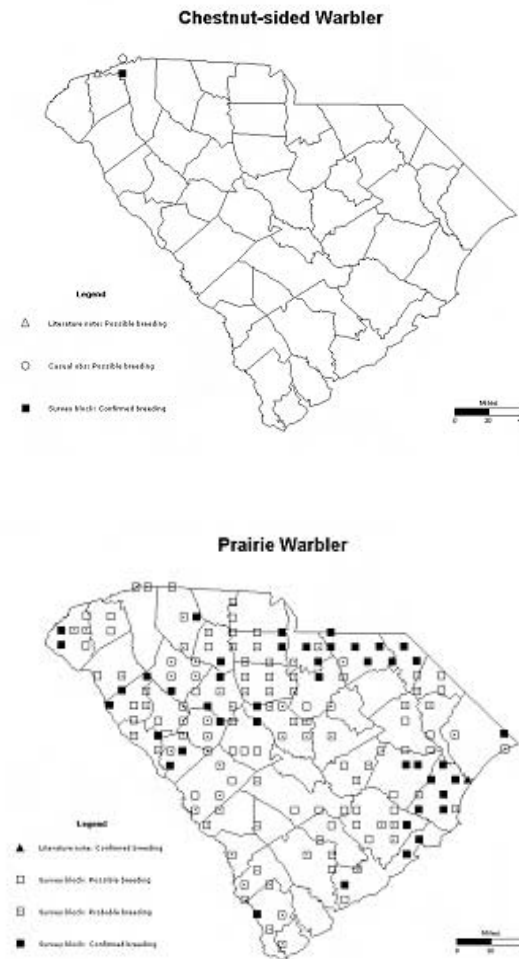
The Bewick's wren primarily breeds and winters in Central America and central and western North America (Kennedy and White 1997). This species has expanded and contracted its range in response to habitat changes in eastern North America and once could be found in the western Appalachian Mountains. Today this bird is rare in the eastern United States and likely extirpated from South Carolina.

The Bewick's wren has been experiencing long-term (1966 through 2004) population declines of 1.76 percent per year (Sauer et al. 2004) in the eastern and central BBS regions.

Habitat and Natural Community Requirements

Disturbance-dependent birds have suffered steep population declines throughout the eastern U.S. (Hunter et al. 2001). Historically fire, floods, windstorms and herbivores maintained habitat conditions conducive to disturbance-dependent species (Askins 2001). Fire suppression, the loss of large canopy trees such as the American chestnut (*Castanea dentata*) and the extirpation of beaver (*Castor canadensis*) and mega herbivores such as elk (*Cervus elaphus*) and bison (*Bison bison*) following European settlement reduced the availability of early-successional habitat throughout the eastern U.S. (Askins 2000).

Although natural ecological forces that create habitat for each of these birds revolve around disturbance regimes, each bird has its own unique requirements. The chestnut-sided warbler is a high elevation specialist most common in second growth of forest clearings, large tree-fall gaps, areas recovering from forest fires and successional growth following beaver activity (Richardson and Brauning 1995).



The prairie warbler's name is a bit of a misnomer because open prairie is not the preferred habitat. This bird requires a shrubby component to habitat. The prairie warbler can be found breeding in southern pine forests with a well developed shrub layer, dunes along the Atlantic coast, scrub oak and pine barrens, and abandoned pastureland or fields (Nolan et al 1999).

The Bewick's wren prefers scrub thickets of stunted vegetation interspersed within an open woodland landscape. Remnant populations in the east are often found near buildings or brushy areas on farms in relatively open country (Kennedy and White 1997).

Challenges

Habitat loss and suppression of disturbance regimes are the main challenges to the early succession bird group. The loss of the American chestnut resulted in reduced availability of larger tree fall gaps that create early successional habitat within a forested landscape. The extirpation of elk and bison, large animals that drive successional processes through herbivory, has also reduced the ecological forces that maintain early succession habitat. Fire suppression and reduced abundance of beaver have also reduced available habitat for disturbance dependent birds.

Even aged timber management reduces the structural complexity of forested landscapes upon which the prairie and chestnut-sided warbler depend. Urban development and the conversion of agricultural land to monoculture plantations has reduced available habitat for the prairie warbler and Bewick's wren.

Other causes of population declines may be attributed to bird strikes at communication towers and windmills, brood parasitism by the brown-headed cowbird (another disturbance dependent species) and habitat loss on wintering grounds.

Conservation Accomplishments

Long-term monitoring programs, such as the Breeding Bird Survey (Sauer et al 2004), have provided population trend data that enables biologists and land managers to prioritize management decisions based on knowledge of population trends.

National initiatives such as the Partners in Flight (PIF) Landbird Conservation Plan (Rich et al. 2004) and the North American Bird Conservation Initiative (NABCI 2005) have provided a method by which interested parties can coordinate conservation activities. These initiatives have provided guidelines for priority species, population and habitat objectives and recommendations for conservation actions. State and federal agencies have implemented habitat improvement projects based on guidelines outlined in PIF and NABCI.

Conservation Recommendations

- Utilize GIS and land type associations to determine total area and distribution of available habitat. Modeling will enable SCDNR to prioritize land acquisition and habitat improvement projects.
- Partner with other land management agencies and make recommendations about habitat improvement projects that benefit early succession species.
- Expand the use of farm bill and other cost share programs to implement activities that integrate habitat objectives for early succession birds.
- Expand participation in the Landowner Incentive Program (LIP) to create or enhance habitat on private lands.
- Promote the use of Best Management Practices that support providing buffer zones and that

increase structural diversity (such as providing small clear cuts).

- Partner with appropriate agency to encourage prescribed burning activities on public and private lands.
- Work with international partners to identify problems on wintering grounds. Where feasible, provide financial incentives to conserve habitat.
- Continue to monitor populations of early succession birds through participation in the BBS.
- Initiate agency supported monitoring programs, such as PIF point counts.
- Expand monitoring programs to areas not adequately sampled.
- Monitor bird response to management activities both pre and post treatment.
- Continue to strengthen partnerships with regional and national initiatives such as the Atlantic Coast Joint Venture, Appalachian Mountains Bird Conservation Region (BCR), PIF and NABCI.
- Pursue opportunities for funding for land acquisition or management activities through partnerships with regional agencies and NGOs.
- Develop partnership with recreational bird watching organizations in the state.
- Research effects of bird strikes on migratory bird populations and partner with the communications industry to work toward solutions.

Measures of Success

The first measure of success will be to implement monitoring programs that will allow SCDNR to document population trends and avian response to management in the state. The next goal will be to determine population and habitat objectives for priority species. Finally, implementing the above mentioned recommendations to provide the appropriate quantity of habitat to support target populations will be important. The ultimate measure of success will be to halt population declines and, once determined, to support populations equivalent to those outlined in population objectives.

Forested Wetlands Bird Group

Acadian Flycatcher *Empidonax virescens*

Swainson's Warbler *Limnothlypis swainsonii*

Louisiana Waterthrush *Seiurus motacilla*

Kentucky Warbler *Oporornis formosus*

Rusty Blackbird *Euphagus carolinus*

Wood Duck *Aix sponsa*

Contributor: Craig Watson

Description

Taxonomy and Basic Descriptions

This group of birds represents four families; species in this group range in length from the small Kentucky warbler (13 cm or 5.1 inches) to the wood duck (54 cm or 21.2 inches). They are grouped together because they either nest or winter primarily in forested wetlands in South Carolina. The families represented are: Tyrannidae (flycatcher), Parulidae (warblers), Icteridae (blackbird) and Anatidae (wood duck).

The three warbler species are very similar in size, while the Acadian flycatcher is slightly larger and the rusty blackbird nearly twice the size of the smaller warblers. The three warblers range in length from around 13 to 15 cm (5.1 to 5.9 inches). However, they are quite different in appearance. Generally, the Kentucky warbler is yellow below and olive above, while the Louisiana waterthrush and Swainson's warbler are mostly brownish, with the Louisiana waterthrush having a streaked breast.

The Acadian flycatcher is a relatively large bird typically weighing 13.1 grams (0.46 ounces). This particular flycatcher has gray legs with green upperparts, a pale grayish to white throat and an olive band across the chest. The bird is yellow on the belly and under the tail. The Acadian flycatcher is similar to other *Empidonax* flycatchers, but is the only *Empidonax* found in South Carolina in the summer (Whitehead and Taylor 2002).

The Rusty blackbird is brown to black overall with a length of 23 to 25 cm (9.1 to 9.8 inches). Its bill is narrow and shorter than its head with a slightly rounded tail nearly as long as its wing. During breeding season the male bird gains a bluish-green gloss to its upper feathers (Avery 1995).

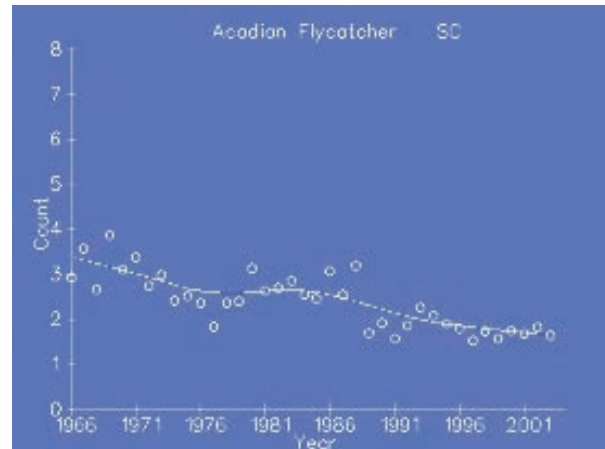
The wood duck is a small to medium-sized duck with males measuring 48 to 54 cm (18.9 to 21.2 inches) and females measuring 47 to 51 cm (18.5 to 20.0 inches). Both sexes have crested heads, broad wings and large, rectangular shaped tails. Sexual dimorphism exists in the coloring of the wood duck's plumage. Males have a sharply colored facial pattern with an iridescent green head, white throat and red eye. The male's crest is often green, purple and white and its breast is a solid burgundy. Females are brown to gray with a white throat and patch around the eye and a gray crest (Hepp and Bellrose 1995).

Status

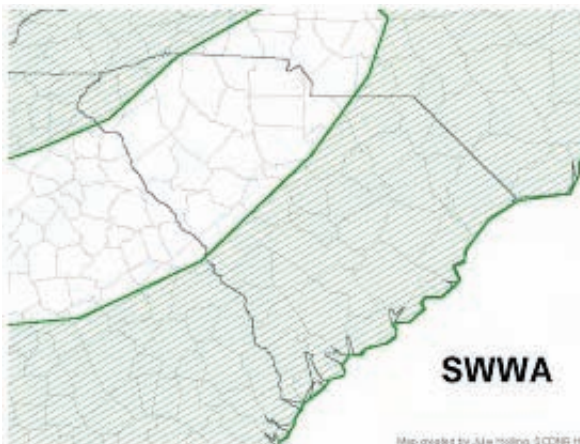
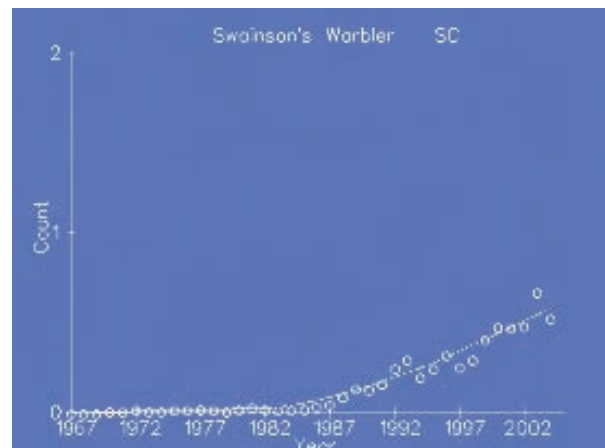
None of these species are officially recognized as threatened or endangered, but all are either experiencing declines or declines are suspected. The Kentucky warbler and the rusty blackbird are recognized by Partners in Flight (PIF) as watch list species that are widespread but have exhibited significant population declines due to multiple threats (Hunter and Demarest 2005; Rosenberg 2004). Swainson's warbler is also on the PIF watch list; due to the restricted distribution and low population size of this warbler, PIF recommends long-term planning and responsibility to maintain population levels at current sizes (Rich et al. 2004). Acadian flycatcher and Louisiana waterthrush are species of continental importance as stewardship species because their range only encompasses the eastern avifaunal biome (Rich et al. 2004). Long term planning and responsibility is recommended to maintain both the Acadian flycatcher and Louisiana waterthrush populations at current sizes. Wood ducks are recognized as species needing long-term planning and responsibility to insure that sustainable populations are maintained (Hunter and Demarest 2005). The South Carolina Governor's Wood Duck Nest Box Project has recorded declines in productivity since 1998 (Perry et al. 2005).

Population Distribution and Size

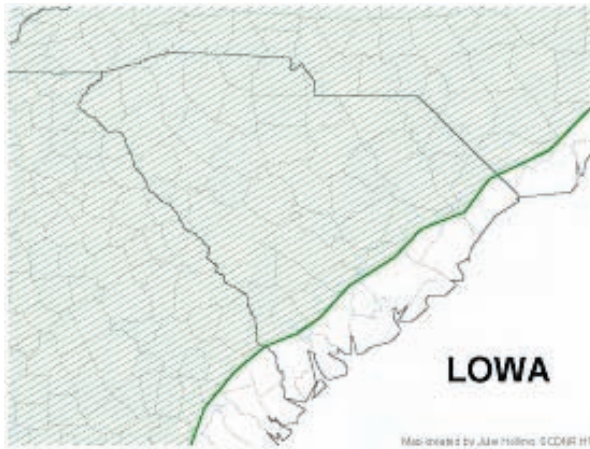
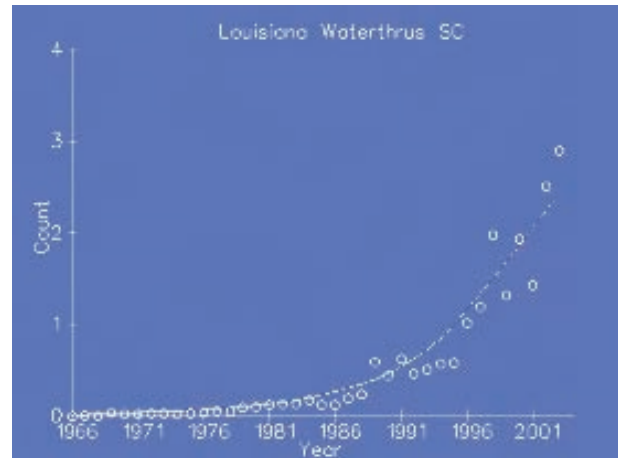
The Acadian flycatcher is a common breeder in the coastal plain and a fairly common breeder in the piedmont and mountain regions of the state (Cely 2003). The general trend over the past 38 years appears to be a steady decline of 1.8 percent (Sauer et al. 2005). The population estimate for Acadian Flycatcher in South Carolina is 180,000 (Rosenberg 2004).



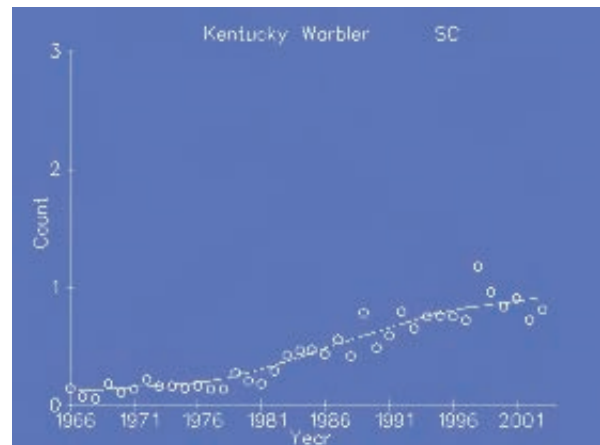
The Swainson's warbler is an uncommon breeder in South Carolina, inhabiting bottomlands in the coastal plain and rhododendron thickets in the mountains (Cely 2003). The 38-year trend graph indicates that the Swainson's warbler breeding populations in South Carolina appear to be increasing within the state (21.9 percent population change from 1966 to 2004) (Sauer et al. 2005). However, birds were only heard on four routes from 1966 to 2004 and the 95 percent confidence interval around the trend estimate is large (-5.6 ± 49.3) (Sauer et al. 2005). Currently, approximately 30 routes are currently being run in South Carolina. The current statewide population objective for Swainson's warbler is 3,600 (Rosenberg 2004).



The Louisiana waterthrush is a fairly common breeder in the mountains, less so in the piedmont, and is known as a migrant from the coastal plain (Cely 2003). Again, the trend in South Carolina appears to be increasing (22.9 percent from 1966 to 2004), but as with the Swainson's warbler, data can be confounded due to sampling errors (95 percent confidence interval is -2.9 ± 48.6 , detected on 11 routes from 1966 to 2004) (Sauer et al. 2005). The current state population estimate is 4,100 (Rosenberg 2004).

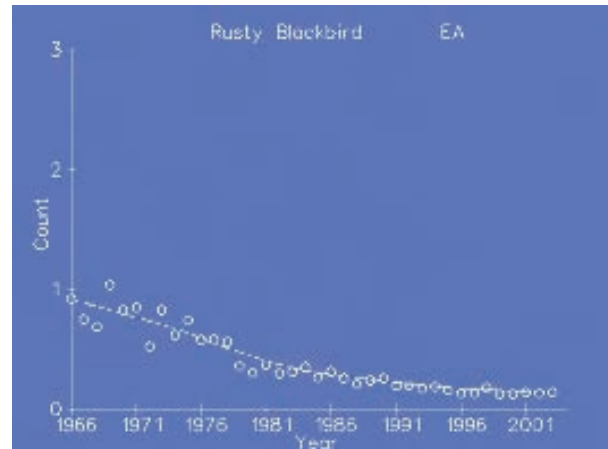


The Kentucky warbler is a common breeder found throughout South Carolina and breeding activity was confirmed in all but a few counties of the state (Cely 2003). Again, the trend in South Carolina appears to be increasing (6.7 percent from 1966 to 2004); yet survey-wide this species is declining (-1.0 population change from 1966 to 2004) (Sauer et al. 2004). The current state population estimate is 11,000 (Rosenberg 2004).



The Rusty blackbird is a fairly common winter visitor to the piedmont and coastal plain, with lesser numbers occurring in the mountains. The overall trend of this species appears to be a long-term steady decline (10.3 percent from 1966 to 2004) across the entire BBS survey area (Sauer et al. 2005). This rate of decline equates to a loss of over 95 percent of the population since the BBS was initiated in 1966. Rusty blackbirds were common on the Christmas Bird Count until

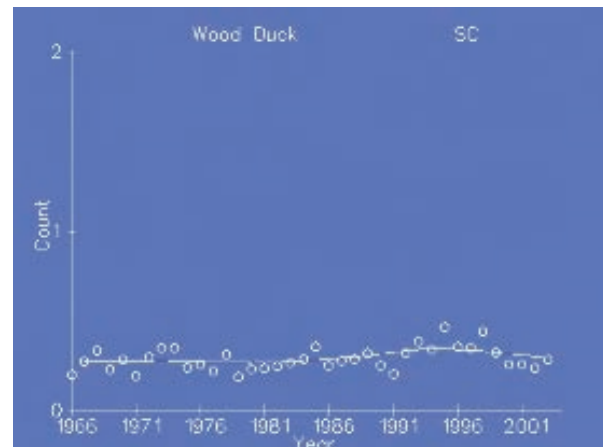
approximately 1970 when the species started a decline that has not ended (National Audubon 2002). It is speculated that the steep population declines observed in the 1970's is possibility due to blackbird control programs.



Population estimates and target 30-year population goals expressed as individual number of birds for South Carolina's priority forested wetland bird species (Rosenberg 2004).

Species	Population Estimate	Continental Objective	SE Coastal Plain BCR	Appalachian Mountain BCR	Piedmont BCR
Acadian Flycatcher	180,000	Maintain	130,000	860	51,000
Swainson's Warbler	3600	Maintain	3400		200
Louisiana Waterthrush	4100	Maintain	98	360	3600
Kentucky Warbler	11,000	Increase by 50%	12,000		5100
Rusty Blackbird	Unknown	Double	Unknown	Unknown	Unknown

The wood duck is a common breeder throughout most of South Carolina (Cely 2003). The BBS indicates a 1.0 rate of increase per year for this species in South Carolina and a 3.8 rate of increase per year for this species throughout the United States from 1966 to 2004 (Sauer et al. 2004).



Habitat and Natural Community Requirements

The Acadian flycatcher is found throughout all of South Carolina in deciduous forests near streams, in bottomland hardwoods and in cypress swamps (Christy 1942; Sprunt and Chamberlain 1970). Key habitat requirements are tall closed canopies with relatively open understories. It appears to require mostly undisturbed mature forests through most of its continental range (Whitehead and Taylor 2002). Flycatchers appear to be an area-sensitive species and require patches sized at least 38 to 120 ha (95 to 300 acres) (Whitehead and Taylor 2002). Nests are typically found in understory shrubs and smaller trees.

The Swainson's warbler is found as a breeder in the mountains and in the coastal plain, occupying very different habitats. In the mountains, this species is associated with an understory of rhododendron thickets under a closed canopy (Brown and Dickson 1994). In the coastal plain, this species is associated with dense understory thickets that occur in forest gaps and edges, primarily along bottomland forests. It appears to prefer damp forests with cane species (*Arundinaria* spp.) at a density of 26,000 to 50,000 stems/ha (Eddleman et al. 1980). In swamp forest habitats, the Swainson's will not typically use inundated areas but will forage along wetter zones (Brown and Dickson 1994). Healthy populations occur in forest tracts no less than 350 ha (865 acres) with nesting habitat no further than 200 m (219 yards) from water (Eddleman et al. 1980). Overstory canopy in suitable habitat would be dense (75 percent or more canopy closure) with trees at least 7.6 m (25 feet) tall. Percentage of ground cover in optimum habitat would be less than 34 percent (Eddleman et al. 1980).

The Louisiana waterthrush is a fairly common breeder in the upper coastal plain, piedmont, and mountains of South Carolina. It is associated with headwater riparian woodlands, rocky streams, swamps and thickets near streams (Robinson 1995). Nests are built on the ground in forested habitats, generally in the sides of stream banks (Hamel 1992). Essential habitat includes large (probably greater than 100 hectares) tracts of mature, deciduous and deciduous-mixed forest along ravines with running water; secondary habitat is characterized by mature, deciduous swamp forest with standing pools of water; generally a forest interior species (NatureServe 2005).

The Kentucky warbler prefers rich, moist deciduous forests, bottomland hardwoods and woods near streams (Hamel 1992). Generally, this species prefers habitat with a dense hardwood understory with well-developed ground cover (McDonald 1998). This species nests on the ground and the forest type, high number of streams and low white-tailed deer density were significant variables in territory selection (NatureServe 2005). Forested areas with an open canopy, dense understory and well-developed ground cover were preferred (NatureServe 2005).

The rusty blackbird is a wetland obligate for its entire life history. In South Carolina, the rusty blackbird is found wintering in swamps and bottomland hardwoods, sometimes associated with other species, but more often not. This species is primarily found in damp, wooded places, such as swamps and wet thickets but can be observed foraging in croplands and lawns with other blackbirds (Hamel 1992).

The wood duck is a common breeder throughout most of South Carolina, with most occurring in the piedmont and coastal plain (Cely 2003). Nest sites are always over or near a body of water usually in areas with abundant deciduous tree cover; nest sites include bottomland hardwoods, beaver ponds, shrub/scrub wetlands and emergent marshes (Hamel 1002). Wood ducks are a secondary cavity nesting species and readily utilize nest boxes (Hamel 1992).

Challenges

By far, the loss and fragmentation of forested wetland habitats are the most obvious challenges to successful conservation of these species. Urbanization, second home development, and intensive timber management primarily cause these losses and habitat alterations. Forested wetlands have been extensively drained and converted throughout the United States; most of the remaining intact-forested wetlands outside of the Mississippi Alluvial Valley occur in the southeastern United States. Conservation of these remaining forested wetlands should be a top priority for any conservation entity. In some cases, a fragmented landscape will not be able to support minimum viable populations. For example, it is estimated that the Swainson's warbler may require 6,000 acres of mature forested wetlands within a forest dominated landscape and 10,000 acres within an agriculturally-dominated landscape (Hunter et al. 2001).

Conservation Accomplishments

A primary objective of the South Atlantic Migratory Bird Initiative has been to delineate focus areas in which public lands serve as the anchors. These focus areas have been important in garnering North American waterfowl conservation act grants for significant land acquisition projects in the state (Watson and McWilliams 2005). Wood duck productivity has significantly benefited from the Governor's Wood Duck Project that was initiated in 1982.

Conservation Recommendations

- Continue conservation and restoration of forested wetland habitats including pocosins and Carolina bays. Care should be taken to increase block/patch sizes in order to decrease the amount of small, isolated forest patches across the landscape in order to sustain minimum viable populations.
- Promote conservation easements on private lands specifically developing and pursuing reforestation programs.
- Reduce the effects of habitat fragmentation by minimizing roads and power line right-of-ways, from bisecting contiguous forested tracts.
- Develop and implement forest management practices that produce large mature forests with tall closed canopies and high tree density with a mosaic of understories.
- Develop best management practices to balance the habitat needs of priority forested wetland species. Identify silvicultural activities that mimic the historical mosaic of young and old forests created by catastrophic events.
- Protect streamside management zones and identify optimal sizes.
- Restore canebrake habitats in the understory of forested wetlands.
- Preserve and improve water quality to ensure aquatic insect biomass and diversity.
- Conduct surveys and studies to collect information on the distribution and life history characteristics of rusty blackbirds in South Carolina.
- Follow green tree reservoir management guidelines to ensure timber survival and production of desired food.
- Continue to implement the wood duck nest box program on private and public lands.
- Develop and implement monitoring programs to better assess breeding and wintering bird

population sizes. Management and surveillance monitoring techniques will need to be assessed to quantify short and long-term population responses in order to answer specific monitoring questions. Measures will need to be developed to integrate state monitoring results into regional and national level databases in order to identify if continental goals are being reached.

- Continue use of the Breeding Bird Survey as a surveillance monitoring technique and consider modifications to make the survey more robust across the state.
- Continue use of the Christmas Bird Count to identify population trends of wintering species.

Measures of Success

Conserving and restoring forested wetland acreages throughout the state will greatly benefit a wide range of taxa. Collecting monitoring data based on habitat restoration and management objectives should result in measurable population responses at the local level. Other bird species that are likely to be positively affected by forested wetland management and restoration include: swallow-tailed kite (*Elanoides forficatus*), cerulean warbler (*Dendroica cerulea*), black-throated green warbler (*Dendroica virens*), prothonotary warbler (*Protonotaria citrea*), worm-eating warbler (*Helminthos vermivorus*), hooded warbler (*Wilsonia citrina*), white-eyed vireo (*Vireo griseus*), Carolina wren (*Thryothorus ludovicianus*), red-shouldered hawk (*Buteo lineatus*), red-bellied woodpecker (*Melanerpes erythrocephalus*), yellow-throated vireo (*Vireo flavifrons*), and ivory-billed woodpecker (*Campephilus principalis*) (Rich et al. 2004).

Grassland Birds

Common Ground-dove *Columbina passerina*

Barn Owl *Tyto alba*

Loggerhead Shrike *Lanius ludovicianus*

Field Sparrow *Spizella pusilla*

Grasshopper Sparrow *Ammodramus savannarum*

Eastern Meadowlark *Sturnella magna*

Contributors: John E. Cely and Laurel Moore Barnhill

Description

Taxonomy and Basic Description

The common ground-dove is one of the smallest doves, measuring roughly 17 cm (0.39 inches) and weighing 30 g (1.06 ounces) (Sibley 2000). Typically, this is a stocky dove with a scaled effect on its head and breast and a short tail. Bright chestnut primaries and wing linings are visible in flight (NGS 1999). Linnaeus first described the common ground-dove in 1758 (NatureServe 2005).

Scopoli, in 1769, first described the barn owl (NatureServe 2005). Barn owls are generally pale with dark eyes in a heart-shaped face, a rusty-brown back and wings and underparts that vary from white to cinnamon (NGS 1999). The average weight of barn owls is 460 g (16.2 ounces) and they are approximately 41 cm (16.1 inches) in height (Sibley 2000).

The loggerhead shrike is a predatory songbird with a strong, hooked bill used to kill and dismember prey (Sibley 2000). Its head and back are bluish-gray with underparts that are white with faint barring. A broad mask of black extends above the eye and thinly across the top of the

bill (NGS 1999). This species is approximately 23 cm (9.1 inches) long and weighs 48 g (1.69 ounces) (Sibley 2003). Linnaeus first described the loggerhead shrike in 1766.

The field sparrow is in the genus *Spizella*, which represents small, long-tailed sparrows. Field sparrows have a gray face with a reddish crown, a distinct whitish eye ring and a bright pink bill (NGS 1999). Overall size of field sparrows is 15 cm (5.9 inches) in length and 12.5 g (0.44 ounces) in weight (Sibley 2000). Wilson first described Field sparrows in 1810 (NatureServe 2005).

Gmelin first described the grasshopper sparrow in 1789 (NatureServe 2005). This ground dwelling species is very secretive with a buffy breast and sides, usually without streaking; a white eye-ring; and a dark crown with a pale central stripe (NGS 1999). Overall this sparrow is small and chunky with a length of 13 cm (5.1 inches) and weight of 13 g (0.46 ounces). Grasshopper sparrows have short tails, long bills and a flat head (Sibley 2000).

Linnaeus, in 1758, first described the eastern meadowlark (NatureServe 2005). This distinctive species has a black V-shaped breast band on yellow underparts and upperparts that are dark brown with dusky brown feather tips (NGS 1999). This species is 24 cm (9.45 inches) in length and 90 g (3.17 ounces) in weight (Sibley 2000).

Status

Birds that use grasslands have shown some of the steepest population declines of any bird group in North America (Price et al. 1995). Partners in Flight (PIF) considers the common-ground dove, the loggerhead shrike, the field sparrow, the grasshopper sparrow and the eastern meadowlark as species of high regional priority that are of moderate continental priority. Although these species are not one of the 100 species listed on PIF's Watch List, they are important to consider for conservation within the bird conservation region (Rosenberg 2004). The PIF Watch List is comprised of species that have multiple reasons for conservation concern across their entire range and species are selected according to the PIF scoring process (Rich et al. 2004).

The grasshopper sparrow merits special attention at the continental level as a stewardship species because its range only encompasses the eastern avifaunal biome (Rich et al. 2004). PIF indicates that this species exhibits high vulnerability. The objective of the stewardship species list is to attain the PIF goal of keeping common birds common. The entire population of grasshopper sparrows has declined by 50 percent or more over the past 30 years; therefore, management actions within the core of this species' range are needed to reverse these long-term declines.

At the physiographic regional scale, the common ground-dove, the loggerhead shrike, the field sparrow and the grasshopper sparrow have high area importance scores that translate to high to moderate priority levels of concern. At the state level, the common ground-dove is also listed as a threatened species in need of management.

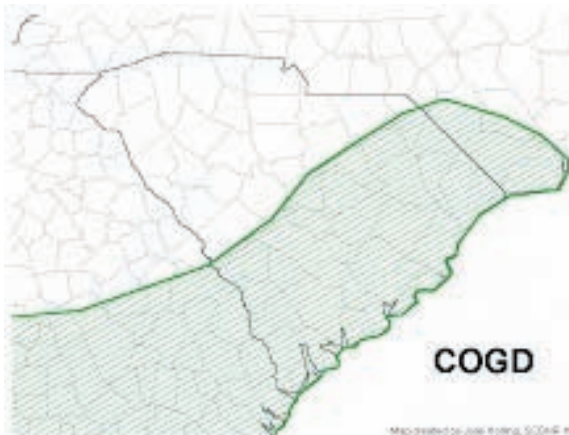
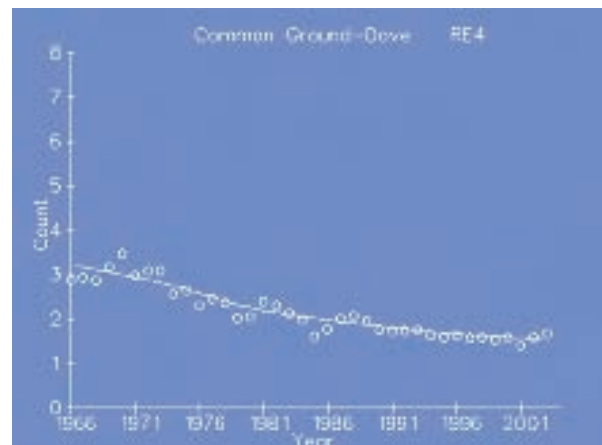
The barn owl is generally thought to be declining over much of its extensive range (Marti 1992). In the mid-1980s, this species was listed as endangered by six midwestern states and by nine other states as a species of special concern.

Population Distribution and Size

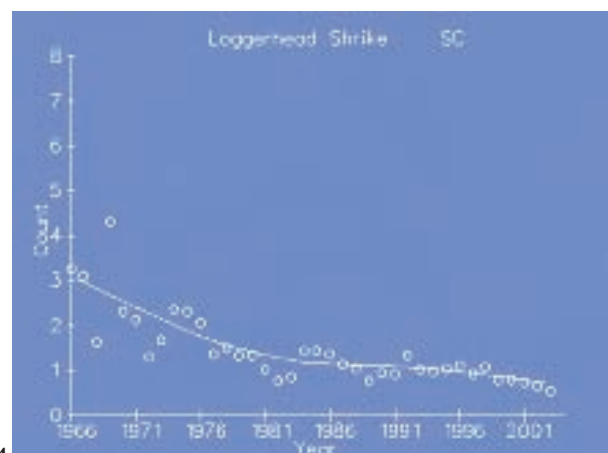
The barn owl is a permanent resident in South Carolina and is found throughout the state. Little information is available on the distribution or population size of barn owls in South Carolina (Cely 2003). However, breeding bird survey (BBS) trends indicate a 2.3 percent decline in population from 1966 to 2003 across the entire BBS survey area (Sauer et al. 2004).



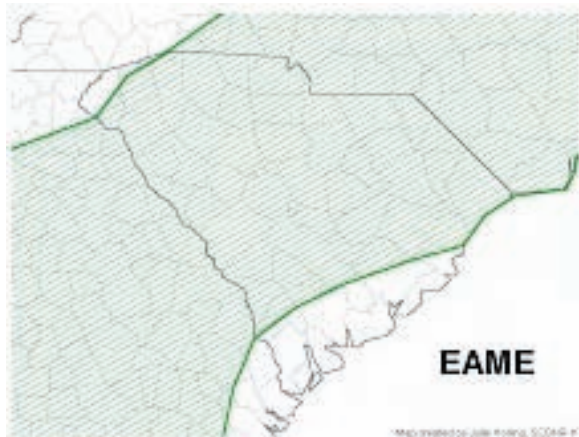
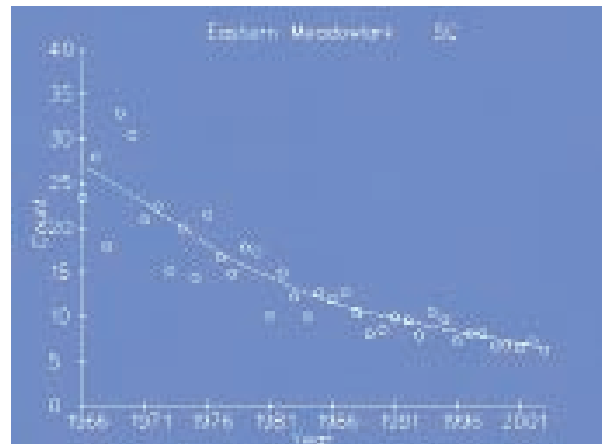
The common ground-dove is also a permanent state resident of South Carolina; most individuals are concentrated along the outer coastal plain. This bird is present in smaller numbers as far inland as the fall line within the sandhills ecoregion. Data for South Carolina indicates an increase of 1.5 percent in the population of common ground-doves from 1966 to 2003; however, long-term declines are indicated by the BBS for the southeast (Sauer et al. 2004). The current state population estimate for common ground-doves is 5,000 birds (Rosenberg 2004).



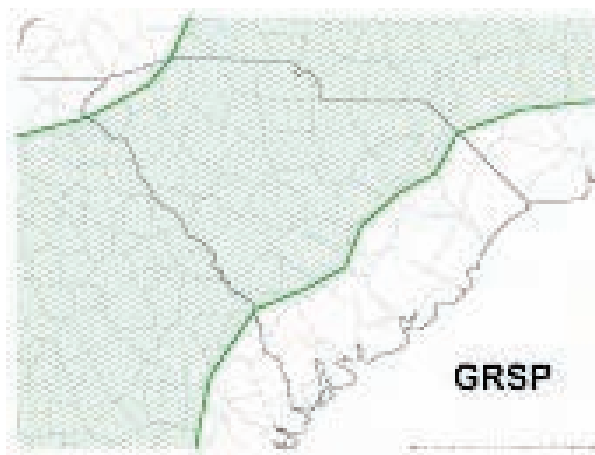
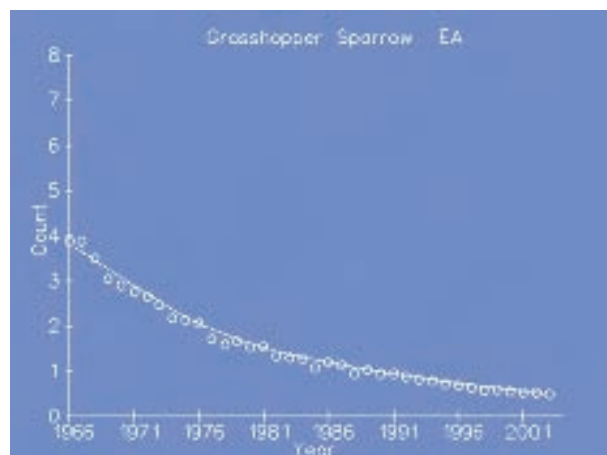
The loggerhead shrike is a permanent resident found statewide, except at higher elevations. It is most abundant in the coastal plain, especially within the farm belt of the inner coastal plain. BBS data has demonstrated declines over significant portions of its range in the east, especially within the piedmont bird conservation region. South Carolina has experienced an annual rate of decline of 3.6 percent from 1966 through 2003 (Sauer et al. 2004). To date, the current estimated state population is 46,500 individuals (Rosenberg 2004).



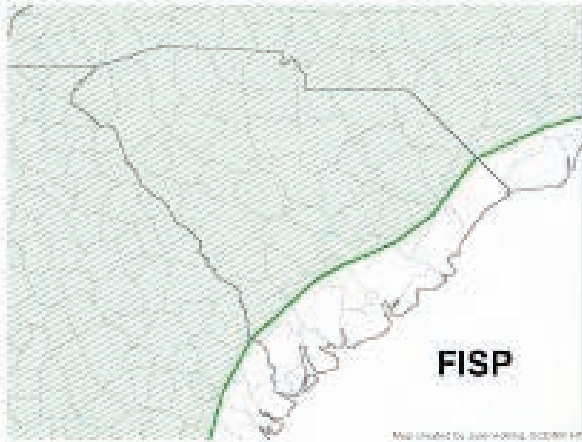
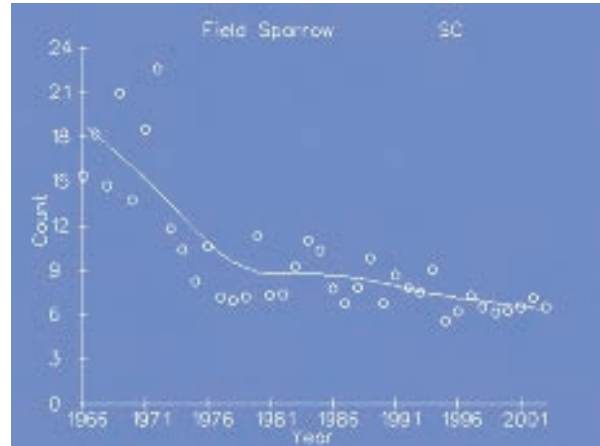
The eastern meadowlark is another permanent resident of South Carolina. Most individuals of this species are concentrated in the piedmont bird conservation region. The eastern meadowlark is also exhibiting long-term population declines throughout much of its range; in South Carolina, it has experienced a 3.2 percent annual rate of decrease from 1966 through 2003 (Sauer et al. 2004). The current estimated state population is 53,000 birds (Rosenberg 2004).



The grasshopper sparrow is a summer resident of South Carolina; it also winters in this state, but is present in smaller numbers than in the summer. Although breeding occurs throughout the piedmont and within the southeastern coastal plain, most breeding grasshopper sparrows are located in the orchard-pasture belt of the upper piedmont (Cely 2003). The current population within South Carolina is estimated at 62,000 birds (Rosenberg 2004). Long-term declines are evident across the state and entire BBS survey area (Sauer et al. 2004).



The field sparrow has a similar distribution to that of the grasshopper sparrow, but is more abundant in South Carolina. The current estimated population of field sparrows within the state is 209,000 birds (Rosenberg 2004). However, data from the BBS indicates a long-term annual decline of 1.6 percent in South Carolina for the period from 1966 through 2003 (Sauer et al. 2004).



Rosenberg (2004) has suggested population sizes and objectives in South Carolina for five of the six priority grassland species based upon continental level population estimates (see table below). Population targets are based on population size and trends and a historical baseline to compare current populations. For Watch List species, the objective is to increase populations to a historical baseline as recorded in the 1960's. For stewardship species, the objective is to increase or maintain populations to 1990s levels (Rich et al. 2004). No population goals are available for the barn owl due to inadequate monitoring techniques. Projected population goals are based on a 30-year period with a target to double populations that have experienced severe declines of 50 percent or more for the past 30 years. For species experiencing moderate declines, the goal is to increase the population by 50 percent in the next 30 years.

Species	Population Estimate	Continental Objective	SE Coastal Plain BCR	Appalachian Mountain BCR	Piedmont BCR
Common ground-dove	5000	increase by 50%	7,500	N/A	N/A
Loggerhead shrike	46,500	double	80,000	N/A	13,000
Grasshopper sparrow	62,100	double	12,000	2,600	110,000
Field sparrow	212,900	double	140,000	9,800	280,000
Eastern meadowlark	53,100	double	28,000	2,200	76,000

Population estimates and target 30-year population goals expressed as individual number of birds for South Carolina's priority grassland bird species (Rosenberg 2004).

Habitat and Natural Community Requirements

Common ground-doves are found at greatest densities within coastal scrub/dune fields. This bird feeds heavily on weed seeds and requires a mix of bare ground and grassy areas for foraging but favors sandy soil. Common ground-doves will nest on the ground; however, they more typically use shrubs or small trees along a woodland edge for nesting sites (Hamel 1992). These doves have also been seen nesting in the crowns of palmettos (*Sabal* spp.). Inner coastal plain habitats

utilized by ground doves consist of recent clearcuts, peach orchards and farmland (Hamel 1992).

The barn owl can be found in such disparate habitats as overgrown weedy urban lots, pastureland, fields and other open rural landscapes as well as in both fresh and salt marshes. This owl nests in outbuildings, grain silos, duck blinds and tree cavities. Barn owls have readily accepted nest boxes erected in coastal marshes (M. Spinks, SCDNR, pers. comm.) Barn owls feed at night and prey almost exclusively on rodents that are typically found in marshes and grasslands. Breeding occurs during all months of the year, but they peak from March to May (Hamel 1992).

Loggerhead shrikes use open lands consisting of expanses of short grass, old fields, orchards, grassy roadsides, cultivated fields and pasture. This bird nests in hedgerows, shrubs and trees, notably red cedar (*Juniperus virginiana*), but will also utilize loblolly pine (*Pinus taeda*) and live oak (*Quercus virginiana*). Nest trees and shrubs are typically in the open. Loggerhead shrikes hunt from power lines, exposed tree limbs, fence posts and other conspicuous perches. Thorn trees, barbed wire or other sharp objects are necessary within the habitat; the loggerhead shrike uses these to impale and cache prey. The loggerhead shrike feeds mainly on large insects and small rodents though it will, at times, take smaller birds.

Eastern meadowlarks create well-concealed nests on the ground in clumps of grass 0.6 m (1.97 feet) in height (Hamel 1992). Typically, this species nests and forages for insects or seeds in fields, orchards, pastures, roadsides and golf course roughs. Eastern meadowlarks may require landscapes dominated by agriculture and grasslands to maintain long-term population viability (Lanyon 1995)

The grasshopper sparrow favors grassy fields for nesting; it is less numerous in weedy fields, pastures and grain fields (Hamel 1992). Nest sites are usually found in vegetation approximately 0.3 m (0.98 feet) high (Hamel 1992). Grasshopper sparrow wintering habitat consists of broomsedge (*Andropogon* spp.) fields, other open fields and open pine savannas. The diet of this bird consists of primarily insects, but does include seeds.

The field sparrow is more tolerant of brush, hedgerows, briar tangles, plum thickets and thicker stands of grass and herbaceous material than the grasshopper sparrow. Field sparrow nests are typically placed on the ground, but shrubs and small trees will sometimes also be used. This species forages by gleaning seeds from the ground, but its diet also includes insects (Hamel 1992). Field sparrows benefit from management of grasslands and scrub/shrub habitats.

The following species are PIF species on the continental watchlist and/or of regional concern that will benefit from increased amounts of grassland habitat on the landscape: short-eared owl (*Asio flammeus*), eastern kingbird (*Tyrannus tyrannus*), Henslow's sparrow (*Ammodramus henslowii*), Le Conte's sparrow (*Ammodramus leconteii*), and dickcissel (*Spiza americana*).

Challenges

Vegetative succession and permanent loss of early successional habitat through urban development and intensified agriculture are primary factors resulting in the long-term population declines experienced by these six species (Lanyon 1995; Ehrlich 1992; Colvin 1985). Although habitat protection will assist in protecting these early-successional species, simply protecting habitat is not expected to increase populations of the birds included in the grassland guild. In order to increase populations, active management of early successional habitat, such as burning, grazing, mowing, disking, and other means to retard plant succession, must be emphasized. Currently, 90 percent of the property in South Carolina is privately owned; of this figure, small landowners own 68 percent.

In general, intensive agricultural practices may reduce habitat suitability for grassland bird species. Mowing and haying and the timing of these activities undoubtedly destroy many nests. The use of pesticides may result in lower insect and rodent availability, thereby reducing foraging opportunities for these birds. Also, in some cases, existing Farm Bill programs may create sinks for wildlife. For example, planting sod-farming grass can preclude nesting and foraging activities for these species, as well as northern bobwhite quail. Active management for early successional habitat is necessary to reverse population declines for grassland birds. The positive side of this problem is that early successional management is straightforward, can be accomplished in a short period compared to growing a 60-year old forest from seed, and the response time for grassland bird populations should be short. Monitoring and documenting the response of grassland birds to Farm Bill programs will allow for improving landowner recommendations (Hunter et al. 2001).

Barn owls have declined due to a loss and alteration of habitat, including older cavity trees used for nest sites and barns, silos and outbuildings associated with agriculture. Additionally, the lack of specific monitoring programs for barn owls has complicated determination of accurate population estimates and trends for this species (Hands et al. 1989). Barn owls will readily inhabit properly designed and placed nest boxes; an expanded nest box program, with adequate monitoring and follow-up, could benefit this species in areas with adequate foraging habitat but a shortage of nest sites.

The decline of common ground-doves could be due to several factors in addition to habitat alteration and loss, especially excess predation by cats, raccoons and other predators on developed barrier islands and inland habitats (NatureServe 2005). In some states, declines are also attributed to loss of birds due to misidentification during mourning dove (*Zenaida macroura*) hunting seasons (NatureServe 2005).

There are other, apparently less significant problems for grassland bird species. Birds are killed by flying into towers and windmills on wind farms. In a report reviewing studies reporting bird mortality at communication towers in the eastern portion of the U.S., 230 species of birds (184,797 individuals) were killed. Of these, 17.8 percent were warblers, 10 percent were sparrows, and 9.5 percent were waterfowl (Shire et al. 2000). Also, nest parasitism by brown-headed cowbirds is common; rates for this type of predation vary geographically. However, nest predation is a major cause of grassland bird population declines (NatureServe 2005; Carey et al. 1994). In some areas, roadsides may represent the best quality and highest quantity of nesting habitat, but the potential for vehicle collisions and invasion by exotic plant species may be high. For example, kudzu (*Pueraria lobata*) grows at an average rate of one foot per day (60 feet during a growing season) enveloping and eventually killing all vegetation in its path, thus destroying nest and foraging sites (MSU 2005).

Additionally, lack of survey and monitoring programs to supplement BBS and other existing programs can result in inaccurate population estimates and trends. A number of specific protocols need to be developed for individuals in this suite of species in order to adequately determine population declines. Additional monitoring efforts and coordination will increase the efficacy of management actions in the future (CBM 2004).

Conservation Accomplishments

The development and implementation of agricultural incentive programs with focused environmental benefits for wildlife have provided significant benefits to wildlife in the state and nation. In fiscal year 2004, NRCS and its partners invested 2.8 billion dollars in conservation

nationally (Knight 2005). Implementation of conservation and monitoring objectives developed for northern bobwhite quail (*Colinus virginianus*) will positively impact the suite of grassland species (Dimmick et al. 2002).

A number of contributions have occurred at the state and species level. A two-year study of loggerhead shrike habitat and nesting productivity was conducted in the coastal plain (Cely and Corontzes 1988). A one-season survey to determine locations of significant common ground-dove populations was conducted in the state (Cely and Glover 2000). The placement of barn owl nest boxes at several coastal SCDNR Wildlife Management Areas has provided nesting structures where limited (M. Spinks, pers. comm.).

Conservation Recommendations

- Research the possible creation of cost-share or incentive based programs to promote the retention of early-succesional habitats. Identify potential partners such as the Natural Resources Conservation Service to help assess the efficacy of such measures.
- Continue to participate in existing efforts to develop and implement agricultural incentives that are beneficial for wildlife. Integrate monitoring objectives and funding mechanisms to support such programs where appropriate. Also, continue to develop program delivery mechanisms.
- Develop partnerships and infrastructure to integrate bird conservation efforts into private land management activities. Pursue private and federal grant programs to implement management objectives.
- Develop a barn owl nest box program and identify potential partners to assist with implementation of that program.
- Establish loggerhead shrike posts in locations where perch sites are limited.
- In grassland bird habitat devoid of site-appropriate herbaceous species or with depauperate seed banks, establish seed sources through propagation from local sources.
- Prevent the spread of existing invasive and non-native grasses in wild areas, eliminating them, where possible.
- Acquire more complete information on the habitat needs of each grassland bird species to determine the best management guidelines. Promote the development and dissemination of best management practices for grassland species utilizing agricultural lands.
- Educate landowners about the use of seed mixtures that benefit wildlife in early succession habitats.
- Identify habitat requirements and dispersal rates for common ground-doves.
- Develop and implement monitoring programs to better assess breeding and wintering bird population sizes. Assess management and surveillance monitoring techniques to quantify short and long-term population responses. Develop measures to integrate state monitoring results into regional and national level databases.
- Continue using the Breeding Bird Survey as a surveillance monitoring technique and consider modifications to make the survey more robust across the state.
- Derive quantitative population-based habitat objectives for priority grassland birds and test assumptions (identify habitat-specific densities, limiting factors) in order to model habitat requirements necessary to meet population objectives.

- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels. Promote the development of a Piedmont bird conservation region initiative.
- Continue participation in Partner's In Flight, other bird initiatives, and North American Bird Conservation Initiative.
- Promote the participation of volunteers and employees to collect survey and monitoring data for grassland bird species.
- Reduce communication tower collisions.

Measures of Success

The landbirds featured here are high-priority representatives of this group for South Carolina and populations should respond positively to focused management practices. The recovery of priority species, primarily through habitat restoration and management, should benefit the many other lesser priority birds that also use grasslands. Monitoring programs with specific objectives should indicate if populations are responding to an increase in the quantity and quality of grassland habitat across the state.

Calculation of habitat objectives will indicate if population objectives determined at the continental level are attainable for the state, and if other or changes in objectives are necessary. In some cases, it may be unrealistic to achieve PIF continental population objectives due to significant and permanent habitat loss. In other cases, South Carolina will be a source for some populations and will contribute to attaining continental population goals.

Gray Kingbird

Tyrannus dominicensis

Contributors: Anna Huckabee Smith and Dennis Forsythe

Description

Taxonomy and Basic Description

The gray kingbird was first described by Gmelin in 1788. Since then, a subspecies, *T. D. dominicensis*, has been described. The gray kingbird is one of the flycatchers and eats insects and some fruits. It is approximately 23 cm (9 inches) in length and weighs 44 g (1.55 ounces). The upperparts are gray while the underside is white. A reddish crown patch is also present, though hard to detect. Cheeks and tail are gray. Unlike the eastern kingbird, a close relative that is more common in South Carolina, the gray kingbird's tail is forked and does not have a white terminal band (Sauer et al. 2000).

Status

The gray kingbird is a peripheral species in South Carolina and is not ranked in this state. It is, however, considered imperiled (S2) in Georgia and Alabama and vulnerable (S3) in Mississippi (NatureServe 2004). The global rank for the species is secure (G5) (NatureServe 2004), although it is a regional priority species in the southeast (C. Hunter, pers. comm.). Southeastern populations are locally migratory (NatureServe 2004) with the majority of the gray kingbird's range and population (90 percent) being in south Florida (Florida Keys) and the West Indies (Cely 2003; C. Hunter, pers. comm.). Florida's Breeding Bird Atlas states that the Florida population, though unranked, is stable at this time (Rowe 2003).

Population Distribution and Size

Sauer et al. (2000) asserts that the species used to breed along the South Carolina coast down to its present-day Florida range and west to Mississippi. The last published breeding record in South Carolina was on Sullivan's Island in 1893 (Cely 2003). Other sightings in fairly recent years include a pair seen on Fripp Island during the breeding season in May 1984 and a pair with a fledgling at Debidue Beach in Georgetown County in 1993 (Cely 2003). It is possible that some birds are breeding along the South Carolina coast as individuals have been seen periodically during the breeding season (Cely 2003).



Habitat and Natural Community Requirements

The gray kingbird is mostly found in the coastal zone in open habitats such as woodlands (hardwood and mixed), scrub-shrub wetlands and old-field situations (NatureServe 2004). In Florida, mangroves are also utilized (NatureServe 2004). The birds typically nest 1.2 to 3.7 m (4 to 12 feet) above the ground in oaks or mangroves, often overhanging water (Rowe 2003).

Challenges

The gray kingbird may be facing special challenges as many coastal habitats are being lost to development. However, it has been proposed that the species is adaptable to the urban landscape in its restrictive Florida range and may, therefore, be stable in areas where it is common (Rowe 2003). The gray kingbird is on South Carolina's priority species list because it needs more study in this state.

Conservation Accomplishments

There are no conservation accomplishments that specifically address the gray kingbird, as this species is marginal in terms of breeding in South Carolina (Post and Gauthreaux, Jr. 1989). It has been considered to be more of a visitor than a true species of concern here in South Carolina (C. Hunter, pers. comm.). However, several coastal Heritage Preserves are most likely providing habitat for this species in South Carolina. Some of these include Capers Island Heritage Preserve, Old Island Heritage Preserve and St. Helena Sound Heritage Preserve. In a recent study of hammock islands in South Carolina, no gray kingbirds were detected (McCord et al. 2004).

Conservation Recommendations

- Conduct constant effort surveys in appropriate habitats along coastal South Carolina to determine if any populations of gray kingbirds are nesting in the state.
- Enlist the cooperation of local birders in reporting breeding for the gray kingbird.
- Determine species habitat requirements and initiate management regimes to help bolster gray kingbird populations.
- Determine to what extent gray kingbird life history data established by Smith and Jackson (2002) should prove useful for South Carolina populations.
- Monitor any effects of habitat conversions on existing populations of gray kingbirds.

Measures of Success

As the aforementioned surveys yield results on presence/absence data, life history traits, and habitat requirements, conservation actions can be further developed.

Marsh Birds

American Bittern *Botaurus lentiginosus*

American Coot *Fulica americana* – breeding populations

Black Rail *Laterallus jamaicensis*

Common (Wilson's) Snipe *Gallinago gallinago*

King Rail *Rallus elegans*

Least Bittern *Ixobrychus exilis*

Pied-billed Grebe *Podilymbus podiceps* – breeding populations

Purple Gallinule *Porphyryla martinica*

Yellow Rail *Coturnicops noveboracensis*

Contributor: John E. Cely

Description

Taxonomy and Basic Descriptions

The common snipe was formerly named Wilson's snipe. The other members of this group have not undergone name changes in recent years.

The members of the marsh bird group vary widely in appearance and size. The rails and bitterns have long, slender beaks and stilt-like legs for wading while the coot and grebe have shorter legs with webbed feet for paddling. Sizes for the species vary from the large American bittern at 58 cm (23 inches) to the small black rail at 11 cm (4.5 inches). The most colorful of the group is the purple gallinule. The male has plumage in shades of green, purple and blue with bright yellow feet and long toes (Sauer et al. 2000).

Status

None of these species are officially recognized as threatened or endangered, but all are experiencing documented or suspected declines. Partners in Flight (PIF) list all three rails as of continental conservation concern (Rich et al 2004) and the king rail is listed as endangered by the Canadian Wildlife Service (E. Ciuizio, KDFWR, pers. comm.). The black rail is also on the SCDNR "special concern" list. Both bittern species are listed as of regional concern by PIF, while the American bittern is listed as a species of "special concern" by SCDNR. Breeding populations of the pied-billed grebe and the American coot are also of regional concern according to PIF. The common snipe is a species of continental conservation concern under PIF and the United States Shorebird Conservation Plan (Brown et al 2001).

Population Distribution and Size

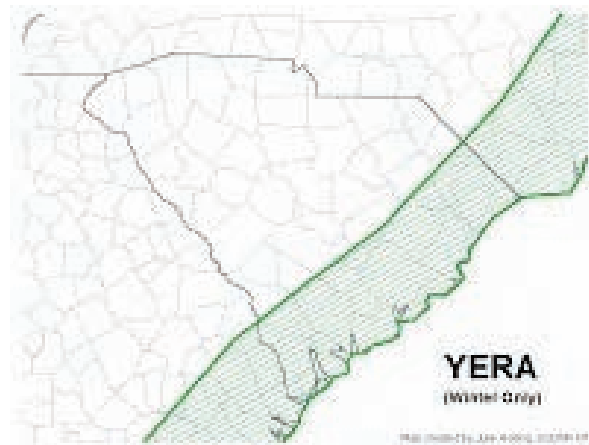
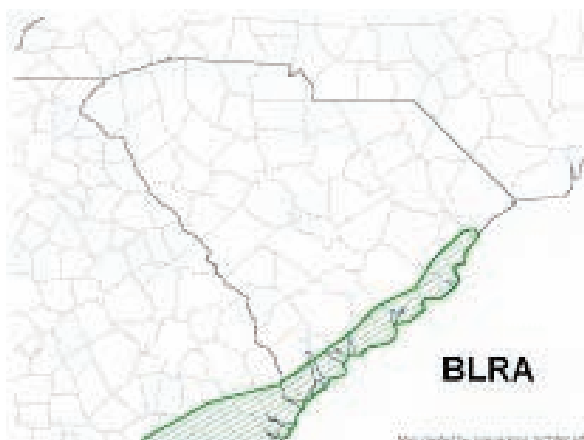
The following table was compiled by Chuck Hunter (USFWS) and summarizes the estimated continental population and trend for each species in this group. These are extrapolated estimates from Breeding Bird Survey data.

Species	Estimated Continental Population & Trend	Residency Status in South Carolina
Yellow Rail	10,000 to 25,000 individuals, stable or unknown trend	Winter
Black Rail	5,000 to 50,000 individuals, likely declining but unknown to what extent	Permanent
King Rail	60,000 to 100,000 individuals, steep declines	Permanent
Least Bittern	<150,000 individuals - (?)	Summer
American Bittern	~3 million individuals -	Winter
Pied-billed Grebe	385,000 individuals ?	Permanent but rare breeder
American Coot	6 million individuals +	Permanent but rare breeder
Purple Gallinule	<500,000 (all of Western Hemisphere) -	Summer
Wilson's Snipe	<3 million individuals, -	Winter

(?) = unknown trend; (+) = increasing; (-) = decreasing

Habitat and Natural Community Requirements

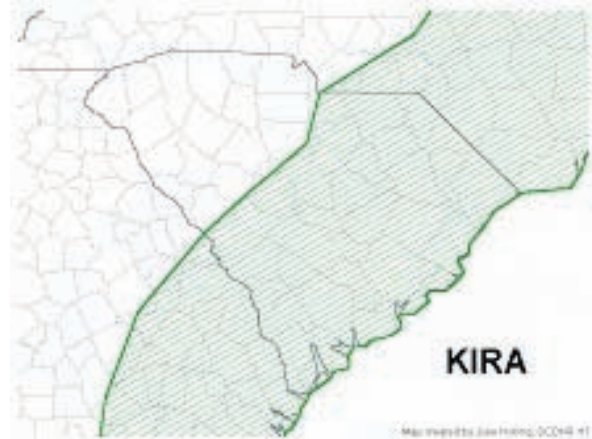
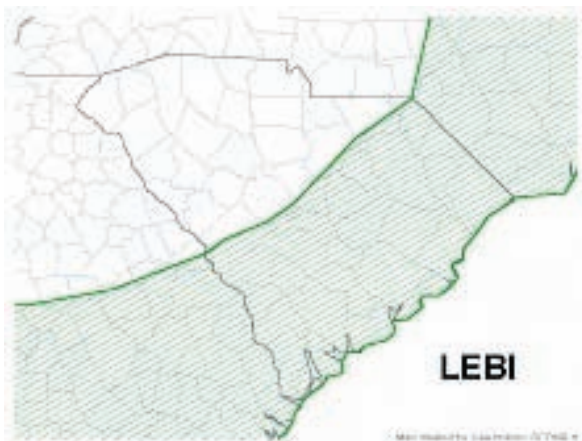
The yellow rail uses freshwater marsh, specifically “damp” marsh, “wet” or low-lying broom sedge fields and pastures, grassy Carolina bays, damp grassy power line right-of-ways and ditch banks. Due to the bird’s small size, it does not use deep-water marshes and impoundments. It is sometimes found in recent clear cuts with scattered puddles of standing water and bunched grasses. Tall or moderate-height grasses seem important for cover. Some woody trees and shrubs are acceptable features in the habitat, but based on personal observations at a yellow rail site in



lower Richland County, South Carolina over an 8 to 9 year period, succession to woody shrubs and trees seemed detrimental. Fire, mowing and other successional retardants are probably needed to maintain suitable habitat conditions. Very little is known about the yellow rail’s distribution and habitat requirements in South Carolina.

Freshwater and brackish marshes of the coastal zone are the habitats of the black rail. It is often found in black-needle rush marshes (*Juncus roemerianus*) and “high

marsh” (infrequently flooded) on the edges of waterfowl impoundments and salt marshes. Like yellow rails, black rails do not use marsh with significant amounts of standing water. Succession to woody plants is probably detrimental to this species. Where calling birds are located, breeding is presumed to occur, but there is only one confirmed nesting record from 1903. Calling locations are spotty, with Bear Island WMA in Colleton County supporting the most significant population located to date. Much more information is needed about its distribution and habitat requirements in the state.



The king rail is primarily found in the coastal zone, but can be found in the coastal plain and sandhills ecoregions. It was formerly found statewide, but few, if any, piedmont locations are currently known (Cely et al. 1993). Considered a freshwater counterpart to the widely distributed clapper rail of coastal salt marshes, king rails have declined to an alarming extent throughout much of the south. Obvious reasons for declines are not apparent, at least in the southeast, as adequate habitats, like cattail marshes and other freshwater marshes with emergent vegetation, are widely available. In the piedmont, the notable increase in beaver populations in the past 35 years should have created king rail habitat.

Similar in distribution and habitat use as the king rail, the least bittern differs in that it has never been known historically to occur as a breeder in the piedmont. It is most abundant in the coastal zone. Habitat requirements may be less exacting than the king rail, as the least bittern is more abundant. Freshwater emergent marsh is used,



especially if cattail is present. In addition, pond and lake margins with emergent vegetation and waterfowl impoundments are frequented. As with most members of the Ardeidae family, the least bittern may need deeper water than king rails for nesting security purposes.

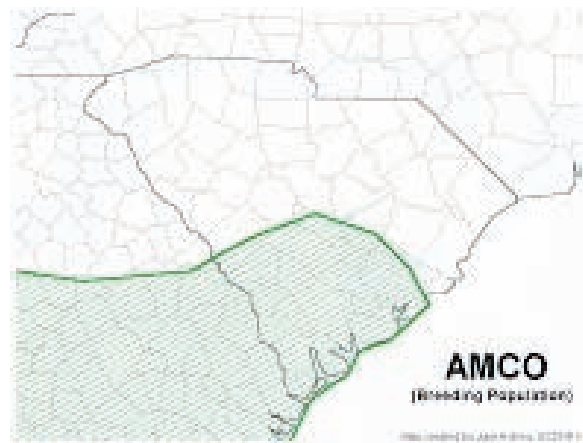


Freshwater tall emergent marsh is used by American bitterns as refuge. Declines may be related to habitat loss on the breeding grounds as more than adequate habitat seems available in South Carolina. The American bittern is distributed statewide but is probably more abundant on the Outer Coastal Plain.

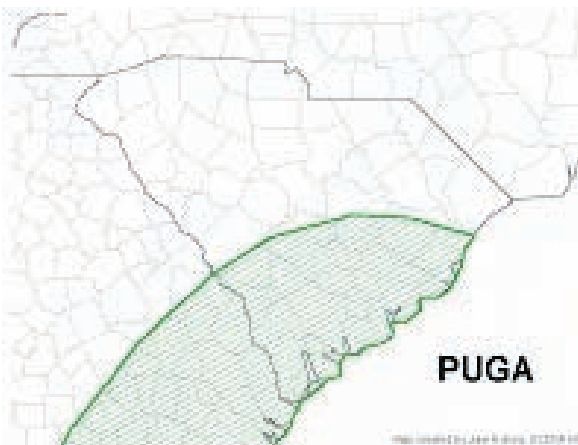
The pied-billed grebe is a fairly common breeder in deep-water impoundments with tall emergent vegetation, in Carolina bays, and other marshes in the coastal zone. In the coastal plain, it is localized, while in the piedmont, it is

rare. Key requirements seem to be deeper water for nest protection and escape along with tall emergent vegetation for cover.

There have been less than five documented breeding records for the American coot, from the inner coastal plain and outer coastal plain. This species is abundant as a statewide winter resident, more so in the coastal plain, on ponds, lakes, waterfowl impoundments and other deep-water habitats where submerged aquatic vegetation is available for food. Breeding habitat is poorly known in the state, but apparently similar to that of the pied-billed grebe.



The purple gallinule is closely associated with ponds and impoundments with thick mats of lily pads and other floating emergents. It is found primarily in the coastal zone from the Santee River southward. South Carolina could have the northern-most population on the Atlantic Coast since it is rare, if not extirpated, in North Carolina.



A common to fairly common winter resident only, the common snipe probably is more widespread in the coastal plain. It utilizes wet bare ground, bare agriculture fields with standing water, recently plowed fields, occasionally short grass fields and sod farms for foraging habitat.



Challenges

Loss of wetland habitat is the most obvious problem, but for some species adequate habitat seems available in South Carolina. Declines may be related to other reasons, as yet undefined, such as pollutants and/or predators. Suppression of natural disturbance regimes causes habitat loss for this group because plant succession reduces the suitability of marsh habitat.

A marsh bird survey conducted by the SCDNR (Cely et al.1993) noted that the majority of recorded marsh birds were associated with coastal waterfowl impoundments and managed wetlands. The future of these species in South Carolina could, therefore, be tied to active waterfowl management programs in the state and any threats to those habitats managed for waterfowl. As most marsh bird management is incidental to waterfowl management, more information is needed on marsh bird management needs. Little is also known about the basic nesting biology of the eight species in this guild that breed in South Carolina.

A critical need is adequate monitoring, both to determine presence and absence and to evaluate population trends; monitoring efforts are especially needed for the three secretive rail species.

Conservation Accomplishments

The continued preservation of wetland habitats including freshwater and saltwater marshes is beneficial to these species. Preservation of areas such as the ACE Basin and Bonneau Ferry (recently purchased by the SCDNR and now a Wildlife Management Area) has provided excellent resources for these species. Some of the best habitats for these species include existing waterfowl impoundments along the coast. Additionally, Conway (2004) has initiated standardized monitoring protocols for these species.

Conservation Recommendations

- Protect and manage wetlands. This includes retarding plant succession through burning, disking, mowing and other measures that restore natural disturbance regimes. This can be accomplished, in part, by increasing the utilization of federal incentive programs that compensate private land owners for wetland restoration activities and practices that reduce erosion and increase water quality.
- Research basic life history and management needs for the species in this guild in South Carolina's wetland habitats.
- Investigate the basic nesting biology of the eight species of this guild that breed in South Carolina.
- Survey appropriate habitat to gather distributional data for these species.
- Establish a monitoring initiative to evaluate population trends for this species.

Measures of Success

The first measure of success would be to implement long-term population monitoring studies, which would yield information about distribution, population status and trends for this group. The next step is to increase quantity and quality of habitat by implementing the above mentioned conservation recommendations. The ultimate measure of success is to document stable population trends for declining species and to increase populations for species in which research suggest it is warranted.

Migratory Shorebird Guild

Piping Plover *Charadrius melodus*

Semipalmated Plover *Charadrius semipalmatus*

Black-bellied Plover *Pluvialis squatarola*

American Golden Plover *Pluvialis dominica*

Whimbrel *Numenius phaeopus*

Long-billed Curlew *Numenius americanus*

Greater Yellowlegs *Tringa melanoleuca*

Lesser Yellowlegs *Tringa flavipes*

Solitary Sandpiper *Tringa solitaria*

Spotted Sandpiper *Actitis macularia*

Upland Sandpiper *Bartramia longicauda*

Semipalmated Sandpiper *Calidris pusilla*

Western Sandpiper *Calidris mauri*

Dunlin *Calidris alpina*

Sanderling *Calidris alba*

Red Knot *Calidris canutus*

Marbled Godwit *Limosa fedoa*

Buff-breasted Sandpiper *Tryngites subruficollis*

White-rumped Sandpiper *Calidris fuscicollis*

Pectoral Sandpiper *Calidris melanotos*

Purple Sandpiper *Calidris maritima*

Stilt Sandpiper *Calidris himantopus*

American Avocet *Recurvirostra Americana*

Least Sandpiper *Calidris minutilla*

Short-billed Dowitcher *Limnodromus griseus*

Long-billed Dowitcher *Limnodromus scolopaceus*

Contributors: Felicia Sanders and Thomas M.

Murphy

Description

Taxonomy and Basic Description

The migratory shorebird guild is composed of birds in the Charadrii suborder. Migrants in South Carolina represent three families: Scolopacidae (sandpipers), Charadriidae (plovers) and Recurvirostridae (avocets). Sandpipers are the most diverse family of shorebirds. Their tactile foraging strategy encompasses probing in soft mud or sand for invertebrates. Plovers are medium size birds, with relatively short, thick bills and employ a distinctive foraging strategy. They stand, looking for prey and then run to feed on detected invertebrates. Avocets are large shorebirds with long recurved bills and partial webbing between the toes. They feed employing both tactile and visual methods.

Shorebirds are characterized by long legs for wading and wings designed for quick flight and transcontinental migrations. Migrations can span continents; for example, red knots migrate from the Canadian arctic to the southern tip of South America. Less frequently, shorebirds may migrate from the northeastern to southeastern U.S., as is the case for the piping plover. Migratory shorebirds in South Carolina may be transient birds on a northbound flight in the spring, a southbound flight in the fall, or wintering birds. Plumage can be strikingly different between summer and winter. Although nesting habitat includes inland tundra and prairies, during the non-breeding season, they forage and roost in mixed species flocks primarily on the coast. Thus, they are aptly named shorebirds.

Status

Although long-term monitoring is absent, surveys of migrant shorebirds in the last three decades indicate most shorebirds are in serious decline (Manomet 2004). Although many shorebird species are in need of protection afforded by federal listing, piping plovers are the only listed shorebird in South Carolina; this species is considered threatened both in the state and federally. The U.S. Shorebird Conservation Plan (<http://shorebirdplan.fws.gov>) combines six categories to classify the conservation status of declining shorebirds to prioritize conservation efforts. Classifications range from “highly imperiled” to “low concern” (U.S. Fish and Wildlife Service 2004a; U.S. Fish and Wildlife Service 2004b). For the purposes of the Plan, however, those in the “low concern” category are still considered a priority since the group as a whole faces the same basic threats.

Highly Imperiled	High Concern	Moderate Concern	Lower Concern
	American golden plover	Black-bellied plover	
	Whimbrel	American avocet	Semipalmated plover
piping plover	Marbled godwit	Greater yellowlegs	Spotted sandpiper
long-billed curlew	Ruddy turnstone	Lesser yellowlegs	White-rumped sandpiper
red knot	Sanderling	Dunlin	Pectoral sandpiper
buff-breasted sandpiper	Solitary sandpiper	Semipalmated sandpiper	Long-billed dowitcher
	Upland sandpiper	Least sandpiper	
	West sandpiper	Purple sandpiper	
	Short-billed dowitcher	Stilt sandpiper	

Conservation status of high priority migratory shorebird species found in South Carolina (U.S. Fish and Wildlife Service 2004a).

Population Distribution and Size

Population sizes of most species are not known because shorebird migration can span continents and breeding grounds are mostly inaccessible arctic and sub-arctic habitats. Censuses at stopover areas are useful for estimating minimum population size. Most migrant species are present year round but are less abundant during short arctic summers. Spring migration along the Atlantic coast is from March to May and fall migration is from July to October (Helmers 1992). Peak shorebird from Cape Romain National Wildlife Refuge (CRNWR) to Dewees Inlet (the Cape Romain Region), occurred in late March while minimum counts were in late June (Dodd and Spinks 2001).

In 1974, Manomet Center for Conservation Sciences (<http://www.manomet.org>) coordinated International Shorebird Surveys (ISS) to monitor shorebird numbers at important stopover sites. Presently, this program is the only statewide shorebird monitoring program in South Carolina. Eleven sites are surveyed in South Carolina: Huntington Beach State Park, Yawkey Wildlife Center, Cape Romain NWR, Pitt Street Bridge, Folly Island, Kiawah Island, ACE Basin NWR, Bear Island Wildlife Management Area (WMA), Hunting Island State Park, Harbor Island, Savannah River Dredge Spoil Site, and Savannah River NWR. Surveys are conducted during fall and/or spring migrations by state and federal employees and volunteers. Data from these surveys are used to identify important areas to individual species, important habitat types and population trends (Manomet 2004).

Surveys of the Cape Romain Region, in comparison with other ISS, indicate this region is the most important area in South Carolina for shorebirds (Sprunt and Chamberlain 1970; Marsh and Wilkinson 1991; Dodd and Spinks 2001; Manomet 2004). The Western Hemisphere Shorebird Reserve Network (<http://www.manomet.org/WHSRN/>) identified essential migratory sites for the western hemisphere also using ISS data. These “Hemispheric Sites” host over 500,000 shorebirds annually, or 30 percent of a species flyway population. Cape Romain NWR is one of only 15 “Hemispheric Sites” identified in North and South America (Harrington et al. 1989; Manomet 2004).

Piping plovers nest in more southern latitudes; thus, an estimate of breeding adults is possible (5,500 breeding adults throughout the species range). The number of wintering piping plovers in South Carolina is approximately 80 individuals. This is greater than one percent of the estimated population (Ferland and Haig 2002).

Statewide surveys of marbled godwits are possible because they are uncommon yet distinctive shorebirds roosting together in a few sites in South Carolina. Statewide surveys by SCDNR in December 2002 counted 345 marbled godwits. Surveys in the Cape Romain Region in December 1988 were consistently over 500 birds (Marsh and Wilkinson 1991), suggesting this species is declining in South Carolina.

Habitat and Natural Community Requirements

Shorebirds roost and forage in coastal wetland habitats as well as inland. They feed on invertebrates found in mudflats, sparsely vegetated shallow water, beaches and oyster reefs. They also regularly feed on horseshoe crab eggs in the spring. Additionally, the purple sandpiper uses rocky intertidal habitats, such as jetties. Different bill lengths and feeding strategies allow mixed species flocks to forage in the same area while exploiting different food resources. Along the coast, tides influence both diurnal and nocturnal foraging. Foraging activity is focused around the time of low tide. At high tide when foraging grounds are covered, birds roost in flocks on high shell rakes, beaches, estuarine islands and, occasionally, docks. Shorebirds may require different habitats for daytime and nighttime roosting. Roosting sites may contain thousands of shorebirds. Dunlin, sanderlings, red knots, small sandpipers and plovers primarily use beaches. Short-billed dowitchers and marbled godwits are found on oyster reefs and docks. Greater yellowlegs, spotted sandpipers and ruddy turnstones use a variety of habitats (Dodd and Spinks 2001).

South Carolina contains many managed coastal wetlands (285.1 km² or 110.1 mi.²) that were historically used for rice production; these areas are currently managed for waterfowl. Managing for spring shorebird migrations requires specific manipulation of water levels. Shallow water can be periodically maintained in wetlands during August to October for fall shorebird migration (Williams et al. 2002). Management of wetlands for shorebirds and waterfowl provides supplemental habitat that may be preferred to natural mudflats (Weber and Haig 1996).

Challenges

Members of this guild share both roosting and foraging sites and are usually impacted by the same factors. Shorebirds are especially vulnerable to habitat degradation because they congregate in large flocks at key stopover sites to replenish fat during long migrations (Myers et al. 1987)

Because of the complicated life history associated with birds of this guild, there are many challenges in conserving these species. Disturbance by humans and boat traffic at foraging areas reduces feeding efficiency, thereby reducing the fat available for migration or winter survival. Disturbance at roosting sites results in an expenditure of energy each time the birds are flushed and may have a cumulative effect of depleting fat reserves, particularly at key stopover areas. There has also been a decline in invertebrate available (for foraging) due to beach renourishment. Over harvests of horseshoe crabs for pharmaceutical use may also impact available forage. Finally, oil spills that degrade marine environments can have potentially major impacts on migrating shorebirds, both by disrupting feeding patterns and by leading to the direct mortality of food sources.

Conservation Accomplishments

The SCDNR coordinated or conducted several surveys, including a coast-wide survey of marbled godwits and large shorebird roosts. SCDNR coordinated surveys in South Carolina as part of the international piping plover surveys (Ferland and Haig 2002). Additionally, SCDNR has conducted year-round shorebird surveys in the Cape Romain Region (Dodd and Spinks 2001).

Conservation Recommendations

- Conduct statewide surveys of large shorebird concentrations and marbled godwit roost sites in order to document important areas or habitats and document annual variability.
- Participate in piping plover surveys and color band resighting.
- Participate in International Shorebird Surveys created and sponsored by Manomet Center for Conservation Sciences.
- Reduce disturbance at foraging and roosting areas by educating the public as to the effects of disturbance and the status of shorebirds.
- Work with government and private land managers to manage important shorebird roost sites.
- Help private landowners manage wetlands efficiently. Brochures and technical advice from trained professionals may be necessary.
- Continue cooperative efforts with the US Fish and Wildlife Service to census and manage important shorebird roosting and foraging sites within Cape Romain National Wildlife Refuge.
- Disseminate information on and encourage use of integrated management of wetlands typically managed solely for waterfowl.
- Develop web site with information on the status, management and natural history of shorebirds in South Carolina.
- Participate in Cape Romain NWR biological review to encourage closure of important shorebird stopover sites.

Measures of Success

This guild of birds is subject to rapid shifts in distribution and abundance and will require adaptive management to respond to these changes. Management priorities may shift if the severity of species' declines is further documented.

Mountain Coniferous Forest Guild

Red-breasted Nuthatch *Sitta canadensis*

Golden-crowned Kinglet *Regulus satrapa*

Red Crossbill *Loxia curvirostra*

Contributor: Ben Thatcher

Description

Taxonomy and Basic Description

The mountain coniferous forest guild includes three widely distributed species that are primarily associated with mature spruce-fir-northern hardwood forests. The three members of this guild are songbirds (Order: Passeriformes) representing three families: Sittidae (nuthatches), Regulidae (kinglets) and Fringillidae (crossbills). All three species are assumed to have distinct high elevation southern Appalachian Mountain populations.

Red-breasted nuthatches are small, weighing approximately 10 grams (0.35 ounces) and

distinguished by a black eyeline, white eyebrow stripe and reddish underparts. Of note behaviorally, the red-breasted nuthatch tends to climb down tree trunks headfirst.

Golden-crowned kinglets are distinguished by their small size of 6 grams (0.21 ounces) and their yellow and orange crown patch that is bordered by black. Orange is absent in females.

Red crossbills weigh 23 to 45 grams (0.81 to 1.58 ounces), lack wingbars and have distinctive crossed mandibles.

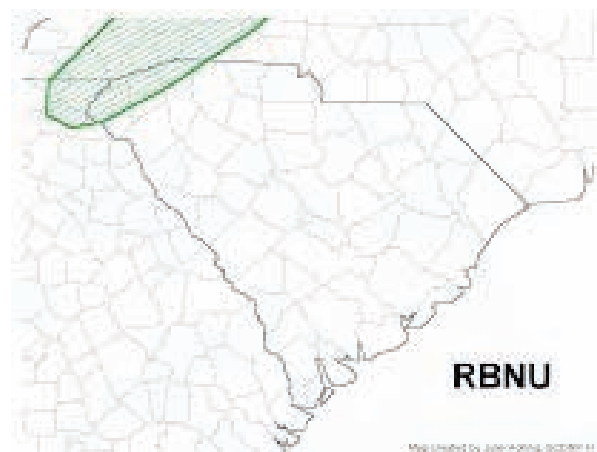
Status

All of these species are protected under the Migratory Bird Treaty Act; however, neither the red-breasted nuthatch nor the golden-crowned kinglet receives special federal status. The southern Appalachian populations of the red crossbill are a federal species of conservation concern (USFWS 2002). Partners in Flight (PIF) has listed the southern Appalachian populations of these species in the highest priority category: Crisis Recovery (extremely vulnerable) (Hunter et al. 1999). None of these species are listed on the South Carolina Rare, Threatened & Endangered Species Inventory.

Regionally, southern Appalachian populations of the red crossbill are categorized as significantly rare on the North Carolina Natural Heritage Program List of Rare Animals. Breeding populations are described as “extremely rare and critically imperiled in the state...” in Tennessee (author 2004). The golden-crowned kinglet and the red-breasted nuthatch are included on the North Carolina Natural Heritage Program Animal Watchlist.

Population Distribution and Size

Global estimates of population size are roughly 18 million red-breasted nuthatches, 34 million golden-crowned kinglets and 15 million red crossbills (Rich et al. 2004). Between 1966 and 2002, the red-breasted nuthatch population increased significantly by 1.5 percent annually throughout their range. The golden-crowned kinglet and red crossbill populations experienced insignificant annual declines of 0.8 percent and 0.7 percent, respectively (Sauer et al. 2004).

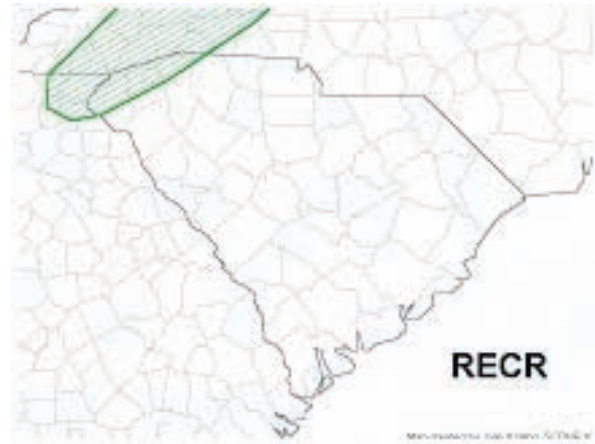


These three species have broad distributions and tend to occur in coniferous forests between the Pacific and Atlantic coasts of Canada, south into the mountains of the southwestern US and along the Appalachians into the southeastern US. The high elevation southern Appalachian populations of these species, though not officially subspecies, are believed to be endemic and isolated from their northern and western populations (Hunter et al. 1999). Therefore,

these southern Appalachian populations are considered equivalent to distinct “species” for conservation planning purposes (Hunter et al. 1999). Two ‘types’ (Type I and Type II) of red crossbills occur in the southern Appalachians (Hunter et al. 1999).

In South Carolina, breeding habitat for the mountain coniferous forest guild occurs mainly in the Blue Ridge Mountains, located in the northwest section of the state. Breeding habitat consists primarily of late successional and old growth hemlock and white pine stands (Hunter et al. 1999). According to the South Carolina

Breeding Bird Atlas (1995) the red-breasted nuthatch was present in Oconee County during the breeding season. Breeding was confirmed for both the red crossbill (Greenville and Pickens Counties) and the golden-crowned kinglet (Oconee County) Additionally, the golden-crowned kinglet may have possibly bred in Greenville and Pickens Counties.



Habitat and Natural Community Requirements

The mountain coniferous forest guild principally breeds in mature or late-successional coniferous forests, particularly those composed of spruce, fir, pine, hemlock, larch and cedar (Adkisson 1996; Ingold and Galati 1997; Ghalambor and Martin 1999). Red-breasted nuthatches are weak excavators; although they may nest in old or natural cavities, most excavate nests in decaying portions of dead or partially dead trees. Consequently, the density of decaying old or dead trees may influence their breeding densities. In the Appalachian Mountains, the highest summer densities of red-breasted nuthatch populations occur in silviculturally undisturbed high elevation coniferous forests (Shriner 2001). Golden-crowned kinglets nest high in conifers, breeding mainly in boreal spruce or fir forests, though they will nest in a variety of forest types (Ingold and Galati 1997). Golden-crowned kinglet breeding densities decline in logged or burned forests, in areas with open canopies and in hardwood forests. Red crossbill populations are nomadic and breed opportunistically from December through September (Adkisson 1996). Red crossbill breeding is strongly influenced by conifer seed availability; they generally breed when adequate mature cone crops are present (Adkisson 1996).

Red-breasted nuthatches primarily forage on the trunks of live conifer trees; they eat arboreal arthropods during the breeding season and conifer seeds during the non-breeding period. Golden-crowned kinglets forage on the tips of branches, on conifer needles and on the trunks of spruce, fir and pine trees. In the southern Appalachians, Type I red crossbill populations have small bills and thus forage mostly on conifers that produce soft or small cones, such as red spruce, white pine and eastern hemlock. Type II crossbills are large-billed and specialize on yellow pines (Adkisson 1996).

Challenges

Range-wide, red-breasted nuthatch populations may be limited by the availability of dead or diseased trees that are suitable for nest sites and winter food source availability (Ghalambor and Martin 1999). In addition, red-breasted nuthatches avoid recent clearcuts and are more abundant in mature, diverse conifer forests than homogeneous, even-aged stands (Ghalambor and Martin 1999).

Forest thinning and spruce die-off may reduce local golden-crowned kinglet populations. However, the kinglet has expanded its breeding range in the midwestern and eastern United States due to the planting of spruce trees (Ingold and Galati 1997). Red crossbills are habitat specialists; population estimates tend to be correlated with the availability of conifer seed. Crossbills will disperse from areas of reduced seed abundance (Adkisson 1996). Logging of mature conifer forests and shortened rotations of managed stands may negatively affect red crossbill populations because older conifers, those 60 years old or more, produce larger cone crops (Adkisson 1996).

In most of the southern Blue Ridge, red-breasted nuthatches, golden-crowned kinglets and red crossbills are currently associated with high-elevation red spruce-Fraser fir-northern hardwood forests, though historically these species may have been more abundant when the landscape contained more old-growth hemlock and white pine (Hunter et al. 1999). High-elevation spruce-fir forests have endured and continue to endure extensive losses of mature Fraser fir due to balsam woolly adelgid infestations. Other factors potentially affecting spruce-fir forests include increased levels of acid deposition and ozone; however, this relationship is currently speculative (Hunter et al. 1999). The death of mature fir trees results in reductions in canopy cover and other changes to forest structure. Red-breasted nuthatch and golden-crowned kinglet populations have declined and red crossbill populations have likely declined where adelgid infestations have caused significant changes to forest structure (Hunter et al. 1999). The PIF conservation statuses of these species are primarily due to concerns over the impacts of past and potential future losses of spruce fir habitat. Although members of this guild depend on high elevation spruce fir forest, they also occur in reduced densities in late successional hemlock-white pine.

In South Carolina, breeding populations of these species are rare and largely restricted to late successional conifer stands. Logging and management actions in these habitats that eliminate dead or decaying trees, reduce the amount or average age of cone-producing trees and/or reduce conifer species diversity may negatively impact one or more species in this guild.

It should be noted that the red-breasted nuthatch is an irruptive migrant. Late successional mixed-pine hardwood and mature Virginia pine stands appear to provide suitable wintering habitats for these birds. However, these red-breasted nuthatches may be from stable northern populations; the importance of these forest types for southern Appalachian populations is unknown.

Conservation Accomplishments

In the southern Appalachians, members of this guild mainly use high-elevation spruce-fir forest. Most (95 percent) of the remaining acreage of spruce-fir forests is on public lands and nearly 80 percent of spruce-fir is late successional. However, despite the protection afforded on public lands, spruce-fir forests continue to suffer from exotic pests (e.g. balsam woolly adelgid) and potentially from pollution originating elsewhere.

Conservation Recommendations

- Determine the distribution, densities and nest survival rates of breeding red-breasted nuthatch, golden-crowned kinglet and red crossbill populations in South Carolina.
- Determine the amount and distribution of late successional hemlock and hemlock-white pine mixed stands that are necessary breeding habitat for this guild in South Carolina.
- Evaluate current and proposed land use strategies for existing habitats and work with landowners to optimize habitat potential for breeding members of this guild. Proposed land use strategies and landowner outreach programs should address the following:

- o Conservation of existing mature coniferous forests.
- o Provide an increase in the amount and extent of late successional hemlock and hemlock-white pine mixed stands.
- o Cooperate on the restoration of high elevation spruce-fir forests.
- o Support management actions that provide both 'soft' (decayed) and 'hard' snags and/or promote large and older trees, increasing habitat use, population densities and reproductive success of red-breasted nuthatches. A study cited in Ghalambor and Martin (1999) suggests leaving 36 hard and 36 soft snags per 40 hectares or 98.8 acres.
- Assess potential effects of predicted hemlock decline due to hemlock woolly adelgid on this guild.
- Verify the assumption that these bird populations are endemic and genetically distinct from larger and more stable northern populations through genetic studies.

Measures of Success

Increases in the amount and quality of breeding habitat should lead to increases in population sizes and nest survival rates. In an adaptive management framework, population density and nest survival data should be collected before and after the implementation of management actions intended to improve habitat quality for this guild. This information should guide subsequent management activities.

Northern Bobwhite

Colinus virginianus

Contributor: Billy Dukes

Description

Taxonomy and Basic Description

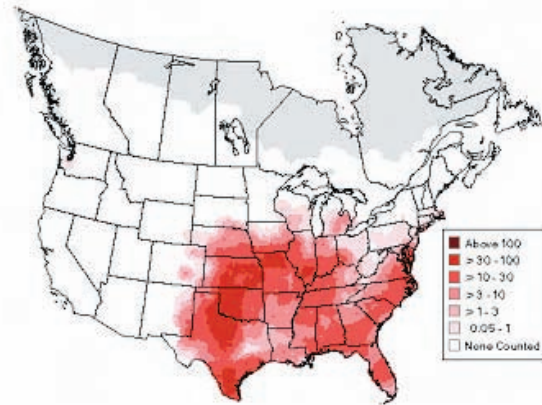
In 1748, Catesby gave the bobwhite quail the name *Perdix sylvestris virginiana*. In 1758, Linnaeus dropped the generic name *Perdix* and substituted *Tetrao*. The generic name *Colinus* was first used by Goldfuss in 1820 and, despite several ensuing name changes, became the accepted nomenclature (Rosene 1984). Bobwhite quail are members of the family Odontophoridae, the New World quail.

Bobwhite quail are predominantly reddish-brown, with lesser amounts of white, brown, gray and black throughout. Both sexes have a dark stripe that originates at the beak and runs through the eye to the base of the skull. In males, the stripe above and below the eye is white, as is the throat patch. In females, this stripe and throat patch are light brown or tan. Typical weights for bobwhites in South Carolina range from 160 to 180 grams (5.6 to 6.3 ounces). Overall length throughout the range of the species is between 240 and 275 millimeters (9.5 and 10.8 inches) (Rosene 1984).

Status

Bobwhite quail are still widely distributed throughout their historic range. However, North American Breeding Bird Survey data indicate a significant rangewide decline of 3.0 percent

annually between the years of 1966 and 2003 (Sauer et al. 2004). In South Carolina, quail populations have declined at a rate of 4.7 percent annually since 1966 (Sauer et al. 2004). Average summer distribution of northern bobwhite quail 1994-2003. From Sauer et al. (2004).



While not on the Partners in Flight Watch List, the concern for northern bobwhite is specifically mentioned due to significant population declines over the past 30 years (Rich et al. 2004). Despite rangewide declines, high densities of quail (6.6 to 7.6 birds/ha) are often maintained on lands where intensive habitat management occurs or conditions are otherwise suitable (Brennan 1999).

Population Distribution and Size

Bobwhite quail occur throughout South Carolina, with higher densities found in the coastal plain than the piedmont (SCDNR unpublished data). Within the coastal plain of South Carolina, quail population densities are higher in the inner coastal plain than in the outer coastal plain and coastal zone. Greater concentrations and more wide-spread distribution of row-crop agriculture in the inner coastal plain creates habitat conditions more favorable for quail than are found in heavily forested landscapes typical of the outer coastal plain.



Quail populations exhibit dramatic seasonal and annual fluctuations, making accurate population estimates difficult. Estimated autumn and breeding populations of bobwhites in 1999 were 20.1 million and 6.7 million respectively (Dimmick et al. 2002). Partners in Flight put the estimated global breeding population at 9.2 million, with 82 percent (7.5 million) occurring in the continental U.S. (Rich et al. 2004).

Quail habitat quality and population levels vary widely across the landscape, resulting in tremendous uncertainty related to extrapolation of population densities to the statewide level. Using assumptions contained in the Northern Bobwhite Conservation Initiative (NBCI) (Dimmick et al. 2002) and data gathered as part of a 2002/2003 hunter harvest survey (Responsive Management 2003), the estimated quail population for South Carolina in autumn of 2002 was 291,078 individuals and the estimated breeding population in the spring of 2003 was 97,026 individuals. However, assumptions contained in the NBCI may not be applicable to South Carolina, and estimates derived using those assumptions may underestimate the South Carolina population by as much as 100 percent.

An assumed autumn population of 291,078 individuals translates into a statewide density estimate of 3.7 individuals/km² (9.6 individuals per square mile). Autumn population estimates

conducted at select areas under intensive quail management in South Carolina have documented populations estimated at 98.9 individuals/km² (256 individuals per square mile) (SCDNR unpublished data). Some forested landscapes on which minimal management for quail has occurred have been documented to support autumn densities of 27.2 individuals/km² (70.4 individuals per square mile) (SCDNR unpublished data).

Habitat and Natural Community Requirements

Bobwhite quails use a variety of cover types throughout their broad geographic range. Early successional habitats such as croplands, grasslands, fallow fields, open pinelands and open mixed pine-hardwood forests that have diverse groundcover vegetation are particularly important in the south (Brennan 1999). Perennial warm-season bunchgrasses are the preferred nesting substrate throughout much of the range of the species. Preferred brood-rearing cover consists of diverse communities of erect annual forbs with abundant insects, bare ground between stems and a foliage canopy.

Eastern towhee, blue grosbeak, yellow-breasted chat, indigo bunting, northern cardinal, gray catbird, brown thrasher and Carolina wren are among the many species that have habitat requirements similar to northern bobwhite such as shrub/scrubland. Those species found in more of an open grassland habitat, which is also frequented by the northern bobwhite, include barn owl, loggerhead shrike, eastern meadowlark, grasshopper sparrow, field sparrow and common ground-dove. All of these species are subject to the same threats as northern bobwhite, and will likewise benefit from habitat enhancement practices aimed at restoring populations of northern bobwhites.

Challenges

Habitat loss due to the effects of urbanization, modern agricultural and silvicultural practices, fire suppression, and introduction of exotic pasture grasses is widely recognized as the primary problem for bobwhite quail populations (Stoddard 1931; Rosene 1984; Barnes 1995; Brennan 1991; Brennan 1999; Thackston and Whitney 2001).

A lack of nesting and brood-rearing cover is believed to be the major limiting factor over much of the range of the species (Rosene 1984; Dimmick et al. 2002). For a more complete discussion of the effects of habitat changes on bobwhite populations and habitat suitability, see the Northern Bobwhite Conservation Initiative (Dimmick et al. 2002).

Conservation Accomplishments

Since 1978, biologists in the Small Game Project have completed over 500 management plans, potentially improving habitat on over 500,000 acres of private land in South Carolina. Additionally, since 1979, an annual bobwhite quail spring call count survey has been conducted as an assessment of the statewide population trend. Since 1987, a statewide quail hunter survey has been conducted to examine regional population trends, hunter effort, hunter success, and age ratio of harvested birds. In 1995, the Southeast Quail Study Group was formed to identify causes of regional bobwhite population declines and to devise solutions to reverse declining trends. In 2001, a Bobwhite Quail/Grassland Birds Working Group was established within the South Carolina Department of Natural Resources (SCDNR) Wildlife Section to address problems of declining habitat for quail and other early-successional species. Since 2001, fall covey count surveys have been conducted on select Wildlife Management Area lands as an index of fall populations. Specific habitat enhancement goals and population recovery goals for bobwhites were identified in the Northern Bobwhite Conservation Initiative (NBCI), a rangewide recovery plan, in 2002. Finally, practice CP-33, Habitat Buffers for

Upland Birds, was added to the list of eligible practices under the Conservation Reserve Program (CRP), with 5,000 acres of habitat buffers allotted to South Carolina in 2004.

Conservation Recommendations

- Increase acreage of volunteer early succession vegetation or native warm season grasses to agricultural landscapes in South Carolina
- Apply appropriate site preparation techniques, selective thinning regimes, and prescribed fire rotations to forest lands in South Carolina
- Consider including protection of farmland and other potential early successional habitat in land acquisition and habitat protection programs.
- Maximize wildlife benefits in USDA Farm Bill programs through regional and national involvement in planning processes and through direct involvement with local and farm-level conservation planning.
- Identify funding sources for state-level cost-share programs to assist landowners with implementation of beneficial management practices for quail and other early-successional species.
- Identify focal areas for quail habitat enhancement within the state based upon existing land cover and quail populations, and strive to focus private lands technical assistance and encourage USDA conservation programs in those areas where habitat enhancement would be most beneficial and the potential for positive population response would be greatest.
- Identify public lands with high potential for quail habitat enhancement and assist responsible agencies with planning efforts for habitat enhancement.
- Identify SCDNR lands with high potential for quail habitat enhancement, establish target population goals and implement management practices necessary to achieve the target population goal.
- Develop predictive models of bobwhite quail occurrence and density based on land cover types from remote imagery.
- Evaluate bobwhite quail colonization rate and population response to habitat enhancement, particularly in forested landscapes.
- Evaluate effect of geographic isolation on bobwhite quail population viability and persistence.
- Evaluate effects of patch size and configuration on bobwhite quail nest success and brood survival.
- Develop improved census techniques for low to moderate densities of quail.
- Identify limiting factors for quail populations in agricultural and forested landscapes in South Carolina.
- Increase number of survey routes in spring call count survey for better statewide coverage and to allow regional trend comparisons.
- Increase number of cooperators in statewide quail hunter survey.
- Document habitat enhancement accomplishments that occur as a result of USDA Farm Bill programs, private lands technical assistance, or quail focus area initiatives.

- Document harvest levels on discrete properties and at the statewide level in order to validate harvest rate assumptions of the NBCI.
- Train additional observers in the fall covey count technique and expand the technique to additional sites in the state.
- Continue annual quail management seminars for private landowners and agency personnel.
- Develop additional technical literature on beneficial quail management practices.
- Utilize agency outlets and cooperative efforts to promote benefits of prescribed burning.
- Establish demonstration areas that illustrate successful quail management practices on public or cooperative private lands within each DNR Wildlife Region.
- Publicize successful quail management efforts on public or private lands through agency outlets and the popular press.
- Evaluate the assumptions contained in the NBCI relative to productivity, harvest rate, and annual survival through directed research

Measures of Success

Population response to habitat management will be monitored on discrete tracts using the fall covey count technique and other techniques as appropriate. Effects of landscape-level changes will be monitored using Breeding Bird Survey data and spring call count survey data. Management-oriented research projects will address emerging questions related to bobwhite population dynamics and habitat enhancement techniques. SCDNR will strive to continue to respond to new data and adapt management actions once assumptions have been further tested.

Painted Bunting (Eastern subspecies)

Passerina ciris ciris

Contributor: William C. Hunter

Description

Taxonomy and Basic Description

Buntings are small new world finches with conical bills. The painted bunting is a small finch, typically 12 to 13 cm (4.7 to 5.1 inches) long and 13 to 19 g (0.46 to 0.67 ounces) (Lowther et al. 1999). The male painted bunting is among the most colorful birds in North America but is often hard to see as it usually stays close to thickets and dense cover. Males have a blue head and nape with bronze-green back, red rump and underparts, and dark wings and tail (Lowther et al. 1999). Even when in full view, male painted buntings may appear dark unless seen close and in good light. Females and immatures of both sexes are almost entirely dull green and are even more rarely seen except when at feeders (Lowther et al. 1999).

Painted buntings breeding in South Carolina belong to the eastern subspecies, *Passerina ciris ciris* (Thompson 1991; AOU 1998). During the breeding season, this subspecies is restricted to four states along the Atlantic Coast: North Carolina, South Carolina, Georgia and Florida. They winter exclusively in south Florida and the West Indies (mostly Bahamas and Cuba) (Lowther et al. 1999). Eastern painted buntings breed relatively late in the season (Duncan 1999; Springborn 1999).

Status

Both Breeding Bird Survey (BBS) and Christmas Bird Counts show steep population declines in painted buntings since the early 1970's (J. Cox, pers. comm.; Cox 1996). BBS data points to three percent declines per year while Christmas counts show a significant decrease in 12 of the 25 counts (Sauer et al 1997). Since the largest populations are found on sea and barrier islands that are poorly surveyed, it is possible that this decline is restricted to the inland habitats where eastern painted buntings breed. However, the Christmas Bird Count data is not subject to that bias. Considering both BBS and Christmas Bird Counts, the eastern painting bunting remains one of the most locally occurring, steepest declining, high priority species within the southeastern U.S. (Hunter et al. 1993). Because South Carolina supports a third to a half of the total breeding population for eastern painted bunting, this state must play a important role in the future conservation of this high priority species.

Population Distribution and Size

Eastern painted buntings are most abundant around the sea islands of Georgia and South Carolina, but are fairly common in the adjacent mainland that is roughly parallel to U. S. Highway 17 and eastward. Their range extends north into coastal North Carolina and south into northeastern coastal Florida. These buntings become uncommon, occurring sporadically farther inland along some river systems, most notably the Savannah River. More recently, Breeding Bird Atlas work in South Carolina and Georgia has documented eastern painted buntings as more numerous than previously thought in fallow fields, woodland edges and hedgerow habitat of the upper coastal plain when looking north and east to the Santee River and on both sides of the Savannah River (Cely 2003; T. Schneider in prep.). Elsewhere in South Carolina, eastern painted buntings are absent or at least restricted to the barrier islands, forming a gap between populations in Georgetown, South Carolina and Bald Head Island, North Carolina.

The vast majority of wintering eastern painted buntings are concentrated in south Florida, Cuba and the Bahamas (Lowther et al. 1999). However, there does not seem to be any one reliable place where large numbers of eastern painted buntings can be located during winter, at least in recent years, which may be cause for serious concern.

The total North American population size for eastern painted bunting is unknown, but can be estimated as well below 500,000 breeding adults (Sauer et al. 1997). Using the approach now employed by Partners in Flight (PIF) in estimating breeding populations using BBS data (Rosenberg and Blancher, in press), South Carolina's population is estimated at 50,354 ($\pm$ 18,704) breeding adults. According to this estimate, 54 percent of the total North American population of breeding adults occurs in South Carolina. There are several caveats that need to be considered with this estimate. First, sea and barrier islands, where the largest populations now occur, are not well represented in the BBS data and additional survey work may raise our estimate of total breeding adults. Second, if we decrease the statistical rigor of the estimate, then maximum population estimate may be as large as 165,112 breeding-aged birds. Third, ability to detect all individual buntings (or at least all singing males) and make adjustments for estimating all breeding adults needs to be evaluated. If coastal sea and barrier islands were fully incorporated, then it is presumed that Georgia, with a larger quantity of quality coastal habitat, would have a higher proportion of the total population than South Carolina. However, it is clear by any of these estimates that both South Carolina and Georgia habitats are extremely important for the majority of breeding eastern painted buntings (Meyers 2004).

Habitat and Natural Community Requirements

Eastern painted buntings are associated with maritime shrub-scrub and grassy habitats mixed in a woodland setting. The species is mostly absent from forests with no understory development and from large patches of scrub-shrub habitat separated from large woodland patches. Nearby grassy fields are also important for post-breeding foraging adults and fledglings (Lowther et al. 1999). High quality habitat is defined as largely forested areas with substantial edge and grassy forest openings and stands exhibiting structural diversity and large amounts of fleshy fruit (Lowther et al. 1999).

Research on annual survival and other demographic characteristics will lead to a more definitive understanding of the habitat requirements of the painted bunting. Current research indicates the defended territory of buntings as ranging from 2 to 10 acres (0.81 to 4.0 hectares) with isolated males holding larger territories from one year to the next; there is also about 95 percent breeding ground site fidelity for males. Annual survival estimates are still to be calculated. Adults use grassy areas for seeds and marshes for arthropod foraging near nest sites in scrub habitat.

Additional research has shown that buntings will use Spanish moss as nest building material, especially in nests found higher in the canopy. Nests found 3 meters (10 feet) or higher in the canopy had higher productivity than nest found lower (Garcia 1994). In general, researches also observed that a greater number of nests were located in medium category trees/shrubs. Additionally, successful nests were located in taller plants with greater distances from the trunk of the tree, greater canopy cover and fewer small limbs. Cely and Glover (unpublished SCDNR data) concluded that early successional habitat associated with fields and field-edges seem to consistently support eastern painted buntings. However, while this research reported a high abundance of eastern painted buntings in these habitats, the potential for nest predation and parasites also increases in such environments and effects on bunting reproductive output has not been studied.

Finally, additional research by Duncan (1999) and Springborn (1999) was conducted on Sapelo Island Wildlife Management Area in Georgia from 1996 to 2000. These studies further described habitats found past the primary dune line where shrubs appear (maritime shrub habitat) as optimal for painted buntings. Pinelands with open canopy had bunting densities about 50 percent of those in optimum shrub-scrub habitat. Buntings preferred open freshwater wetlands to salt marsh. Data on telemetry of buntings on Sapelo Island indicate home ranges of 7 to 18 acres (2.8 to 7.3 hectares). Males had larger home ranges compared to females and buntings had significantly smaller home ranges in shrub-scrub habitat with high grass cover when compared to open pine forest habitat. With these data, it is estimated that areas between 1,200 and 2,500 acres are required to support 100 to 200 breeding pairs of eastern painted buntings.

Challenges

Because the eastern painted bunting is a true edge species, populations may be particularly vulnerable to increased nest parasitism by brown-headed cowbirds (*Molothrus ater*) and increased nest depredation. Although actual causes for eastern painted bunting declines remain unclear, continued changes in landscape in inland areas are correlated with documented population declines (Hunter et al. 1993). During the BBS of inland sites in Georgia and South Carolina, landscape changes have included a doubling in developed land from 4 to 9 percent, an increase in pine plantation from 25 to 35 percent, while agriculture has declined from 18 to 9 percent (Meyers 2004). During this same time period, no change in emergent wetlands has been documented. Assuming that we have a correct understanding of eastern painted bunting habitat

characteristics, 35 to 45 percent of the variation in eastern painted bunting population change is accounted for through changes in landscapes (Meyers 2004).

There appears to be a delicate balance between a landscape with enough fields to support larger populations of eastern painted buntings, but with enough forest to keep predators and cowbirds at a low enough level to maintain high reproductive success. However, the landscape context of the inner coastal plain of South Carolina is changing to the point where conditions are becoming less suitable overall for supporting eastern painted bunting populations. Converting agriculture areas to hard edges, residential areas or pine plantations results in less suitable habitat for eastern painted buntings. Overall landscape conditions may become less favorable for eastern painted buntings outside of public lands like Santee National Wildlife Refuge in the inner coastal plain with continued land conversion (Hunter pers obs).

Because eastern painted buntings breed late in the season, these birds could be prone to global climate change (Duncan 1999; Springborn 1999).

Preliminary results from sea islands indicate few problems with nest predators or cowbirds in these protected areas; however, future coastline development may contribute to higher levels of nest parasitism and nest predation on these otherwise secure sites. On sea and barrier islands, development pressure is increasing at many privately owned sites. Development is expected to adversely affect island populations in the same manner as those on the mainland. Also, on sea and barrier islands, feral horses and hogs severely damage and destroy forests by trampling and uprooting understory shrubs, as well as overgrazing grassy habitats. Where feral horses and hogs are established, eastern painted buntings are not expected to thrive.

Management of public lands through the use of prescribed burning may affect eastern painted bunting populations. In many areas, prescribed fire is an essential management tool for providing and maintaining appropriate conditions for eastern painted buntings. However, fire at high frequency return intervals may eliminate the shrub layer, while fire at low frequency return intervals also may eliminate the shrub layer as well as the grassy conditions over time. Present experience suggests an average return interval between 3 to 6 years in maritime habitats is adequate to maintain the mosaic of structure eastern painted buntings prefer, while not allowing succession to proceed too far. Of course, once a burn occurs, there will be a temporary reduction in habitat quality (Hunter, pers obs).

Golf courses may provide marginal habitat for eastern painted buntings under certain circumstances, especially when all native vegetation is removed and there is a high reliance on pesticide and herbicide use. However, an increasing number of golf courses are modifying their practices to accommodate native birds in general and eastern painted buntings specifically in coastal South Carolina. The U.S. Fish and Wildlife Service is working with golf course managers in the South Carolina with the objective of maintaining eastern painted bunting populations in what is otherwise a rapidly developing landscape (Gordon et al. 2003).

Conservation Accomplishments

The eastern painted bunting has been identified as one of the highest priority species in need of conservation in the southeast; South Carolina and Georgia are the most important states to ensure the future security of this species. Agencies and industrial landowners are incorporating the needs of this species in management plans. Also linkages to other conservation efforts where there are mutual conservation interest, such as the Northern Bobwhite Conservation Initiative,

are underway. An “Eastern Painted Bunting Working Group” has formed and meets annually to review existing information and encourage future research, education, and outreach initiatives. A listserv exists to increase communication among managers and researchers. A website summarizing information on eastern painted buntings (Meyers 2004), including much of the information in this report can be accessed at <http://www.pwrc.usgs.gov/pabu/>.

Conservation Recommendations

- Protect and maintain existing high quality maritime woodland, shrub-scrub, and grassy habitats through easements/purchase.
- Determine more specific habitat objectives as research reveals a better understanding of present status for breeding populations
- Target programs for both public land managers and private landowners to encourage provision of adequate cover, food and habitat that presents minimal nest parasitism and depredation.
- Continue to conduct and support research on habitat selection, reproductive success and taxonomy of eastern painted buntings
- Conduct and support public outreach programs to solicit observations of buntings and cowbirds from feeder watchers throughout the range of the species.
- Establish a network of sites for monitoring the population trends of eastern painted buntings and address responses to local management and landscape conditions. Among generalized habitats used by eastern painted bunting there are four that merit treatment at the macro-scale, as follows:
 - o Sea Islands/Barrier Islands – evaluate habitat management practices and suitability over long term.
 - o Coastal Mainland – evaluate development pressures on buntings.
 - o Agricultural Interior – evaluate farming and forestry practices on buntings and determine how to implement conservation practices.
 - o River Corridor – evaluate forestry practices and flood plain dynamics.
- Provide news releases when appropriate to announce key events or findings involving eastern painted buntings that would allow opportunities to highlight general conservation goals and needs for the public.

Measures of Success

Of particular importance in measuring success of conservation actions for this species is demonstrated stability for eastern painted bunting populations on sea islands. Measures of reproductive success should be used to gauge population health and habitat quality.

Peregrine Falcon

Falco peregrinus

Contributors: Ben Thatcher and Anna Huckabee Smith

Description

Taxonomy and Basic Description

The peregrine falcon is a crow-sized raptor in the family Falconidae (Order: Falconiformes). Adults have slate-gray upperparts, pale underparts with dark bars and spots and a dark facial stripe from the eye down to the side of the cheek. Immature birds are similar to adults, but with pale to brown upperparts and dark streaks on buffy underparts. Male peregrines measure 36 to 49 cm (14 to 19 inches) while females measure 44 to 58 cm (17 to 23 inches).

Status

The peregrine falcon was listed as Federally Endangered in 1970 and transferred to the 1973 Endangered Species Act because of large-scale population declines from the 1950's to mid-1970's. The species saw total extirpation in the U.S. east of the Rocky Mountains, and reduction in North America to 324 nesting pairs in that time period. Population declines were caused mainly by effects of synthetic organic chemicals, like DDT, on nesting success. After listing, peregrine falcon populations rebounded, largely due to captive breeding programs and reductions in DDT and other organic chemicals in the environment. By 1998, the species had returned to much of its former range and continental populations were viable. Therefore, the species was federally de-listed in 1999 (USFWS 2003).

As of 2003, the peregrine falcon was listed as endangered on the South Carolina Rare, Threatened & Endangered Species Inventory. It is also protected under the Migratory Bird Treaty Act under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975).

Population Distribution and Size

Peregrine falcons have a worldwide distribution. In the United States, the species was formerly extirpated from large portions of its historic range but now breeds locally in western, northern, midwestern and eastern states. By 2002, there were more than 2000 breeding pairs in the U.S. and Canada (White et al. 2002).

Peregrine falcons have successfully bred at Table Rock State Park in Pickens County, South Carolina annually since 1990. However, it is not known where the juveniles go once they depart (Cely, pers. comm.). Most other peregrine falcon observations occur during the wintering season or during migration. Post and Gauthreaux note the peregrine as an uncommon winter visitor on South Carolina's coast and a rare winter visitor to the coast, interior or piedmont of South Carolina (1989).



Habitat and Natural Community Requirements

Peregrines breed in most North American terrestrial biomes, although occupied habitats usually contain cliffs for nesting with open gulfs of air for foraging (White et al. 2002). The species historically nested on ledges along cliffs 8 to 400 m (26 to 1,312 feet) high. However, they will also use nest boxes and artificial structures like towers and buildings, as well as abandoned stick nests such as those previously built and occupied by osprey, red-tailed hawk, bald eagle and common raven (White et al. 2002). Peregrine falcon density is limited by availability of suitable nest locations and by territorial spacing (White et al. 2002).

Peregrine falcons mainly prey upon birds (77 to 99 percent by frequency), ranging in size from hummingbirds (2.5 to 3.5 g or 0.08 to 0.12 ounces) to small Canada geese (1,400 g or 49 ounces). They also occasionally eat mammals and, rarely amphibians, fish and insects. In North America, Peregrines eat more than 429 avian species and 23 mammal species, 10 of which are bats. Prey is usually captured in the air while the falcon is in flight, but also from the surface of the water or ground. The peregrine falcon generally captures prey with its feet and kills by dislocating the cervical vertebra. Surplus prey is cached.

During migration and the wintering period, peregrine falcons prefer wetland areas that have concentrations of waterfowl and shorebirds (White et al. 2002).

Challenges

Peregrines are sensitive to loss or modification of nest sites, though they can switch among alternate sites if more than one exists in a territory (White et al. 2002). They are also sensitive to human presence above a nest cliff (Cely, pers. comm.). Loss or degradation of wetlands may negatively impact non-breeding peregrines. Continued conservation of this species will require more precise knowledge of breeding and potential breeding sites as well as information regarding winter distributions.

Conservation Accomplishments

By 1998, most North American populations had stabilized due to intensive captive breeding programs and reductions in DDT and other organic chemicals in the environment. The species was federally de-listed in 1999.

Conservation Recommendations

- Conduct statewide surveys to identify areas used by breeding and non-breeding peregrines.
- Protect existing and potential peregrine falcon nest sites from destruction, physical alteration and excessive human disturbances. Barrier islands, inland lagoons and other coastal and inland wetlands that support abundant prey for non-breeding peregrines should also be protected, particularly those within 24 km (15 miles) of active nests.
- Modify peregrine falcon nest sites to increase safety from predators and inclement weather.
- Construct alternate safe nesting places on buildings, towers or elsewhere for peregrine falcons (see Anderson 2004).
- Monitor peregrine falcon population trends and breeding productivity, including banding juveniles from the Table Rock area.
- Monitor nesting peregrines at known locations in South Carolina. This includes continued coordination with USFWS personnel.

- Determine the historical distribution of peregrine falcons in South Carolina and evaluate potential sites for peregrine reintroduction.

Measures of Success

The protection of nesting and foraging sites, coupled with the creation of alternate safe nesting sites, should result in a net increase in South Carolina's peregrine falcon population and in an increase in use during migration. Peregrine population trends and distributions in South Carolina should be monitored over time to assess potential changes.

Pine Savannah Bird Group

American Kestrel (southeastern race) (*Falco sparverius paulus*)

Brown-headed Nuthatch (*Sitta pusilla*)

Henslow's Sparrow (winter population) (*Ammodramus henslowii*)

Bachman's Sparrow (*Aimophila aestivalis*)

Contributors: Laurel Moore Barnhill and Donald Imm

Description

Taxonomy and Basic Description

The Henslow's sparrow is a mid-sized insectivore-granivore songbird averaging 13 cm (5.11 inches) in length and 13 grams in weight (NatureServe 2005). This species has a large flat head, gray bill and short tail. Adults are greenish on the head, nape and central crown strip with dark chestnut wings (NGS 1999).

The Bachman's sparrow is a large -songbird, averaging 15 cm (5.91 inches) in length and 19.5 g (0.69 ounces) in weight. This species has a large bill, fairly flat forehead and a long, rounded dark tail (NGS 1999). Adults are gray above and heavily streaked with chestnut or dark brown. Their breast and sides are buff or gray with a whitish belly and a thin, dark eye line (NGS 1999, Sibley 2003). Three subspecies exist; however, populations are seldom differentiated by subspecies (NatureServe 2005).

The brown-headed nuthatch is a small bird, approximately 11 cm (4.3 inches) in length and 10.5 g (0.37 ounces) in weight. This nuthatch has a brown-cap, dark back and dull buff under parts (NGS 1999).

The American kestrel is the smallest falcon with a length of 27 cm (10.6 inches), wingspan of 58 cm (22.8 inches) and a weight of 117 g (4.13 ounces) (NGS 1999; Sibley 2003). Adults are identified by a russet back and tail, double black stripes on a white face, and blue-gray wings (NGS 1999). Howe and King first described the southeastern subspecies in 1902 (NatureServe 2005); this subspecies is nonmigratory and resides primarily in the piedmont and coastal plain of South Carolina. The male of the southeastern subspecies is smaller and less spotted ventrally than the males of more northern races. However, the northern races are migratory and may coexist with the southeastern subspecies outside of the breeding season (NatureServe 2005).

Status

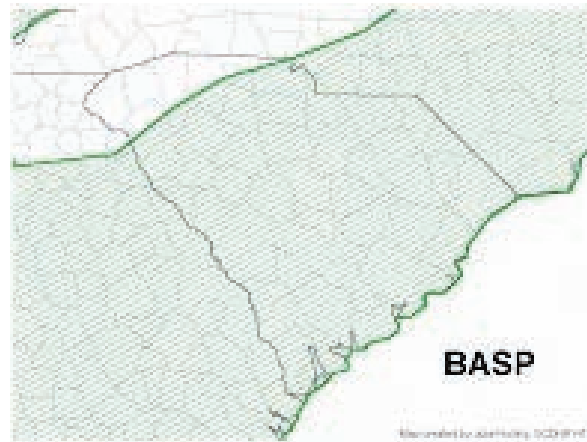
Bachman's sparrows, brown-headed nuthatches and Henslow's sparrows are all designated as species of high continental importance by the Partners In Flight (PIF) prioritization process (Hunter and Demarest 2005 and Rosenberg 2004). This designation indicates that the risk of significant population decline or range-wide extinction is high for these birds.

Bachman's sparrows and Henslow's sparrows are species that are affected by many issues across their entire range; PIF recommends immediate action to address multiple causes of concerns (Rich et al. 2004). The brown-headed nuthatch is considered moderately abundant or widespread, but is experiencing declines and threats. While the brown-headed nuthatch is still widespread, the species will require significant management action to prevent range-wide extirpation and further population declines.

PIF designates the American kestrel as a species of high regional responsibility at the continental level (Rosenberg 2004). The southeastern subspecies is an extremely high priority species for the South Atlantic Coast physiographic area (Hunter et al. 2001). The American kestrel is ranked as secure globally (G5), but the southeastern subspecies is vulnerable (T4) (NatureServe 2005).

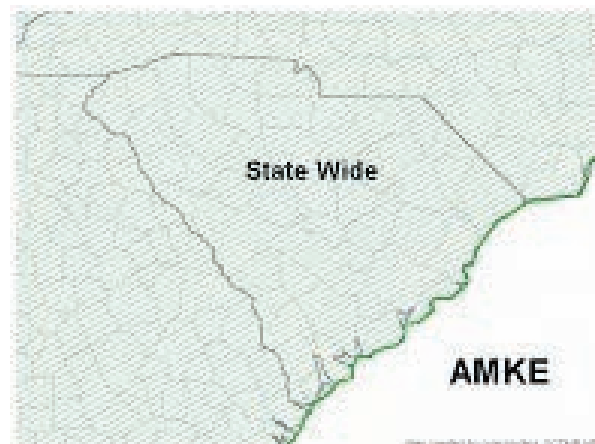
Population Distribution and Size

The Bachman's sparrow, the brown-headed nuthatch and the southeastern subspecies of the American kestrel are resident species to South Carolina. Historically, the core distribution of each of their ranges coincided closely with the distribution of the red-cockaded woodpecker (*Picoides borealis*), longleaf pine (*Pinus palustris*) and short leaf pine (*Pinus echinata*) (Hunter et al. 2001). Breeding bird atlas records for Bachman's sparrows transect the state within the piedmont and coastal plain while records for brown-headed nuthatches and American kestrels were scattered throughout the state (Cely 2003).



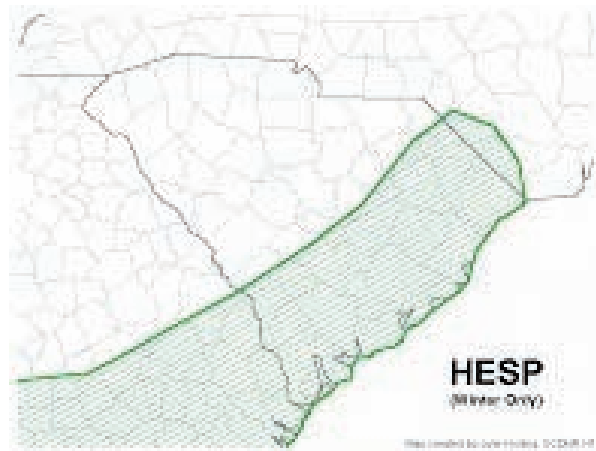
Immediate attention is necessary to reduce long-term population declines of Bachman's sparrow; the Breeding Bird Survey (BBS) indicates a 1.3 percent rate of decline per year for South Carolina from 1966 to 2003 (Sauer et al. 2004). The rate of decline is greater in the piedmont region (13.5 percent) than in the coastal plain (2.2 percent). The statewide objective for the Bachman's Sparrow is a

doubling of the population over the next 30 years due to severe declines in the population trend during the past 30 years (Rosenberg 2004). Statewide objectives are defined based upon trends at the continental level (Rosenberg 2004); but species assessments based on physiographic region scales also indicate population declines that make this species an extremely high conservation priority



(Hunter et al. 2001). The current population estimates for the piedmont and the coastal plain physiographic regions of South Carolina are 21,000 and 1,700 individuals, respectively (Rosenberg 2004)

The same BBS indicates a 1.2 percent rate of decline per year for brown-headed nuthatch in South Carolina and 1.6 percent decline throughout its range from 1966 to 2003 (Sauer et al. 2004). Due to this level of decline, the statewide objective is to increase the population by 50 percent over the next 30 years (Rosenberg 2004). Statewide objectives are defined based upon trends at the continental level (Rosenberg 2004); but assessments considering area importance also indicate population declines at the physiographic region scale that call for significant action (Hunter et al. 2001). The current statewide population objective is 174,000 individuals (98,000 in the South Atlantic Coastal Plain and 76,000 in the piedmont).



The southeastern subspecies of the American kestrel has greatly declined; the BBS indicates an 8.3 percent rate of decline per year for the coastal plain from 1966 to 2003 (Sauer et al. 2004). There are currently no BBS trend scores available for South Carolina. The overall population trend for the coastal plain indicates a need to increase the population by 50 percent over the next 30 years (Hunter et al. 2001). Continental population estimates are available for this species, but caution should be exercised when extrapolating to the state level due to consideration of various subspecies. All subspecies are common during the winter due to migration; however, breeding activity of the southeastern subspecies is low (Hamel 1992).

Henslow's sparrows winter throughout the coastal plain and piedmont, extending inland from the coast and through the sandhills (Cely 2003). The state population estimate is currently unknown in part due to the BBS being a survey based upon breeding bird data. Long-term declines are evident for this species across its range; the BBS indicates an 8.6 percent annual decline across the United States from 1966 to 2003 (Sauer et al. 2004). The statewide population objective is to double the population over the next 30 years (Rosenberg 2004).

Habitat and Natural Community Requirements

Each of these species is dependent upon southern pine dominated landscapes for all or part of their life cycle.

Bachman's sparrows are ground nesters within dense cover. These birds also forage for insects and seeds on the ground. Traditionally, Bachman's sparrows have been associated with mature pine forests, especially longleaf with bunch grass understories comprised of wiregrass in the east (*Schizachyrium scoparium*) (Hunter et al. 2001). Highest breeding concentrations of these sparrows are found in open pinelands where a thick ground cover of grasses and forbs are present (Hamel 1992). This species can also be found nesting in overgrown fields with low numbers of pine trees. In either case, the key elements appear to be a dense ground cover of grasses and forbs with low volumes of vegetation in the under- and midstory levels (Dunning and Watts 1990). The diameter of overstory pine does not seem to be a critical factor for Bachman's sparrows either in the breeding or wintering season. It is likely that, in areas not subject to frequent prescribed

fire, grasses and forbs could become too thick for this species to nest and forage, as a degree of openness is necessary.

While the Bachman's sparrow occupies the understory of open pinelands, the brown-headed nuthatch occupies the overstory of mature, open pinelands. This cavity nesting species requires dead or older trees as a nesting substrate and forages on both dead and live trees to glean insects (Hamel 1992). Brown-headed nuthatches avoid short rotation pine forests (less than 80 years) because these birds excavate nests in older pine trees, which often have dead limbs present (Hunter et al. 2001). Frequent fire rotations benefit this species, as well as the sympatric red-cockaded woodpecker, by maintaining a sparse midstory and diverse groundcover composition, increasing arthropod biomass for forage (Taylor 2003).

The American kestrel is a secondary cavity nesting species. Currently, very few of these birds nest in natural cavities due to a lack of standing snags in open pinewoods and agricultural areas (Hunter et al. 2001). Use of artificial nests in South Carolina has lead to an increase in the population (Cely and Sorrow 1988). Optimal nest sites are in extensive open areas with scattered trees (pine or hardwood). Kestrel foraging occurs in open areas, such as plowed and grassy fields, roadsides, savannas and woodland margins (Hamel 1992). The productivity of foraging habitat may be influenced by land use. In Florida, kestrels nesting in longleaf-dominated sandhills were more productive than those nesting in agricultural areas, primarily due to the quality and abundance of prey items (Bohall-Wood and Collopy 1987).

The winter habitat requirements of Henslow's sparrows are poorly understood. In the Gulf Coastal Plain, the species winters in moist grassy areas (pitcher plant bogs) under open pinewoods. They can also be found in broomsedge (*Andropogon spp.*) or other grasses that are moist (Hamel 1992; Plentovitch et al. 1999; Burhans 2002). Soil moisture and the density and height of ground vegetation may be important factors determining habitat quality (Hunter et al. 2001). In the coastal plain of South Carolina, Henslow's sparrows winter in grassy, non-inundated Carolina bays and in utility rights-of-way maintained in grasses (Champlin and Kilgo, unpubl. data). In South Carolina, pine savannas may be rarely used and soil moisture may not be as important as elsewhere; xeric upland rights-of-way supported as many sparrows as Carolina bays and no birds were found in pine savannas (Champlin and Kilgo, unpubl. data). However, moist areas beneath a pine canopy may be more important coastward; two birds were captured in such habitat in southern Allendale County. More information about the wintering habitat requirements of Henslow's sparrows is necessary.

Challenges

The greatest challenge to viability of these species is directly related to the location and condition of their optimal habitat: the pine savannah. Although longleaf pine is ecologically the most important species of pine within the southeast region and South Carolina, other pine species, such as loblolly (*P. taeda*) and slash pines (*P. elliottii*) have become more important economically. Longleaf pine forest cover type extended over 92 million acres of the entire southeast landscape prior to European settlement of North American. However, by the 1930's, the majority of these pines had been harvested and today, less than three percent of the original longleaf forests remain (Frost 1993). The loss of longleaf and pine stands, especially those with intact understory, is particularly devastating to plant and animal species that are dependent upon a fire maintained ecosystem for ground layer composition and structure. This effect is evident in areas where frequent fire rotations are not presently conducted. It is suggested that restoration of longleaf

communities can best be accomplished by burning on a two to three year rotation during the growing season (Tucker et al. 2005). However, only approximately half of the available longleaf stands were burned once within the last five years (Outcalt 2000). Additionally, in sites where longleaf and other pine species are planted after significant agricultural use, a seed bank for a desirable herbaceous layer may no longer be present, decreasing the ability to restore important habitat for these species (Walker and Van Eerden 1996; Frost 1993; Imm in press). Therefore, loss of the longleaf pine ecosystem seems to be limiting populations of birds in this guild.

Management actions that reduce or completely eliminate fire rotations, shorten timber rotations and/or reduce forest diversity of pinewoods adversely affect the overall structure of this habitat (Frost 1993). Additionally, restored and planted pine sites may no longer provide the appropriate herbaceous ground cover due to deficiencies in the existent seed bank (Imm and McLeod *in press*). An increase in land conversion to agricultural and urban uses has also resulted in significant losses of all forested habitat types across the state. Although it is unlikely that historical acreage of longleaf can be restored, if managed correctly, all species of pine can provide benefits to wildlife (Franklin 1997; Brockway et al. 2004).

Additionally, lack of survey and monitoring programs to supplement BBS and other existing programs (point counts, call surveys, mist net stations) can result in inaccurate population estimates and trends. Additional monitoring efforts would increase the efficacy of management actions in the future.

Conservation Accomplishments

Restoration of the longleaf pine ecosystem on state and federal lands across the state have provided the most significant accomplishment to date for conservation of these pine savannah species. The Natural Resources Conservation Service developed the Longleaf Pine Ecosystem Conservation Priority Area in 1998 in order to promote longleaf restoration on private lands. Private organizations, such as the Longleaf Alliance and the American Forest Foundation have also contributed in the effort to restore longleaf ecosystems. For example, the American Forest Foundation has supported the publication of the *Conservation Handbook for Birds in Georgia: a guide for family forest owners* (DeBerry in press) that can provide public outreach support for conservation and maintenance of these important ecosystems.

These efforts were also significantly benefited by completion and implementation of the updated red-cockaded woodpecker Recovery Plan in 2003 (U.S. FWS 2003). Management recommendations for longleaf ecosystems described in the recovery plan would also accomplish conservation goals for these pine savannah species. Additionally, development of forestry best management practices for the state and implementation on federal, state and private lands have positively affected longleaf pine ecosystem conservation.

Finally, measuring accomplishments for these species depends on participation by state employees and volunteers in the Breeding Bird Survey and other bird surveys established in South Carolina (Christmas Bird Count, International Migratory Bird Day, Backyard Feeder Watch). Volunteers have also assisted with monitoring efforts to measure population increases and declines in order for researchers and managers to best determine habitat objectives.

Conservation Recommendations

- Continue restoration of longleaf pine ecosystems across the state.
- Enhance the wildlife value of agricultural lands by partnering with NRCS, FSA and others

to develop conservation programs. Integrate monitoring objectives into such programs, where appropriate.

- Increase acreage to reduce forest fragmentation at the landscape scale while protecting and building upon existing areas that support source populations of pine dependent species. Develop corridors linking forested tracts across the state. Conduct a landscape level spatial analysis to determine total forest area, geographic distribution of pine forest types (and all other forest types), fragment size, and quantitative characteristics (ownership patterns) to assess ecosystem change and current potential.
- Consider utilization of models based on spatial analysis and geographic information system tools to highlight areas of greatest conservation need for pine savannah habitats. Such methods could increase efficiency in land acquisition and implementation of private lands programs.
- Continue involvement in and delivery of private, state and federal conservation programs targeted towards pine savanna (USFWS, Land Owner Incentive Program; Department of Energy, Carbon Sequestration Initiative).
- Promote the use of best management practices for all pine species in stewardship plans, including increased rotation length, decreased stocking densities, promotion of site prep burning, decreased use of chemicals, increased use of growing and dormant season prescribed fire, increased width of streamside management zones, selection of site specific species.
- Implement measures to reduce concern about air quality and burning. Educate the public about the importance of burning for wildlife species.
- Promote retention of snags and other potential cavity trees to increase the number of structures available for cavity nesting species.
- In the case of American kestrels, promote the placement of nest boxes in appropriate habitat types.
- In areas devoid of site-appropriate savanna species or with depauperate seed banks, establish wiregrass (*Aristida stricta*, *A. beyrichiana*) and other herbaceous species through propagation from local seed sources.
- Identify wintering habitat requirements of Henslow's sparrows in South Carolina.
- Assess attainability of continental level bird population objectives for the species identified in South Carolina based on land-use patterns, population trends, and habitat needs; develop biological models of population/habitat relationships.
- Derive quantitative population-based habitat objectives for priority pine savanna species and test assumptions (identify habitat-specific densities, limiting factors) in order to model habitat requirements necessary to meet population objectives.
- Develop and implement monitoring programs to better assess breeding and wintering bird population sizes. Management and surveillance monitoring techniques will need to be assessed to quantify short and long-term population responses in order to answer specific monitoring questions. Measures will need to be developed to integrate state monitoring results into regional and national level databases.
- Continue use of the Breeding Bird Survey as a surveillance monitoring technique and

consider modifications to make the survey more robust across the state.

- Increase the collection of survey and monitoring data. For example, develop training workshops or establish a bird counting team.
- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels. Promote the development of a piedmont bird conservation region initiative.
- Promote existing and develop new partnerships to facilitate increased land acquisition.
- Include information in all media outlets available about the value of the longleaf ecosystem to the state and region in order to promote conservation ethics.
- Promote participation of volunteers for collection of survey and monitoring data.

Measures of Success

Restoring the longleaf pine ecosystem in significant quantities across South Carolina and the southeastern landscape will provide benefits to a wide range of taxa. At the very least, restoration of understory characteristics in all types of pine savannas should result in increased ecological function of that habitat. By restoring the understory, the increased plant species richness will result in increase food web complexity and expand species-specific relationships (plant-pollinator). Further, restoration of the understory can facilitate burning by reducing maintenance costs due to modified fuel conditions.

Calculating habitat objectives will indicate if population objectives are attainable for South Carolina and whether changes to these objectives are necessary. In some cases, it may be unrealistic to achieve PIF continental population objectives due to significant and permanent habitat loss. In other cases, South Carolina will be a source for some populations and measures will need to be developed to integrate monitoring results into regional and national level databases.

Collecting monitoring data based on habitat restoration and management objectives should result in measurable population responses at the local level. Other bird species that are likely to be positively affected by pine savanna management and restoration include: red-cockaded woodpecker, prairie warbler (*Dendroica discolor*), eastern towhee (*Pipilo erythrophthalmus*), wood thrush (*Hylocichla mustelina*), northern bobwhite (*Colinus virginianus*), red-headed woodpecker (*Melanerpes erythrocephalus*), yellow-throated warbler (*Dendroica dominica*), pine warbler (*Dendroica pinus*), white-eyed vireo (*Vireo griseus*), Carolina wren (*Thryothorus ludovicianus*), red-shouldered hawk (*Buteo lineatus*), red-bellied woodpecker (*Melanerpes erythrocephalus*) and yellow-throated vireo (*Vireo flavifrons*) (Rich et al. 2004).

Management efforts for species identified within this plan that will also positively impact other state priority species including fox squirrel (*Sciurus niger*), flatwoods salamander (*Ambystoma cingulatum*) and indigo snake (*Drymarchon corais couperi*).

Red-cockaded Woodpecker

Picoides borealis

Contributor: Nicole Chadwick

Description

Taxonomy and Basic Description

Red-cockaded woodpeckers were first described by the amateur naturalist Vieillot (1807) and named *Picus borealis*. In 1810, Alexander Wilson, unaware of Vieillot's previous description, described the species as *Picus querulus* because of its distinctive vocalizations (Wilson 1810). The species is now recognized as *Picoides borealis*. The common name used today, red-cockaded woodpecker, was given to the species by Wilson. Cockade was a common term for a ribbon or other ornament worn on a hat as a badge during Wilson's time, and refers to the small patch of red feathers on adult males, located between the black crown and white cheek patch on the head.

Red-cockaded woodpeckers are relatively small; adults measure 20 to 23 cm (7.8 to 9 inches) and weigh 40 to 55 g (1.4 to 1.9 ounces) (Jackson 1994; Conner et al. 2001). They are smaller than other southern woodpeckers except the downy woodpecker (*Picoides pubescens*) and are similar in size to yellow-bellied sapsuckers (*Sphyrapicus varius*). Red-cockaded woodpecker size varies geographically, with larger birds to the north (Mengel and Jackson 1977).

Red-cockaded woodpeckers are relatively slender, long-tailed and small-billed woodpeckers. They are black and white with a coarsely barred back, white cheek patch and black crown. Their breasts and bellies are white to grayish-white with spots on the sides changing to bars on the flanks. Outer tail feathers are white with black barring and central tail feathers are black. Adult plumage is extremely similar between sexes and generally indistinguishable in the field. The only difference between adult males and females is the presence of the red cockade at the upper edge of the white auriculars, which is virtually invisible in field situations (Jackson 1994). Juveniles appear similar to adults but may be distinguished in the field by duller plumage, white flecks often present just above the bill on the forehead and diffuse black shading in the white cheek patch. Juvenile males have a distinctive red patch on the crown and may be distinguished from juvenile females in this way (Jackson 1994).

Status

The red-cockaded woodpecker was among the first species to be listed as endangered in 1970 and received federal protection under the Endangered Species Act of 1973. The red-cockaded woodpecker was once a common bird. However, by 1970, the species had declined to fewer than 10,000 individuals in widely scattered, isolated and declining populations (Jackson 1971; Ligon et al. 1986). The red-cockaded woodpecker is listed with 12 other avian species as a species of highest concern on the Partners in Flight watch list (Partners in Flight). Most populations of red-cockaded woodpeckers are currently stable to increasing, due to advances in knowledge of red-cockaded woodpecker population dynamics and the use of highly effective management tools, such as artificial cavities and translocations. However, population viability is still threatened by the small, scattered and isolated nature of most red-cockaded woodpecker populations. Downlisting of the species is not expected until at least 2050 and delisting is not expected until 2075 given current population status and expected rates of growth (USFWS 2003). The South Carolina Department of Natural Resources Heritage Trust program describes the species as imperiled state-wide because of rarity or factor(s) making it vulnerable (S2) while globally the species is ranked as vulnerable (G3).

Population Distribution and Size

Red-cockaded woodpeckers are monitored based on the number of groups (a breeding pair with 0 to 7 helpers) and the clusters on which they depend (the actual physical cavity trees and acreage surrounding those trees). In 2000, there were an estimated 14,068 red-cockaded woodpeckers living in 5,627 known active clusters across eleven states; this number represents only 3 percent of the estimated red-cockaded woodpecker abundance at the time of European settlement. In

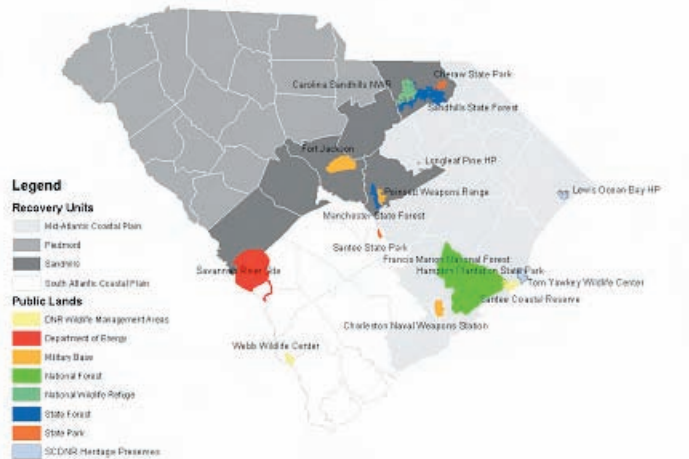
South Carolina, there were 133 groups on state-owned lands and another 524 groups on federal properties in 2000 (USFWS 2003). In addition, there were estimated to be another 400 groups on private lands in South Carolina (Cely and Ferral 1995). Based on these numbers, there were over 1,000 red-cockaded woodpecker groups in 2000 representing nearly 20 percent of all known red-cockaded woodpecker groups.

Red-cockaded woodpecker populations on public lands in South Carolina by recovery unit. Each population has a designated role in recovery. Also listed are the property ownership (Agency), the type recovery population, the current number of active red-cockaded woodpecker groups, and the population goal for the property. Primary core (Primary) populations are those that will have at least 350 groups at recovery, secondary core (Secondary) populations are those that will have at least 250 groups at recovery, significant support (Significant) are those populations that have a population goal of 10 or more clusters, and important support (Important) are those populations that have a population goal of less than 10 groups.

Recovery Unit Population	Agency	Type	Current Status	Population Goal
Mid-Atlantic Coastal Plain				
Francis Marion National Forest	USFS	Primary	344*	350
Lewis Ocean Bay Heritage Preserve	SCDNR	Significant	3	10
Longleaf Pine Heritage Preserve	SCDNR	Important	4	4
Sandy Island		Significant	32	35
Santee Coastal Reserve	SCDNR	Significant	9	16
Wedge Plantation		Important	2	2
Yawkey Wildlife Center	SCDNR	Significant	9	15
Sandhills				
Carolina Sandhills National Wildlife Refuge	USFWS	Secondary	116*	193
Sandhills State Forest	SCFC	Secondary	57	127
Cheraw State Fish Hatchery	SCDNR	Important	1	1
Cheraw State Park	SCPRT	Significant	5	25
Fort Jackson	DOD	Significant	35	126
Manchester State Forest	SCFC	Important	3	3
Poinsett Weapons Range	DOD	Significant	11	30
South Atlantic Coastal Plain				
Savannah River Site	DOE	Secondary	45	250
Charleston Naval Weapons Station	DOD	Significant	0	12
Persanti Island	SC	Important	4	3
Santee State Park	SCPRT	Important	0	7
Webb Wildlife Center	SCDNR	Significant	11	30
Total			669	1239

* Population status from 2000 breeding season.

Populations of red-cockaded woodpeckers are distributed across the southeastern United States and managed by distinct recovery units, across which recovery criteria must be met for the species to be removed from the Endangered Species List. In South Carolina, there are recovery populations in 3 of the 13 recovery units. These recovery units are the Sandhills Recovery Unit, the Mid-Atlantic Coastal Plain Recovery Unit and the South Atlantic Coastal Plain Recovery Unit.



Habitat and Natural Community Requirements

Red-cockaded woodpeckers depend on open, park-like mature pine woodlands and savannahs with large old pines for nesting and foraging habitat. Large old pines are required because these birds excavate roost and nest cavities in living pine trees. The cavities are excavated completely within the heartwood; therefore, the trees must be old and large enough to have room for the cavity chamber. Additionally, old trees are more likely to have heartwood decay, which greatly facilitates cavity excavation. The cavity trees must be in open stands with little or no hardwood midstory and little or no hardwood in the canopy. Once the midstory reaches cavity height, red-cockaded woodpeckers typically abandon the cluster. Red-cockaded woodpeckers will use nearly all of the southern yellow pines for cavity trees, including loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), pond pine (*Pinus serotina*), slash pine (*Pinus elliottii*) and longleaf pine (*Pinus palustris*), but prefer longleaf pine (Jackson 1994).

Red-cockaded woodpeckers have very large foraging territories requiring vast areas of open pine habitat. Suitable foraging habitat consists of large mature pines, little or no midstory and abundant herbaceous ground cover including native bunchgrasses and forbs. Red-cockaded woodpeckers require 30 to 81 contiguous hectares (75 to 200 acres) of this foraging habitat, depending on the habitat quality. Red-cockaded woodpeckers prefer to forage on mature longleaf pine trees, but will forage on younger trees and other pine species and the occasional hardwood tree. High quality foraging habitat that results in the highest red-cockaded woodpecker productivity is contiguous open stands of mature longleaf pine with an herbaceous ground cover (Jackson 1994).

Red-cockaded woodpeckers evolved in a fire-dominated ecosystem. The history of fire in the southeast has both natural and human components. Fires were ignited naturally due to frequent lightning strikes. Both Native Americans and European settlers used fire to clear land and improve hunting grounds. Frequent fires resulted in an open forest with large pines, little to no midstory and diverse herbaceous ground cover; this represents the ideal habitat for red-cockaded woodpeckers and other species of the longleaf pine ecosystem. However, much of the currently available habitat has been subjected to fire suppression and has become unsuitable for red-cockaded woodpecker use due to the presence of a dense hardwood midstory and/or canopy. Fire is essential to maintaining and restoring southern pine ecosystems, particularly the longleaf pine

ecosystem, and is essential to red-cockaded woodpecker habitat maintenance and restoration (USFWS 2003).

Challenges

Lack of suitable habitat is the underlying cause for all the primary threats to red-cockaded woodpecker species viability. First, there is very little of the open mature pine habitat remaining. Over 97 percent of the longleaf pine habitat that covered the southeast has been destroyed. Of the remaining three percent, less than one percent is thought to be in pristine condition.

The serious threats from this lack of habitat fall into 4 basic categories (USFWS 2003):

1. insufficient number of existing suitable cavities and the continued net loss of cavity trees in the environment (Costa and Escano 1989; James 1995; Hardesty *et al.* 1995);
2. habitat fragmentation and the resulting impacts on genetic variation, dispersal, and demography (Conner and Rudolph 1991);
3. lack of sufficient amounts of quality foraging habitat (Walters *et al.* 2000, 2002; James *et al.* 2001); and
- 4 risks of extinction inherent to critically small populations (Shaffer 1981, 1987).

Red-cockaded woodpeckers depend on mature pine trees for both cavity excavation and foraging substrate. Lack of mature pine trees in suitable habitat because of past and present fire suppression and silvicultural practices resulted in a severe shortage of these trees in the landscape. Red-cockaded woodpecker groups that lack sufficient cavities for the group have been shown to decrease reproductive output. Decreased reproductive output has also been linked to an insufficient amount of quality foraging habitat. Habitat fragmentation reduces the ability for red-cockaded woodpeckers to disperse between clusters. This reduces the ability of individuals to find breeding vacancies, which influences both the genetic variation of populations and overall demographic stability. Most critically, small populations face an inherent set of risks related to the size of the population. These risks include extirpation due to random environmental, demographic, genetic and catastrophic events (Shaffer 1981, 1987).

The Longleaf Pine Heritage Preserve was purchased by the SCDNR for protection of the existing red-cockaded woodpecker population. The current size of the property is not large enough to support a self-sustaining population of red-cockaded woodpeckers. The purchase of additional lands would increase the available habitat and potential population size in that area.

In South Carolina, there are two primary threats that affect the availability of habitat, and, ultimately, red-cockaded woodpecker recovery now and in the future. The first is a lack of prescribed fire in existing and potential habitat. It has become increasingly difficult for private landowners and government agencies to burn their properties for wildlife management because of liability issues. Until this problem is solved, more and more landowners will opt not to conduct prescribed burning activities. The ultimate result will be less suitable habitat for red-cockaded woodpeckers and other wildlife.

The second major threat to red-cockaded woodpeckers in South Carolina is the risk of natural catastrophes, specifically hurricanes. Nearly all red-cockaded woodpeckers in South Carolina are present in the coastal plain and face significant risks from hurricanes. Cavity trees are particularly susceptible from winds associated with tropical weather systems and foraging habitat can be devastated from hurricane force winds (Conner *et al.* 2001).

Red-cockaded woodpecker surveys on DNR lands are ongoing; complete surveys should be conducted at least once every 10 years. Further, the last update to red-cockaded woodpecker status on private lands in South Carolina was conducted in the late 1980's to early 1990's. Private lands status should be updated periodically by field surveys and questionnaires to determine the current trend and management needs on private lands. This goal can largely be achieved by annual reports completed by Safe Harbor enrollees.

Currently, funding through Endangered Species Act Section 6 and other USFWS funding provide support for the red-cockaded woodpecker programs. However, the level of funding does not provide for habitat acquisition and major management projects as noted below.

Conservation Accomplishments

Conservation accomplishments can be divided into three major categories. The first relates to advances in understanding population dynamics and advances in management techniques related to stabilizing and increasing populations of red-cockaded woodpeckers. The second category results directly from the recovery plan for red-cockaded woodpeckers (USFWS 2003). The third category of accomplishments relates to the successful development and implementation of the Safe Harbor program in South Carolina.

Population Dynamics/Management

- Increased knowledge of population dynamics due to extensive research in South Carolina and across the southeast has led to better translocation procedures which facilitates red-cockaded woodpecker population growth range-wide.
- Cavity creation technology advanced allowing the unprecedented growth of existing populations and the creation of new populations through a combination of cavity creation and translocations.
- Due to these practices, most populations of red-cockaded woodpeckers on public lands were stabilized to increasing by the mid 1990's. Prior to these advances, all populations, with the exception of one, were declining.

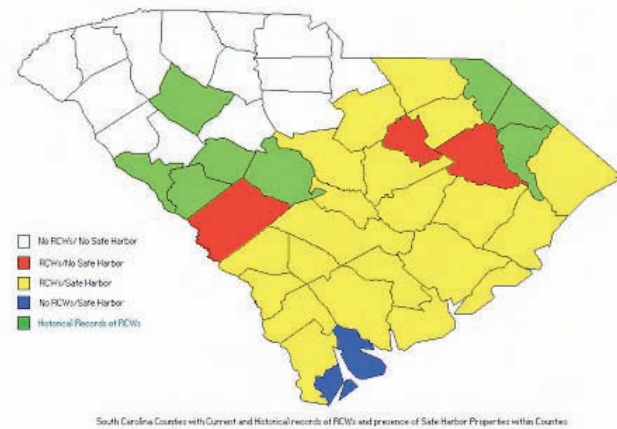
Red-cockaded Woodpecker Recovery Plan

- Drafts of the red-cockaded woodpecker recovery plan established required population goals for all federal properties and for one state property, Sandhills State Forest, and suggested goals for all other public properties in South Carolina. These established goals have resulted in population growth across all federal properties and most state properties.
- Recovery plan guidelines established standard practices for management and reporting, resulting in a consistent recovery effort range wide, including South Carolina.
- Recovery plan guidelines call for annual average growth rates of five percent on all recovery populations. These goals have been met on most properties, resulting in overall growth on public lands in South Carolina.
- Translocation, intensive habitat management and creation of recruitment clusters have yielded marked increases in many populations in recent years.

Safe Harbor Program

In March of 1998, the South Carolina Department of Natural Resources became the second agency to hold a statewide permit for a Safe Harbor Program in the nation. South Carolina's

Safe Harbor Program has been very successful with nearly 300 groups of red-cockaded woodpeckers and nearly 161,875 ha (400,000 acres) enrolled in the program. This represents nearly 75 percent of red-cockaded woodpeckers on private lands in South Carolina. Of these lands, over 36,422 ha (90,000 acres) have been committed to prescribed burning, over 21,448 ha (53,000 acres) have been committed to a program of mechanical midstory control, nearly 7,689 ha (19,000 acres) have been committed to a program of chemical midstory control and over 1,214 ha (3,000 acres) have been replanted to longleaf pine.



Key conservation accomplishments related to this program include the following:

- This program has ensured habitat maintenance and enhancement for nearly 300 groups of red-cockaded woodpeckers on private lands.
- This program has led to widespread reintroduction of fire to the landscape, thus maintaining and restoring critically imperiled longleaf pine habitat.
- This program has improved relationships between the private sector and government organizations, producing a cooperative effort toward conservation.
- Several thousand acres of forest that were previously planted with off-site species, such as loblolly pine, have been restored to longleaf.
- The program has been far reaching; 24 of 27 counties with recent records of red-cockaded woodpeckers have agreed to participate in this program.

Conservation Recommendations

- Consider purchase of properties adjacent to Longleaf Pine Heritage Preserve as they become available.
- Continue administration of the Safe Harbor Program by enrolling properties with significant red-cockaded woodpecker populations and/or longleaf pine habitat and offering technical/management support to landowners.
- Manage red-cockaded woodpecker habitat by adhering to the management objectives of the recovery plan for this species prepared by the USFWS (2003), including:
 - o Application of frequent fire to foraging and cluster habitat.
 - o Protection and development of large mature pines throughout the landscape.
 - o Protection of existing cavities and provisioning of artificial cavities as necessary to facilitate population growth or to stabilize existing populations.
 - o Creation of recruitment clusters to promote population growth.
 - o Restoration of sufficient habitat quality and quantity to support species recovery.

- When possible, provision artificial cavities in existing red-cockaded woodpecker populations on SCDNR land to stabilize and increase numbers of this species with the eventual objective of reaching the recovery goal for that population.
- Conduct studies to determine the actual effect of southern flying squirrels on red-cockaded woodpecker nesting and cavity use in populations of various sizes. Use studies of southern flying squirrel population dynamics and natural history to determine the most effective management techniques to deter any possible negative effects to red-cockaded woodpecker nest success and population growth.
- Monitor size and trend of populations on all state-owned properties on an annual basis including:
 - o Number of active cavities
 - o Number of potential breeding groups
- Monitor recovery population on Sandhills State Forest and Cheraw State Park more intensively including:
 - o Number of active cavity trees
 - o Number of potential breeding groups
 - o Number of actual nests including clutch size, number of chicks, number successfully fledged, and sex of all individuals
 - o Band all birds at these populations for monitoring purposes
- Monitor any birds translocated to or from state-owned properties to determine translocation success.
- Monitor any populations on state-owned properties donating birds for translocation to determine the effect on the donor population.
- Provide technical support to private landowners and other public land managers on issues of red-cockaded woodpecker management and recovery in cooperation with representatives of the USFWS.
- Conduct a workshop on red-cockaded woodpeckers for forestry and environmental consultants working in South Carolina. Topics covered should include survey and management techniques, the Safe Harbor application process and federal and state regulations as they relate to red-cockaded woodpeckers.
- Develop and maintain a red-cockaded woodpecker and Safe Harbor web site for SCDNR.
- Produce quarterly red-cockaded woodpecker newsletters for distribution to Safe Harbor participants, foresters and environmental consultants.

Measures of Success

If management recommendations are followed we should expect to see the following:

- Enrollment and maintenance of at least 300 groups of red-cockaded woodpeckers in the Safe Harbor Program.
- No net loss of red-cockaded woodpecker groups on private properties enrolled in the Safe Harbor Program.

- Recovery goals for red-cockaded woodpeckers will be met on all state-owned lands by the time of de-listing.
- Adequate monitoring and surveys will result in an accurate measure of red-cockaded woodpecker status and trends on public and private lands facilitating management decisions to make recovery goals.
- Outreach efforts will educate the public about issues relating to red-cockaded woodpecker management and legal responsibilities.

The overall result of these efforts will be that the red-cockaded woodpecker will meet recovery criteria in South Carolina, thus facilitating the removal of the species from the endangered species list.

Rock Outcrop Guild

Common Raven *Corvus corax principalis*

Dark-eyed Junco *Junco hyemalis*

Contributor: Ben Thatcher

Description

Taxonomy and Basic Description

The common raven is the largest North American passerine (Order: Passeriformes) at 689 to 1,625 g (24 to 57 ounces) (Boarman and Heinrich 1999). The dark-eyed junco is a much smaller North American passerine at 18 to 22g (0.63 to 0.77 ounces) (Nolan et al. 2002).

The common raven is glossy-black, with long, pointed wings and a wedge-shaped tail. The dark-eyed junco has a white belly, gray or blackish ‘hood’ and back, dark eyes and distinctive white outer tail feathers. Four subspecies of common raven occur in North America, with *C. c. principalis* resident from Alaska to Greenland, south to British Columbia and Saskatchewan and through the Appalachian Mountains (Boarman and Heinrich 1999).

The dark-eyed junco was formerly split into five distinct species. However, all of these are now lumped into one species (Nolan et al. 2002). The dark-eyed junco now informally consists of five distinctive “groups” encompassing 15 recognized subspecies. The southern Appalachian subspecies (*J. h. carolinensis*) of the slate-colored junco group is a resident in South Carolina, and another slate-colored junco subspecies, *J. h. hyemalis*, winters in the state (Nolan et al. 2002).

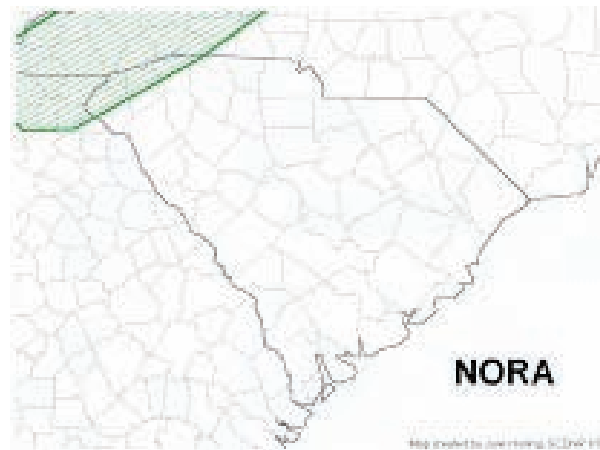
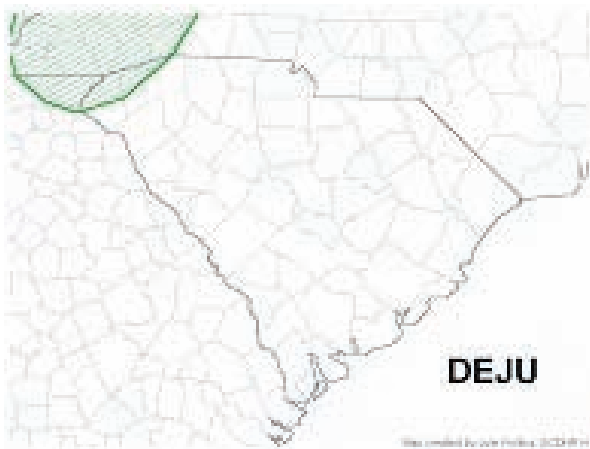
Status

Both the common raven and the dark-eyed junco are protected under the Migratory Bird Treaty Act but receive no special federal status. According to Partners in Flight, the common raven and the dark-eyed junco are low priority species within the southern Blue Ridge physiographic area (Hunter et al. 1999). However, they may be of local conservation concern in some states. They are not listed on the 2003 South Carolina Rare, Threatened & Endangered Species Inventory, but are of special interest to ornithologists in this state. The common raven is listed as threatened in Tennessee, as endangered in Kentucky and as extinct in New Jersey and Alabama (Boarman and Heinrich 1999). Based on these designations, South Carolina’s populations could be viewed as responsibility groups; hence the common raven is included on the priority list for the SC Comprehensive Wildlife Conservation Plan.

Population Distribution and Size

Global population size estimates are 260 to 630 million for the dark-eyed junco (Rich et al. 2004; Nolan et al. 2002) and 16 million for the common raven. Approximately 4 million ravens occur in the U.S. and Canada (Rich et al. 2004).

The common raven is resident from Alaska south to southern Mexico, from western Canada to Maine, and south along the Appalachians to northern Georgia (Boarman and Heinrich 1999). The dark-eyed junco breeds from Alaska south to northwest New Mexico, from western Canada to Maine, and south along the Appalachians to northern Georgia (Nolan et al. 2002).



The common raven is a resident in South Carolina (Boarman and Heinrich 1999) and breeds in Greenville County and possibly Pickens County (Cely 2003). The dark-eyed junco breeds in Oconee, Pickens and Greenville Counties and is likely a resident in extreme northwest South Carolina (Nolan et al. 2002). Populations of common raven and of (breeding) dark-eyed junco are apparently rare in the state. Southern Appalachian dark-eyed junco populations (*J. h. carolinensis*) are partial, altitudinal short-distance migrants. As such, some males remain near high-elevation

breeding territories during the winter, whereas females and some males move to lower elevations during this period (Nolan et al. 2002).

Habitat and Natural Community Requirements

The common raven occurs in a broad range of habitats, but prefers contoured landscapes with thermals for long-distance foraging and cliffs. This bird also requires trees or structures (buildings) for nesting (Boarman and Heinrich 1999). In the Southern Appalachians, the common raven often nests in the same areas as peregrine falcons. Most common raven nests in Tennessee and North Carolina are located on rock ledges and cliffs.

The dark-eyed junco often breeds in coniferous and deciduous forests, open woodlands and bogs. In the southern Appalachians, the dark-eyed junco is associated with eastern hemlock trees (Shriner 2001). Dark-eyed junco nest site characteristics are highly variable; however, nests are often on or near the ground in a small cavity on a sloping bank or rock-face. A nest can also be found among roots, under projecting rock or at bases of or elevated in trees. When nests do occur in trees, they are rarely located over 15 m (49 feet) in height (Nolan et al. 2002).

The common raven is a generalist omnivore that eats carrion, as well as eggs, freshly killed small animals, grains, insects, fruits and garbage (Boarman and Heinrich 1999). The common raven cannot open carcasses and relies on, and often follows, carnivores and scavengers (Boarman and Heinrich 1999).

The dark-eyed junco feeds mainly on seeds and arthropods taken from ground and leaf litter during the breeding season. During the winter, the junco will feed from the ground and low plants (Nolan et al. 2002).

Challenges

The common raven was likely formerly extirpated in South Carolina due to human persecution (Boarman and Heinrich 1999). The species may have been driven out of South Carolina, where it was shot for allegedly killing infant lambs (Boarman and Heinrich 1999). Logging may have also contributed to the species' decline in Virginia and Pennsylvania at the beginning of the twentieth century (Boarman and Heinrich 1999). Conversely, degradation of native habitat (development) likely contributed to common raven population increases in some areas due to increased food (human garbage), water (irrigation) and shelter (structures) (Boarman and Heinrich 1999).

The dark-eyed junco is currently an abundant species. However, predicted eastern hemlock declines due to the hemlock woolly adelgid are likely to have negative consequences on breeding populations of this species.

Conservation Accomplishments

In the early 1900s, common raven populations had decreased throughout eastern North America. However, by the 1950s, the populations had increased and the species had re-colonized sections of its previous range (Boarman and Heinrich 1999).

Conservation Recommendations

- Survey and monitor high elevation sites to determine the distribution, densities and nest survival rates of breeding common raven and dark-eyed junco populations in South Carolina.
- Evaluate ways to supplement natural re-colonization for the common raven to attain historic population densities.
- Monitor common raven and dark-eyed junco breeding sites and protect them from destruction or excessive human disturbance.
- Determine the amount and distribution of eastern hemlock in the state and the extent to which breeding dark-eyed junco populations use this habitat.

Measures of Success

As the above-mentioned action items are accomplished and yield valuable information, adaptive management procedures will be evaluated and implemented for these two bird species.

Ruffed Grouse

Bonasa umbellus

Contributor: Judy A. Barnes

Description

Taxonomy and Basic Description

Linnaeus first described the species in 1776. Since then, many subspecies have been named. Johnsgard (1983) distinguishes 11 subspecies; Atwater and Schnell (1989) list 12; and del Hoyo et al. (1994) recognizes 14 subspecies. The ruffed grouse is a gallinaceous bird in the order Galliformes and the Family Phasianidae, which includes grouse, quail, turkey and pheasants.

The ruffed grouse is a chicken-like bird that weighs about 500 grams (1.1 pounds.). The genus *Bonasa* means “good when roasted” in Latin and the specific epithet *umbellus* means “sunshade” referring to the long, shiny, black or chocolate colored neck feathers most prominent on the male. Males tend to be slightly larger than females and have a large tail that it fans to attract a mate or defend its territory. The female’s tail is similar but smaller and usually is the best external basis for determining sex (Gough 1998). Across most of its range, a fully-grown tail feather of over 14.9 cm (5.87 inches) in length usually belongs to a male; less than 14 cm (5.5 inches), a hen. Ruffed grouse have two or more color phases ranging from a grayish to a reddish-brown color. Red phased grouse become more prevalent in milder climates and gray birds are more abundant where winter climates are more severe. Male ruffed grouse are aggressively territorial throughout their adult lives and proclaim their area by a “drumming” display. The male usually stands on a log, stone or mound of dirt and beats his wings against the air to create a vacuum, creating a drumming sound. The substrate, often called a “drumming log,” is used strictly for a stage; the bird does not strike the “log” to make the sound (Rusch et al. 1999).

Chicks are precocial and are not much larger than a man’s thumb when they leave the nest. They are very mobile and begin flying when about five days old. The hen may lead her brood as far as four miles from the nest to a summer brood range during their first 10 days of life. By 17 weeks of life, the chicks have reached their adult weight and usually disperse to find their own home range at 18 weeks.

Status

According to Breeding Bird Surveys, ruffed grouse populations have been in decline throughout the Appalachian region over the past 35 years. Except for localized declines, ruffed grouse generally appear to be stable and secure in Canada and the western United States but numbers appear to be declining in the eastern United States (Atwater and Schnell 1989; Rusch et al. 1999).

Though the ruffed grouse is considered peripheral in South Carolina’s southern Appalachian ecoregion, eggs and young have recently been found in the vicinity of the Foothills Trail in Pickens County (Huckabee 2000). The species is included as a species of concern because South Carolina could provide more suitable habitat for ruffed grouse if disturbance regimes such as prescribed fire are used and early successional habitats are created within its mountain range.

Population Distribution and Size

Ruffed grouse is the most widely distributed upland game bird in North America (Gullion 1977). Its range spans from northern Georgia north through Labrador in the east, and west throughout

northern California into Alaska. In the central portion of the United States, ruffed grouse are found in the Great Lakes states north into Canada to the tree line (Gullion 1977). Trippensee (1948) described the range of ruffed grouse; according to his range map, this species did not occur in South Carolina. However, he reported that isolated units of the species still maintained themselves outside the indicated range. Nesbitt (1966) reported that though the literature did not disclose information regarding population levels and distribution, ruffed grouse did occur in the northwest mountain counties of Greenville, Pickens, and Oconee in South Carolina. Population numbers are relatively low in the southern and southwestern parts of its range. Average recorded densities are about eight drumming males or 22 adult birds per km² (56.9 birds per square mile) but good habitats are over represented in these studies (Rusch et al. 1999). Northern populations show approximately 10-year cycles. Other populations can exhibit significant year-to-year variation, largely dependent upon spring weather and its effects on brood production.

Densities vary between forest types. Throughout their range, ruffed grouse find most of their habitat needs in mixed age, upland hardwoods. In more northern reaches of their range, ruffed grouse are associated with aspen (*Populus tremuloides*) stands that meet all of their food and cover requirements (McDonald et al. 1998). In southern portions where aspen is sparse to absent, ruffed grouse are typically associated with upland oak (*Quercus* spp.) stands (Cole and Dimmick 1991).

Habitat and Natural Community Requirements

Ruffed grouse have four main habitat requirements: nesting cover, a “drumming log” for males, brood cover for females and fall/winter cover (Atwater and Schnell 1989). Proctor (2003) indicated that in the southern portions of their range where long-term snow cover is absent; ruffed grouse utilize other methods of winter cover for protection from predation and thermal insulation. During winter in the southern Appalachians, ruffed grouse can be found using evergreen thickets in the form of rhododendron (*Rhododendron* spp.) and mountain laurel (*Kalmia latifolia*). Not only do ruffed grouse seek refuge in such evergreen habitats, but also in the southern Appalachians, ruffed grouse often forage on the leaves and buds of Mountain laurel where the largely popular aspen trees of the north are absent (Stafford and Dimmick 1979). Ruffed grouse in Tennessee were found to utilize evergreen thickets comprised mainly of mountain laurel where desirable higher stem density stands were lacking (White and Dimmick 1978). Young clear-cuts, that provide tall and dense stands of sapling age trees, also provide excellent year round cover where ruffed grouse can find adequate food and protection from aerial predators. Literature concerning home range sizes of ruffed grouse varies widely, with differing tendencies in males and females. Densities of ruffed grouse and habitat quality also play a large role in determining average home range size for a particular area.

The Appalachian region is classified as oak-hickory or mixed-mesophytic forest associations; this classification is based on literature review, canopy tree composition and abundance data collected as part of the Appalachian Cooperative Grouse Research Project (ACGRP) (Tirpak, 2002 unpublished data) and a Relative Phenology Index. Oak-hickory forests are dominated by chestnut (*Quercus prinus*), white (*Q. alba*), northern red (*Q. rubra*), scarlet (*Q. coccinea*) and black (*Q. velutina*) oaks and shagbark (*Carya ovata*), pignut (*C. glabra*), mockernut (*C. tomentosa*) and bitternut (*C. cordiformis*) hickories. Mountain laurel and great rhododendron are important understory species. Dominant species on mixed-mesophytic sites are sugar (*Acer saccharum*) and red (*A. rubrum*) maple, yellow birch (*Betula alleghaniensis*), basswood (*Tilia Americana*), black (*Prunus serotina*) and pin (*P. pensylvanica*) cherry, yellow poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), beech (*Fagus grandifolia*), northern red oak and eastern hemlock (*Tsuga canadensis*).

The ACGRP (2004) reports the nutritional quality of ruffed grouse diet differs markedly between the core range and the Appalachian region. Throughout most of their range, ruffed grouse depend on aspen buds, twigs and catkins to meet their nutritional requirements. In contrast, ruffed grouse diets in the Appalachian region consist of the leaves and seeds of herbaceous plants, buds of beech, birch and cherry trees, acorns and the fruits of grape, greenbrier, and numerous other soft mast producers. In the Appalachian region, diets of grouse tend to be higher in tannin and phenol levels, which serve as potential toxins. Additionally, Appalachian diets tend to have lower protein levels than the diets of grouse in the northern United States and Canada. The poor nutritional quality of grouse diets in the Appalachian region may result in increased foraging time and predation risk, as well as decreased body condition, reproductive potential and chick survival.

Challenges

In the Appalachian region, habitat loss and degradation are the principle causes for ruffed grouse population declines. Fire suppression, maturing eastern deciduous forests, and lack of management practices involving timber harvest are major causes of habitat degradation and loss. The quantity and quality of ruffed grouse habitat has declined in recent decades in the Appalachian region (ACGRP 2004).

Although the ruffed grouse is still a popular game species, hunting mortality is considered compensatory to some extent and is not thought of as a major factor controlling grouse populations. In a recent study, it was reported that, on average, hunting accounted for only 12 percent of all mortality and ranged from 0 percent to 35 percent across sites and years. This study did not conclude or infer that hunting would be compensatory at higher harvest rates (ACGRP 2004).

Conservation Accomplishments

Prior to 1996, ruffed grouse management in the Appalachian region was based on research conducted in the northern United States and Canada. ACGRP was established in 1996 by state natural resource agencies to investigate potential factors limiting ruffed grouse populations in this region. Data were collected on twelve study sites in eight states over a six-year period. Partners in this project were varied and provided funding and personnel as well as study sites. Partners consisted of state wildlife agencies, universities and various foundations and conservation organizations.

The objectives of the ACGRP were to:

1. Estimate survival rates and identify limiting factors,
2. Estimate reproductive rates and identify limiting factors,
3. Determine if harvest mortality is compensatory or additive, and
4. Evaluate habitat selection and quality.

This enormous undertaking has provided much needed information for management of ruffed grouse habitat in the Appalachian region. State wildlife agencies now have critical information to develop management strategies to slow or stop the decline of ruffed grouse in the Appalachian region.

Another accomplishment was the purchase of the Jocassee Gorges and creation of the Franklin Gravelly Wildlife Management Area, a core area of South Carolina's grouse range.

Throughout the Appalachian region, land ownership varies and includes National Forest land, state public land and industrial land. In South Carolina, land ownership is similar and a majority

of potential grouse habitat will be protected by virtue of being within National Forests and state public land.

Conservation Recommendations

- Implement management practices developed through the ACGRP (2004) on DNR lands and encourage implementation of these practices on National Forests and other public lands within the state. These practices include:
 - o Maintain current ruffed grouse harvest levels and season; the current level of hunting pressure does not limit populations.
 - o In mixed-mesophytic areas, employ “traditional” early successional grouse management techniques that emphasize using timber harvest techniques that will provide a diversity of aged stands interspersed among mature forests.
 - o In oak-hickory dominated sites, forest management should strive to provide both food (acorns) and cover (early successional habitat) needs of grouse in close proximity. Clearcutting, shelterwood, two-age and group selection silviculture offers managers alternatives to create these contrasting needs of acorns from mature oak trees in association with cover from young stands.
 - o Manage roads gating and planting preferred herbaceous foods to supplement existing natural foods.
- Conduct surveys to evaluate ruffed grouse population response to habitat management.
- Partner with private landowners and interested constituents to publicize and implement the recommendations of the ACGRP.
- Continue to provide information on ruffed grouse in Small Game Habitat Management Programs for SC constituents.

Measures of Success

An observable increase in numbers of ruffed grouse within its range in South Carolina would be considered a sign of success of implementation of the above management practices. Surveying participants in Small Game Habitat Management Programs within the state to determine whether they are implementing management practices for ruffed grouse could assist in determining the success of those programs.

Sea Ducks

Black Scoter *Melanitta nigra*

White-winged Scoter *Melanitta fusca*

Contributor: Walt Rhodes

Description

Taxonomy and Basic Description

Black and white-winged scoters are classified in family Anatidae, subfamily Anatinae and tribe Mergini. The tribe Mergini is represented mostly by the sea ducks, although some species in this tribe will inhabit freshwater habitats. Species within this tribe are differentiated from the other tribe of diving ducks, Aythyini (bay ducks), because members do not breed until their

second year and complete elaborate courtship displays that bear little resemblance to other ducks (Bellrose 1980).

Black scoters weigh slightly more than 907 grams (2 pounds) and are just under 51 cm (20 inches) long. Male black scoters are completely black save for a yellow protuberance at the base of the bill. Juveniles of both sexes and adult females are brownish-black with lighter patches about the cheeks, chin and throat (Bordage and Savard 1995).

White-winged scoters are slightly heavier and larger than black scoters. Male white-winged scoters measure between 53 and 58 cm (20.4 and 22.8 inches) and weigh between 1,260 and 1,780 g (2.8 and 3.9 pounds). Females measure from 48.3 to 54.9 cm (19 to 21.6 in.) and weigh between 950 and 1,500 g (2.1 and 3.3 pounds). White-winged scoters are the easiest to identify of the three species of scoters that inhabit North America because of the conspicuous white speculum that contrasts against an otherwise all black wing. The other two species have a completely black wing. Male white-winged scoters feature a black bulbous base on the bill and a small white patch that curves below and behind the eye that helps distinguish them from other scoter species. Juvenile and female white-winged scoters can be separated by other scoters by bill and minor plumage differences. White-winged scoters of both sexes also have pinkish feet (Brown and Frederickson 1997).

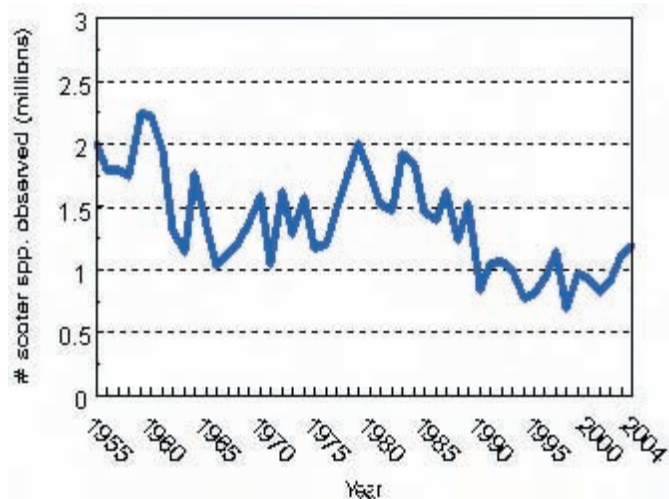
Status

Black and white-winged scoters are not federally listed species but are protected under the Migratory Bird Treaty Act. The North American Waterfowl Management Plan (2004) lists all scoter species as decreasing in numbers in North America.

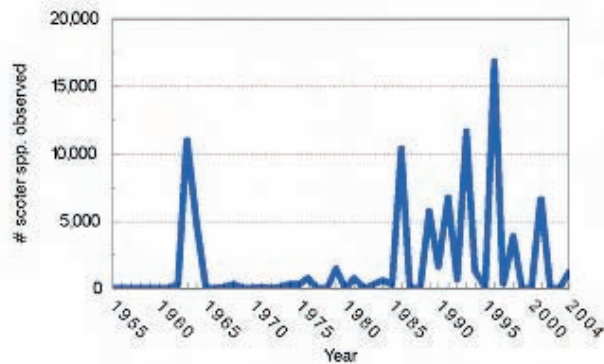
Population Distribution and Size

Population information for all scoters species has been lacking. However, recent research efforts have begun to provide a better understanding of breeding, molting and wintering ecology of these species.

Breeding grounds of the eastern population of black scoters are centered in northern Quebec (Bordage and Savard 1995); breeding populations have also been reported to the west of Hudson and James Bays. White-winged scoters nest from the prairies of North Dakota northwest across Canada and into Alaska. Some of the highest nesting densities of white-wings occur in the Northwest Territories near Great Slave Lake. Some surveys have been conducted on molting and staging areas. Canadian Wildlife Service surveys have found over 70,000 black scoters staging in the spring along the Restigouche River of New Brunswick and over 200,000 scoters (mostly black and surf scoters) in the St. Lawrence Estuary and Gulf. Surveys during molting have found around 50,000 scoters, mostly male surf and white-winged scoters, in the St. Lawrence Estuary (CWS 2004). Thousands of black scoters have been reported molting on James Bay (Ross 1994, Bordage and Savard 1995).



Number of scoters observed during the waterfowl breeding population and habitat survey, 1955-2004.



Number of scoters observed during midwinter waterfowl survey in South Carolina, 1955-2004.

Because it is difficult to differentiate among the three species of scoters from a fixed-winged aircraft, scoter species are lumped together during spring breeding surveys. Within the traditional area of the Waterfowl Breeding Population and Habitat Survey, scoters as a group appear to have declined. Scoters species are also noted in the Eastern Survey Area, a more recent breeding waterfowl survey conducted since 1990. Comparable estimates from 1996 through 2004 demonstrate an increased population, with estimates numbering over 200,000 birds (Serie and Raftovich 2004).

Some short-term data for individual scoter species is available from the Atlantic Coast

Sea Duck Survey. This survey, which follows a transect located a quarter of a mile off the coast from Maryland, including portions of Chesapeake Bay, to southern Georgia, has been conducted 10 of the last 14 years since 1991. Black scoters (number observed: 2,689-14,927) showed an increasing trend before leveling off in the late 1990's while white-winged scoters (number observed: 392-4,829) showed no trend. Black scoters were the most common species seen off of South Carolina (usually more than 1,000) while white-winged scoters were rare (less than 25) to non-existent (Serie and Raftovich 2004).

Christmas Bird Count and midwinter waterfowl survey data are also highly variable. Black scoters have been recorded every year since 1961 in Christmas bird counts. Numbers have ranged from 1 to 5,400 and averaged approximately 750 birds. White-winged scoters were observed much less frequently and in lower numbers. The first observation was of three white-winged scoters in 1940. The highest number documented on a Christmas bird count was 532 in 1983. White-winged scoters have been recorded in 17 of the last 25 counts but have typically numbered less than 25 birds. Scoters are not differentiated during the midwinter waterfowl survey but nearly all of the scoters seen are black scoters (W. Rhodes, pers. obs.). Scoter species numbers have been variable since 1955, with most birds seen during the last 20 years (the average is 3,500 birds). Post and Gauthreaux (1989) stated black scoters were an abundant winter visitor while white-winged scoters were uncommon. They note only a few sightings away from the coast for each species.

Habitat and Natural Community Requirements

Black and white-winged scoters are found in the littoral zone of the Atlantic Ocean off of the South Carolina coast. There is scant wintering information about either species in South Carolina. Studies conducted elsewhere in their wintering range determined that the birds feed primarily on benthic organisms, including mostly mollusks and some crustaceans. Locations of scoters seen during the midwinter waterfowl survey indicate that birds are usually in water less than 15 m (50 feet) deep and often shallower (W. Rhodes pers. obs.).

Challenges

Like other migratory birds wintering in South Carolina, black and white-winged scoters are subject to threats outside of the state that can affect their numbers locally. Within South Carolina,

they are faced with additional problems. Despite a long hunting season and liberal bag limit (107 days/4 birds), there appears to be no interest in hunting scoters in South Carolina. Harvest survey estimates have been zero for nearly every season since 1961 for both black and white-winged scoters (Serie and Raftovich 2002, 2004). Lack of hunter harvest is a problem because the majority of studies that estimate population levels and trends are based on data collected from hunter harvest birds.

Because the Port of Charleston is currently the fourth largest port in the U.S., shipping traffic is tremendous. Scoters are at risk from oil spills and exotic benthic species introductions from ballast water discharges related to shipping traffic. Coastal tourism is a major industry in South Carolina and beach renourishment is common along the coast. Often, source sites to mine sand are offshore in habitats (water depths) frequented by scoter species. It is not known what impact this activity has on scoters from a disturbance, roosting or feeding standpoint. Further, harmful algal blooms have been documented along the South Carolina coast. These outbreaks could negatively affect scoter food resources regardless of their timing.

Conservation Accomplishments

Aerial surveys as part of the Atlantic flyway midwinter waterfowl survey have captured the presence of scoter species wintering in South Carolina; however, data is not recorded by species. Land-based Christmas bird counts have documented the occurrence of black and white-winged scoters in the state.

Conservation Recommendations

- Establish annual surveys to document black and white-winged scoter numbers and distribution.
- Research black and white-winged scoter populations that winter off of the South Carolina Coast.
- Establish baseline data on migration timing, population size and distribution/location of scoters during winter.
- Partner with Sea Duck Joint Venture and other groups to meet research objectives.
- Monitor water quality and benthic organisms in offshore habitats used by scoter species.
- Continue to maintain a rapid response procedure to oil spills, including documentation of effects to scoter species and rehabilitation.
- Ensure adequate regulations are in place to protect offshore habitats utilized by scoter species.

Measures of Success

Little is known about black and white-winged scoter populations that winter off of the South Carolina coast. Obtaining baseline information, such as migration timing, population size and distribution/location of the birds during winter, would be considered a measure of success for these species.

Seaside Sparrow

Ammodramus maritimus

Contributors: John E. Cely and Dennis M. Forsythe

Description

Taxonomy and Basic Description

The seaside sparrow is a geographically variable species within the order Passeriformes (perching birds), family Emberizidae (AOU 1998).

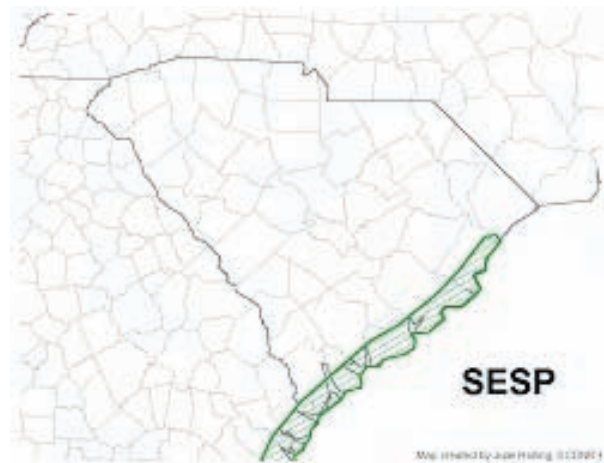
The seaside sparrow is olive-gray to olive-brown, has a relatively long bill and short, sharp tail. The back and breast are streaked, but not always conspicuously so. The facial pattern is distinctive with the supraloral spot and supercillium yellow from above the eye to the bill and a pale sub-moustachial stripe. The malar stripe is dark and the throat pale. These birds are about 12.5 to 15 cm (5 to 6 inches) in length and weigh about 24.2 g (0.85 ounces). Males are slightly larger with sexes similar in coloration (Rising 1996).

Status

The seaside sparrow is designated as a high priority landbird by South Carolina Partners in Flight (PIF) and South Atlantic Migratory Bird Initiative (SAMBI). A Florida subspecies, the dusky seaside sparrow, *A. m. nigrescens*, is now extinct, while the Cape Sable seaside sparrow (*A. m. mirabilis*) is critically endangered.

Population Distribution and Size

This species occupies a very narrow strip of salt and brackish marsh along the outer coastal plain "tidewater region." Post and Gauthreaux (1989) gives its status as "resident, fairly common in summer and common in winter. Apparently, winter numbers are augmented by migrants from further north." Typically, the breeding birds belong to the dark subspecies *A. m. macgillivraii* while additional wintering birds belong to the lighter subspecies *A. m. maritimus*. This species has also been found nesting in coastal marshes as far inland as the town of Hanahan near Goose Creek, South Carolina.



Because the seaside sparrow is poorly sampled by the BBS, due to its inaccessible habitat, there are no trend figures or objectives for South Carolina.

Habitat and Natural Community Requirements

The seaside sparrow is found exclusively in salt and brackish marshes consisting of cord grasses (*Spartina* spp.), true rushes (*Juncus* spp.) and bulrushes (*Scirpus* spp.). Post and Gauthreaux (1989) note that in order to avoid extreme tidal fluctuations, seaside sparrows move up the estuaries to nest. Significant populations occur in black needle-rush marshes at the Tom Yawkey Wildlife Center, Cape Romain National Wildlife Refuge, and other areas featuring extensive coastal marsh.

Challenges

While the seaside sparrow has one of the most restrictive breeding ranges of any passerine, its habitat has one of the most stringent regulatory protections of any type in the country. Prior to the enactment of tidelands protection, some seaside sparrow populations had been severely impacted by salt marsh ditching and possibly pesticide spraying for mosquito control. Post and Greenlaw (1994) suggest the species can serve as an indicator of coastal marsh ecological integrity.

Post and Greenlaw (1994) note that southern populations, such as found in South Carolina, suffer high nest predation rates from rodents.

Most seaside sparrow research has been conducted in the northeast and Florida. Currently, demographic research on the seaside sparrow is being conducted at Stono and Headquarters Islands. However, basic information on demographics, nesting habitat, site fidelity, predation and other biological parameters are needed. Monitoring techniques should be a high priority, as the species does not lend itself to traditional sampling methods.

Conservation Accomplishments

Other than habitat protection measures through regulation, acquisition, and easements, no conservation/research measures specifically directed to seaside sparrows have been enacted.

Conservation Recommendations

- Maintain current regulations and statutes protecting tidal wetlands.
- Where possible, restore ditched and altered marshes.
- Control predators in areas of high seaside sparrow nest predation.
- Support efforts to collect basic information on demographics, nesting, habitat, site fidelity, predation and other biological parameters.
- Inform the public and constituents about research and survey results and habitat needs, as this species is little known to the general public.

Measures of Success

Stabilization or increases in populations would be considered successes. This may be accomplished through proper monitoring techniques and habitat protection.

Swallow-tailed Kite

Elanoides forficatus

Contributor: John E. Cely

Description

Taxonomy and Basic Description

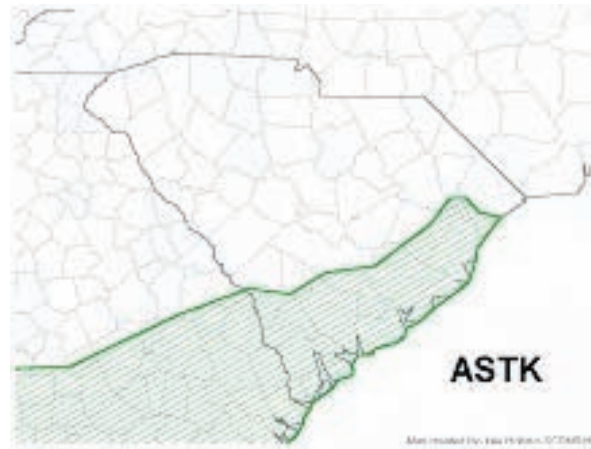
The swallow-tailed kite, first named by Linnaeus in 1758, underwent a common name change in 1999 from American swallow-tailed kite back to simply swallow-tailed kite, the original name. This bird is unmistakable with its narrow, 1.2 m (4 feet) wingspan and long; 25.4 cm (10 inch) forked outer tail feathers. The dorsal coloration is black while the head and underparts are white. Average weight for adults is a little over 454 g (1 pound), with females being slightly heavier than males. This bird spends much of the day in flight catching insects and other foods, including anoles, treefrogs, small snakes and nestling birds. It eats, drinks and bathes on the wing.

Status

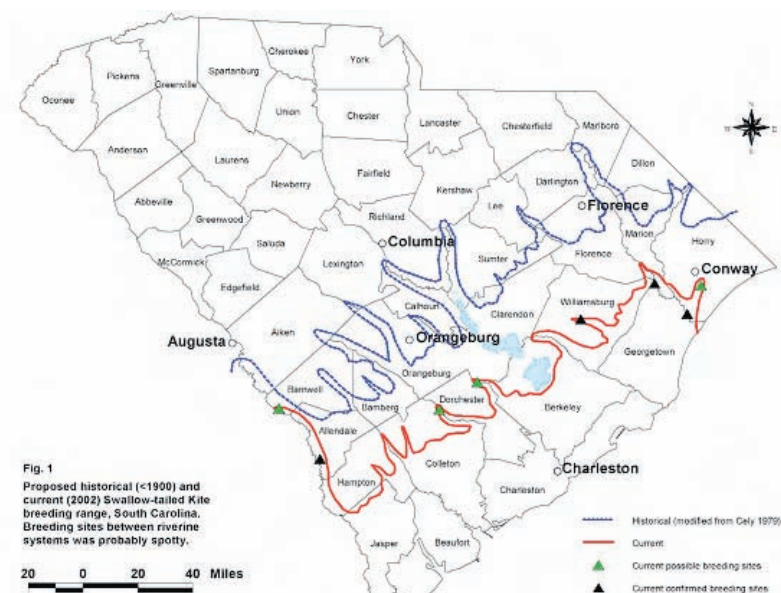
Currently, the kite occupies a remnant breeding range of seven, possibly eight, southern states that historically included at least 21 states as far north as Minnesota (Cely 1979). It is state-listed by South Carolina Department of Natural Resources (SCDNR) as an endangered species and a high priority species of concern by Partners in Flight (PIF).

Population Distribution and Size

The swallow-tailed kite is found in floodplain forests and other large tracts of forested wetlands/mixed pine habitats of the outer coastal plain (OCP) from South Carolina to east Texas. At least one unsuccessful nesting attempt was documented in 2002 in Arkansas's White River bottoms, approximately 321.8 km (200 miles) north of the nearest nesting population (Bednarz, personal communication). There was a possible range extension into coastal North Carolina at the Cape Fear River in 2003. The estimated population for the entire U.S. is 800 to 1,150 pairs (Cely and Sorrow 1990); about 60 to 65 percent of these birds reside in Florida (Meyer 1995). The estimated number of breeding pairs in South Carolina is 120 to 170; these are primarily found in large floodplain forests and swamps of the OCP, with significant populations occurring on the lower Great Pee Dee, Santee, Edisto and Savannah Rivers and in the Francis Marion National Forest (FMNF).



The disappearance of the swallow-tailed kite from three-fourths of its U.S. breeding range between 1880 and 1910 was one of the most dramatic range contractions of any bird before the post-WW II peregrine falcon crash. Since about 1940, populations have apparently stabilized with some evidence of a modest range expansion into former habitat, such as eastern Texas and parts of coastal South Carolina. Due to limited samples, no reliable trend data from the Breeding Bird Survey (BBS) is available.



Habitat and Natural Community Requirements

The kite is closely associated with large tracts of forested wetlands of the OCP, such as those found at the FMNF and along the lower Savannah, Edisto, Santee and Great Pee Dee Rivers. It shows a strong preference for nesting in dominant or codominant loblolly pines (*Pinus taeda*) growing within or on the edges of wetland forests. However, kites will regularly use bald cypress (*Taxodium distichum*) when pines are unavailable. Kites have also been recorded nesting in water tupelo (*Nyssa aquatica*), sweetgum (*Liquidamber styraciflua*) and willow oak (*Quercus phellos*).

The average dimensions of loblolly pine nest trees at the FMNF were 32 m (104 feet) tall and 49 cm (19 inches) diameter breast height (dbh). Pines were located within pine stands averaging 13.5 m²/ha (60 square feet) basal area/acre and were 61 years of age (Cely and Sorrow 1990). Dimensions for cypress nest trees were similar to the pines; these trees had an average height of 29 m (96 feet), with a diameter above the swell of 50.5 cm (20 inches) and a basal area of 13.5 m²/ha (60 square feet). Cypress ages were not determined but all were at least second, if not third, growth and probably no more than 75 years of age (Cely, unpublished data). Nest trees were only slightly larger than surrounding trees. The average distance to a waterway for kite nests in South Carolina was 135 m (455 feet), but this distance ranged from 25 to 544 m (82 to 1,795 feet) (Cely and Day, unpublished data). As Spanish moss (*Tillandsia usenoides*) is a key component of nest construction, this epiphyte may be a necessary ecological requirement.

Based on telemetry research, swallow-tailed kites have a large home range that encompasses thousands of acres (Cely and Sorrow 1990). Foraging birds use a variety of stand types and ages and will often commute long distances, up to 24 km (15 miles), from the nest site, to feed on various insects. These include beetles, dragonflies and grasshoppers associated with upland fields, pastures and freshwater marshes. Other swallow-tailed kites are attracted to “hot spots” of insect abundance; feeding aggregations sometimes consist of more than 50 birds.

Challenges

Although there appears to be suitable, but unoccupied habitat in South Carolina, primary challenges to the swallow-tailed kite are wetland loss and drainage. The kite’s social behavior, resulting in a clumped distribution of “nest neighborhoods,” may limit its ability to disperse to unused habitat. Most nest sites occur on private lands; although the species is apparently compatible with some forest management practices, as evidenced by its current use of industrial forest lands, extensive clear-cutting and short rotations are likely problematic for this species.

Specific threats along its migration routes and wintering grounds in southern Brazil are unknown at this time, but significant land use changes could negatively impact the species.

Because the species feeds relatively low on the food chain, there is a concern about a suspected vulnerability to persistent pesticides and reproductive failures such as found with peregrine falcons, bald eagles and osprey. However, there is no evidence to date to indicate such vulnerability. Shooting mortality could have played a role in the extirpation of local populations in the late 1800’s and early 1900’s (Cely 1979; Meyer 1995).

Conservation Accomplishments

Considerable research efforts have been directed towards the species during the past 15 to 20 years, notably in Florida, but also in South Carolina, Georgia and Louisiana. In South Carolina, initial efforts focused on using radio telemetry to locate nests, determine productivity, describe nesting habitat and quantify home range and habitat use. Within the past eight years, telemetry

research has been coordinated with other states and investigators to focus on annual survival, natal site fidelity, migration routes and wintering locations.

In some instances, nest site information has increased land acquisition incentives and protection efforts, such as at the Waccamaw National Wildlife Refuge and the lower Santee/FMNF. Because of the species' large home range, it could serve as an umbrella species for the conservation of other area-sensitive wetland wildlife including neotropical migrants, barred owls, red-shouldered hawks, pileated woodpeckers, river otter and black bear.

Conservation Recommendations

- Incorporate swallow-tailed kite nest locations into land management and protection efforts.
- Encourage the use of Streamside Management Zones (SMZs) to protect swallow-tailed kite nests that are close to a river or stream.
- Increase the estimated number of protected swallow-tailed kite nests and nest sites through increases in public ownership, easements, Memoranda of Understanding and fee simple purchase.
- Whenever possible, work with land managers and foresters and provide guidelines, based on current habitat descriptions, to protect swallow-tailed kite nest sites during timber harvest operations.
- Begin studies of demographics, nesting habitat, effects of disturbance and habitat alteration in order to develop more specific swallow-tailed kite management guidelines.
- Collaborate with other states in monitoring and researching current swallow-tailed kite populations and their demographics
- Assist with development of a feasible swallow-tailed kite monitoring method that would detect a population decrease in the state over a 10 to 15 year period.
- Work with the general public, NGOs, volunteers, other state and federal agencies, timber companies and private landowners to share results, generate support and increase partnerships for the protection of swallow-tailed kites.

Measures of Success

A recovery goal has been established at approximately 100 birds per river drainage in the species' range. South Carolina's portion of this goal is approximately 400 nesting pairs statewide. The areas most likely to contain swallow-tailed kites are the Pee Dee and Savannah Rivers, Francis Marion National Forest, the ACE Basin and associated floodplains.

Tundra Swan

Cygnus columbianus

Contributor: Walt Rhodes

Description

Taxonomy and Basic Description

Tundra swans are the largest migratory waterfowl species found in South Carolina and measures over 48 cm (4 feet) long with an average weight for adults and immatures of 2.8 and 2.6 kg

(16 and 13 pounds), respectively. The bird is characterized by its distinctive long, straight neck, black bill, all-white plumage and unique call. Immature tundra swans feature a gray plumage and pinkish bill. Each trait is replaced with adult characteristics by the end of their first winter. Tundra swans can be distinguished from snow geese and white pelicans by the lack of black wingtips and from feral mute swans, which feature a S-curved neck and orange bill. Differentiation from trumpeter swans is more difficult. Both species have all-white plumage but a trumpeter is much larger and has a more vociferous call. True segregation can be accomplished by dissection. A trumpeter swan has a more convoluted windpipe, including a vertical loop, than a tundra swan (Limpert and Earnst 1994).

Tundra swans are classified in family Anatidae, subfamily Anserinae and tribe Anserini. They are classified in this tribe along with six other species of swans found in the world and true geese. This tribe is characterized by similar plumage and voice of the sexes, one annual molt, lifelong pair bonds, simple courtship displays, sexual maturity at 2 or 3 years and care of the young by both sexes (Bellrose 1980).

Status

Tundra swans are not a federally listed species but are protected under the Migratory Bird Treaty Act.

Population Distribution and Size

There are two populations of tundra swans in North America. The western population, numbering around 100,000 birds, breeds primarily in western Alaska and migrates through western Canada to wintering areas in California, Utah and the Pacific Northwest. The eastern population breeds from the Seward Peninsula of Alaska eastward to northern Hudson Bay and Baffin Island, with a major concentration in the Mackenzie River Delta. The birds migrate through a narrow corridor of prairie Canada and the Great Lakes before reaching the wintering grounds along the mid-Atlantic coast from Maryland to South Carolina.

The eastern population of tundra swans numbers approximately 100,000 birds and has increased by an average of 3 percent annually over the last 10 years (USFWS 2004). Historically, the majority of these birds wintered in the Chesapeake Bay region, but a shift began during the 1980's, as much as 75 percent of the population now winters in coastal North Carolina. Reasons for the shift were decline in submerged aquatic vegetation and competition from expanding mute swan populations in the Chesapeake Bay. Post and Gautreaux (1989) list tundra swans as a rare winter visitor on the coastal plain and very rare in the piedmont of South Carolina. The number of tundra swans observed during the Atlantic flyway midwinter waterfowl survey has seen an increase to 250 swans since 2000 (Serie and Raftovich 2004).

Habitat and Natural Community Requirements

Tundra swans feed largely on leaves, seeds, stems and tubers of aquatic and marsh plants. In the mid-Atlantic region, they routinely feed in agricultural fields. Nearly all tundra swans in South Carolina are found on brackish (5 to 20 ppt) managed wetlands in the ACE Basin, primarily near Bear Island Wildlife Management Area, with scattered sightings on the same habitats north of Charleston. These wetland types are characterized by populations of widgeongrass (*Ruppia maritima*), saltmarsh bulrush (*Scirpus robustus*) and dwarf spikerush (*Eleocharis parvula*). Managed wetlands probably provide the entire winter habitat needs (foraging/roosting) of tundra swans in South Carolina since the birds are rarely observed elsewhere.

Challenges

Being a very large bird, tundra swans have few natural predators. However, tundra swans spend half of their annual cycle on migration (Petrie and Wilcox 2003), where they face considerable challenges, such as staging area degradation, collisions and disease. Eastern population tundra swans are hunted, but there appears to be no negative effects since the population has been increasing. The reported harvest in 2003 was 2,861 swans, which is below the 1999 through 2003 average of 3,397 birds.

Tundra swans are not hunted in South Carolina and their main threat is habitat related. Swans appear to spend the entire winter on managed wetlands, habitat types that are very dynamic, costly to maintain, have stringent permitting requirements and require diligence to properly manage. Currently, there are approximately 28,000 hectares (70,000 acres) of managed wetlands in coastal South Carolina. These habitats are both publicly and privately owned, and swans are located across ownership types. The needs of wintering tundra swans appear to be met today but the conservation and continued proper management of managed wetlands is imperative for the future.

Conservation Accomplishments

Aerial surveys as part of the Atlantic flyway midwinter waterfowl survey have detected the presence of tundra swans wintering in South Carolina. Land-based Christmas bird counts have likewise documented the occurrence of tundra swans in the state. So far, habitat preferences have been anecdotally documented for the state by the South Carolina Department of Natural Resources (SCDNR). Finally, portions of habitats used by wintering tundra swans are protected by state and federal ownership.

Conservation Recommendations

- Maintain properly managed wetlands in the tundra swan's core wintering area.
- Initiate appropriate research projects for tundra swans as management needs arise.
- Ensure adequate funding for maintenance of managed wetlands under public ownership.
- Provide technical assistance to private landowners of brackish water managed wetlands.
- Continue closed hunting season of tundra swans in South Carolina.
- Monitor water quality and waterfowl disease potential on managed wetlands, especially if hand-reared mallard populations increase.
- Better document habitat use, activity budgets and migration arrival and departure to ensure appropriate supervision of managed wetlands.
- Continue to record the presence/absence and abundance of tundra swans in the state under a coordinated survey effort.

Measures of Success

Appropriate research projects will be initiated as management needs arise for tundra swans. As with most migratory bird species, little, if anything can be done to force tundra swans to migrate to South Carolina; however, ensuring that adequate habitats exist is vital for the long-term success of the species in the state.

Waterfowl and Allies Guild

Dabbling Ducks

Mallard *Anas platyrhynchos*

Black Duck *Anas rubripes*

Northern Pintail *Anas acuta*

Blue-winged Teal *Anas discors*

Mottled duck *Anas fulgiva*

Allies

Common Loon *Gavia immer*

Horned Grebe *Podiceps auritus*

Contributor: Robert D. Perry

Description

Taxonomy and Basic Description

Dabbling Ducks: Mallards and black ducks are similar in size; adult males weigh approximately 1.25 kg (2.75 pounds). Northern pintails are smaller, longer and more slender than mallards and black ducks; adult pintail males weigh 1.03 kg (2.26 pounds). Blue-winged teal are of the smallest of waterfowl; adult males weigh 0.46 kg (1.02 pounds) (Bellrose 1980). Mottled ducks are of similar size and body weight as mallards and black ducks.

One of the most widely recognized of all waterfowl, winter mallard drakes have an iridescent green head and predominantly gray body with a chestnut colored chest. Mallard hens are straw-brown with streaks of dark brown in winter. On the wing, the violet blue speculum bordered by a pronounced white stripe identifies the mallard in any plumage. Both sexes of black ducks have a sooty-brown, splotched plumage considerably darker than the mallard hen. Black duck speculum colors are metallic purple to metallic green without borders. In winter, adult male northern pintails are easily identified by long and pointed, black sprig-like tail feathers and a chocolate-brown head. Hen pintails are dusky-brown with noticeably lighter streaks and short, pointed tail feathers. Blue-winged teal drakes are identified by a steel-blue head and neck with a white, crescent shaped stripe anterior to the eye in the winter. Blue-winged teal hens are mottled-brown all over throughout the year. Both sexes have predominant chalk-blue shoulder patches. Mottled duck plumage is intermediate between a black duck and a hen mallard, and speculum colors vary as do those of black ducks. Proper identification of a mottled duck at hand typically requires examination by trained personnel to distinguish it from a black duck. During the period May-October large, dark waterfowl observed near salt or brackish marsh generally would be mottled ducks since they are non-migratory and mallards or black ducks would not be present in South Carolina during this time frame (Bellrose 1980).

Common Loon. Common loons are larger water birds than dabbling ducks and weigh up to 1.6 kg (3.53 pounds). Common loons swim low in the water; often the entire body is under water and only the neck and head are emerged. The straight, thick, pointed bill is gray in winter. The predominant winter color of common loons is evenly gray on the head and back with a white neck and underside. Males and females are descriptively similar except that males are typically larger (Rimmer 1992; McIntyre and Barr 1997).

Horned Grebe. Horned grebes resemble small, compact ducks, but they have short, pointed bills. They weigh only 0.3 to 0.5 kg (0.66 to 1.10 pounds). The winter plumage of horned grebes is drab with white cheeks, throat and breast. The crown, nape of neck and back are darker. Male and female horned grebes look alike, but males are often considerably larger (Stedman 2000; Handford and Kirschbaum 2001).

Status

Dabbling Ducks. Mallards, black ducks, Northern pintails and blue-winged teal are high priority waterfowl species as identified by the North American Waterfowl Management Plan (NAWMP). Mallards and blue-winged teal generally are considered species with increasing or stable continental population status trends. However, recent declines have been noted in both species in South Carolina (Perry et al. 2005). Declines in South Carolina wintering mallard populations were concurrent with continental and Atlantic flyway population declines of the mid-1980's (Gordon et al. 1989; Smith and Reynolds 1992). Black ducks and northern pintails both have decreasing population status rangewide (NAWMP 1998). Mottled ducks are non-migratory in SC; little data are available to accurately quantify the status of mottled ducks along the South Atlantic coast. Harvest data and field observation indicate mottled duck populations appear to be stable along coastal South Carolina.

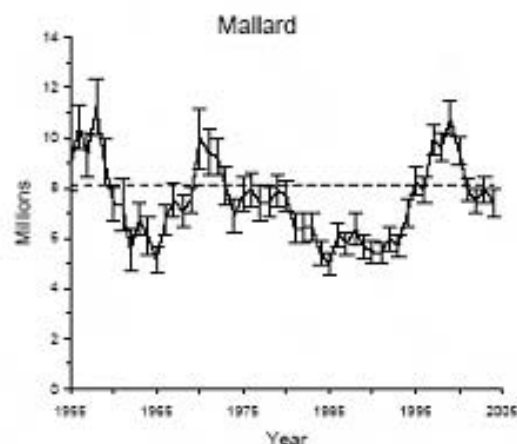
Common Loon. McIntyre and Barr (1997) indicated that North American Breeding Bird Survey data demonstrate increases in common loon productivity over a 20-year period, from 1970 through 1989. Baselines documenting wintering population numbers, however, are not well established. Basic information on population demography and factors limiting expansion of common loon populations are not well understood and need further study (Rimmer 1992; McIntyre and Barr 1997).

Horned Grebe. Kaufman (1996) indicated horned grebes appear to have declined in recent decades. The lack of data documenting the population status of horned grebes makes it difficult to accurately determine their status. As in the case of common loons, baseline numbers documenting wintering population status of horned grebes are not well established.

Population Distribution and Size

Dabbling Ducks. Continental waterfowl populations, including species for which South Carolina provides important wintering habitat, are estimated annually in North America using a complex set of related aerial and ground surveys that determine habitat conditions and numbers of breeding ducks. Mottled ducks are non-migratory waterfowl native to and typically located along coastal areas of Alabama, Louisiana and Texas. Mottled ducks were introduced to South Carolina during the late 1970's, and they occur along coastal marshes descriptively similar to those of coastal Louisiana and Texas (Cowardin et. al. 1979; Stutzenbaker 1989).

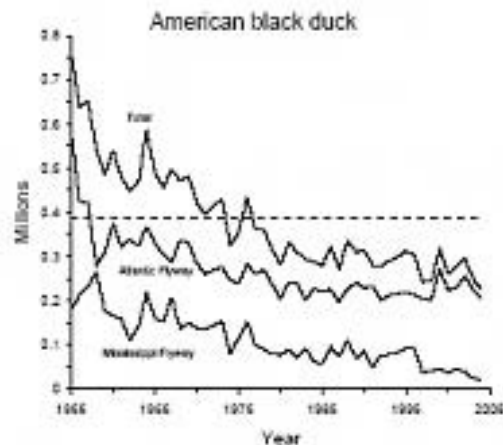
Mallard populations wintering in South Carolina originate in distinct breeding population reference areas; the majority of mallards wintering in this state appear to originate from the mid-continent



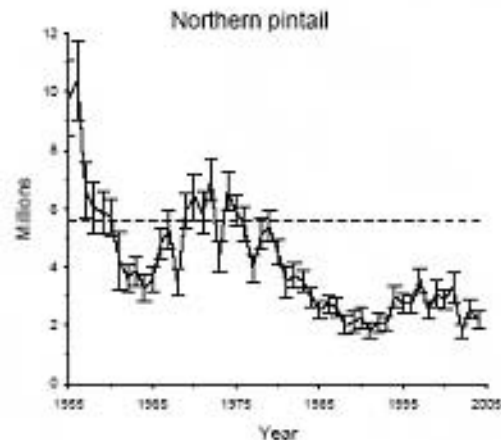
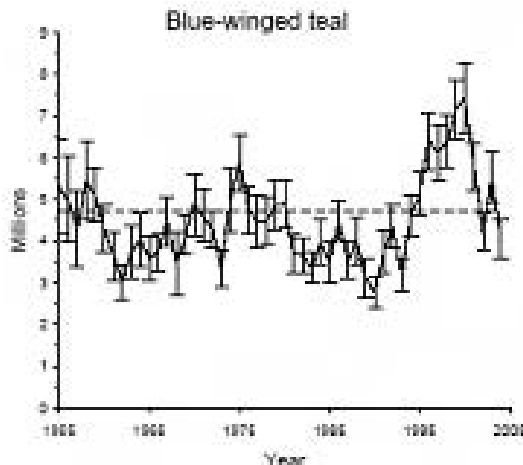
reference area that encompasses the western and central Great Lakes areas and the traditional prairie-pothole regions of the north-central United States and south-central Canada. Fewer mallards that winter in South Carolina originate from eastern Canada (Bellrose 1980; Bellrose and Crompton 1970; Munro and Kimball 1982; Nichols and Hines 1987; Sheaffer and Malecki 1996). Mallard production between 1955 and 2004 and the associated NAWMP population goal for this species are depicted in the adjacent graph (USFWS 2004).

South Carolina wintering black ducks originate primarily from eastern Canada (Bellrose 1980; Bellrose and Crompton 1970; Kirby 1988; Blandin 1992).

Conroy et al. (2002) indicate continental black duck populations declined greatly during the period from 1950 through 1970, but have stabilized somewhat since then. In an extensive review and modeling exercise Conroy et al. (2002) could neither resolve which factors contributed to black duck declines, nor determine the management actions necessary to stabilize or increase black duck populations. Black duck production between 1955 and 2004 and the associated NAWMP population goal for this species are depicted in the adjacent graph (USFWS 2004).



South Carolina wintering northern pintails originate from the mid-continent reference area and areas eastward in Canada toward James Bay (Bellrose 1980). Johnson and Grier 1988) suggested that northern pintails entering production grounds in spring from the southern portal, including the South Atlantic Flyway, settle in the mid-continent. The mid-continent prairie-pothole region has suffered more from drought than any other area important to waterfowl production. Droughts, therefore, have adversely affected northern pintail populations more so than any other species of waterfowl (Smith 1970;



Derksen and Eldridge 1980; Johnson and Grier 1988; Hestbeck 1995). Breeding populations of northern pintails are of special concern for all waterfowl enthusiasts (NAWMP 1998). Northern pintail production between 1955 and 2004 and the associated NAWMP population goal for this species are depicted in the adjacent graph (USFWS 2004).

The impact of drought in North American mid-continent regions lowers recruitment and survival of blue-winged teal (Sousa 1985). Johnson and Grier (1988) demonstrated that blue-winged teal are not philopatric. However, they are strong pioneers; blue-

winged teal have been reported nesting well outside their normal breeding range in response to newly flooded habitat (Bellrose 1980). Recent improvement in blue-winged teal productivity may be based on the ability of this species to adapt to a changing environment. Blue-winged teal production between 1955 and 2004 and the associated NAWMP population goal for the species are depicted in the adjacent graph (USFWS 2004).

Recent mid-winter waterfowl inventory (MWI) trends indicate relatively stable South Carolina wintering mallard populations after substantial declines in their wintering numbers over a two-decade period. Counts obtained through the MWI include an average of 3,259 mallards per year between 1999 and 2004. Numbers of wintering black ducks have also stabilized in South Carolina; an average of 860 black ducks per year have been observed from 1999 through 2004. Black ducks are believed to be under-represented in MWI estimates because they tend to be distributed in expansive emergent, tidal salt marsh; such areas are not usually included in MWI survey routes. There has been a substantial decline in wintering populations of northern pintails in South Carolina since 1985. MWI counts from 1999 through 2004 estimate that an average of 5,518 northern pintails primarily used traditional habitats along coastal South Carolina in managed brackish wetlands. Blue-winged teal also winter primarily along coastal South Carolina in managed fresh and brackish wetlands, from 1999 through 2004, an average of 1,490 blue-winged teal were counted per year during MWIs.

Very little data exist on productivity of mottled ducks in South Carolina. Periodic summer surveys have been conducted indicating relative stability of mottled duck populations along coastal areas (SCDNR unpublished data). There are no reliable winter population data for mottled ducks in South Carolina since observers often lump the few mottled ducks observed along with black duck tallies.

Common Loon. Common loons spend much of their time in Canada; world population was estimated to number between 500,000 to 700,000 individuals in the mid-1990s (Rose and Scott 1996, cited in McIntyre and Barr 1997). Large declines in breeding populations were recorded in the northeastern US from 1971 through 1990 (Rimmer 1992). However, Droegge and Sauer (1990, cited in Rimmer 1992) documented a significant 2.2 percent annual increase in North American common loon production between 1966 and 1989. Differences in these reports



may be related to stabilized or improved production in more rural, western areas as opposed to northeastern United States habitats impacted by urbanization and development pressures. No accurate database exists documenting wintering population status of common loons in South Carolina.

Horned Grebe. Horned grebe populations are believed to be declining; limited data exist to accurately document reasons for this decline or current status of the population (Stedman 2000).



Habitat and Natural Community Requirements

Dabbling Ducks. Gordon et al. (1989) described the importance of south Atlantic coastal wetlands to dabbling ducks, particularly managed tidal wetlands in South Carolina. These wetlands periodically provide habitat for up to 40 percent of the wintering dabbling ducks in the Atlantic Flyway. These species predominantly demonstrate a strong fidelity for particular wintering sites, which indicates the importance of site-specific wintering habitat management for dabbling ducks (Robb 2002).

Mallards historically wintered in South Carolina in large numbers along coastal emergent freshwater wetlands and associated inland freshwater lacustrine and riverine habitats. These ducks are notorious pioneers into new habitats; there is substantial anecdotal evidence as well as landowner/manger observations that migratory mallards are wintering in newly constructed inland impoundments across the state since 1990. Many of these impoundments, managed exclusively for ducks, are planted to cereal grains, important food resources for wintering waterfowl. Wintering mallards are readily attracted to these shallowly flooded grain impoundments where disturbance is limited; they will move considerable distances in order to exploit these sites. Currently, sufficient band return data to support the hypothesis that large numbers of migrating and wintering mallards are moving to and using these habitats does not exist. However, there may be a temporal lag in band returns as the dynamics of mallard habitat utilization undergo changes (Munro and Kimball 1982).

Migrating black ducks prefer emergent coastal wetlands and mud flats in South Carolina (Morton et al. 1989). Fewer black ducks use inland lake and riverine habitats (Johnson and Montalbano 1989). Wintering black ducks also require adequate food resources, open water and shelter from low temperatures and human disturbance. Vegetation, including seeds, and aquatic organisms make up the black ducks' diet during the winter. Widgeon grass (*Ruppia maritima*) is particularly important to the black duck; this plant is very important in management of brackish wetlands along coastal South Carolina. Important invertebrate prey species are located primarily in mud flats and include mollusks, crustaceans and insects (Lewis and Garrison 1984).

Emergent salt and freshwater wetlands and tidal mud flats are important habitats for all dabbling ducks, particularly black ducks. Field et al. (1991) estimated 106,921 ha (264,200 acres) of salt marsh, 46,460 ha (114,800 acres) of freshwater marsh and 4,979 ha (12,300 acres) of tidal flats occur in South Carolina. Tiner (1984) estimated that over 30,757 ha (76,000 acres) of managed wetlands in South Carolina are the result of continued maintenance, development and water level manipulation of impoundments formerly used for colonial rice culture. These habitats are vital wintering habitat for all dabbling ducks. Northern pintails and blue-winged teal wintering in South Carolina use managed fresh and brackish wetlands almost exclusively (Gordon et al. 1989). Additionally, many black ducks wintering along coastal regions of the state use managed wetlands during some portion of the diurnal cycle (Gordon et al. 1989). Virtually all life cycle requirements of mottled ducks in South Carolina are met within the confines of a narrow range of habitat occurring specifically within coastal, brackish managed wetlands.

Common Loon. In winter, common loons are generally located utilizing shallow coastal marine habitat. However, these birds will also use lakes and rivers where forage organisms, such as small fish crayfish, shrimp and leeches, are available (McIntyre and Barr 1997; Rodriguez and Kirschbaum 2002).

Horned Grebe. Horned grebes winter mainly on salt or brackish water in South Carolina, but can also be located on lakes and rivers where the water does not freeze. Protected bays, exposed shores and, occasionally, larger freshwater lakes are important winter habitat (Kaufman 1996). Fish and crustaceans comprise the balance of winter diet, but small mollusks and some plant material may be consumed (Kaufman 1996; Stedman 2000). Horned grebes have been seen (pers. obs.) using canal networks in saline and brackish managed wetlands along coastal South Carolina; these habitats are rich in fish, crustaceans and invertebrates (Gordon et al. 1989). These areas may play a greater role in providing winter habitat for horned grebes than has previously been documented.

Challenges

Land use development directly impacts aquatic ecosystems (Langner and Flather 1994). Conversion of historically expansive agricultural and forested landscapes adjacent to important emergent wetlands and riverine and lacustrine habitats to urban use is the major cause for loss and degradation of waterfowl habitat. More than half of coastal South Carolina's historically significant plantations have been developed into residential communities. Many of these sites are within major riparian corridors. Development reduces availability of habitat for wintering dabbling ducks and allies through loss and degradation of habitat, alteration of food chains and degradation of related aquatic resources due to pollution and upland runoff (McKenzie et al. 1980, Sandifer et al. 1980; Bildstein et al. 1991).

The Center for Wildlife Law (1996) indicated population growth in South Carolina has increased to 116 people per 2.59 sq km (1 square mile), which has greatly increase development pressure on natural landscapes. South Carolina also has lost 27 percent of its wetlands since 1780 with more than half of that loss occurring since 1960 (Center for Wildlife Law 1996). Population growth and concurrent wetland habitat loss along coastal areas are of the most significant reasons requiring planning attention and holistic conservation approaches benefiting vital coastal resources (Bildstein et al. 1991).

Destruction of emergent wetlands along tidal, coastal areas is a problem for wintering black ducks and mottled ducks (Conroy et al. 2002). Invasive species, most notably common reed (*Phragmites communis*), are a concern in and around coastal managed wetlands. The common reed engulfs formerly productive wetlands and renders them useless as wintering waterfowl habitat.

Northern pintail population declines are continental in scope with primary causes rooted in widespread conversion of prairie grasslands to agriculture (Miller and Duncan 1999). In South Carolina, the greatest challenge is protection and proper management of critical coastal wintering habitats. Body condition of northern pintails when they arrive on breeding grounds in the spring is directly related to habitat indices on wintering grounds. Raveling and Heitmeyer (1989) indicated quality of winter habitat might affect northern pintail body reserves and, therefore, recruitment more so than any other dabbling duck.

Johnson et al. (1984) indicated the most critical management need of mottled ducks is to develop and maintain a reliable population survey. MWI data do not accurately reflect mottled duck numbers in South Carolina. Johnson et al. (1991) indicated less than one percent of the mottled ducks in Florida were counted in MWI surveys in that state, and Ballard et al. (2001) stated that according to their surveys, there were substantially more mottled ducks in Texas than previously reported using the MWI to estimate the population status of these ducks.

Common loon populations are also reduced in the face of habitat loss and degradation, human disturbance through recreation or development of secluded habitats, and pollution such as mercury and other heavy metals. Oil spills are catastrophic to common loons because they become unable to thermoregulate, fly, swim or dive when their plumage is only slightly saturated with oil (McIntyre and Barr 1997; Rodriguez and Kirschbaum 2002). Lead poisoning from fishing sinkers (Perry 1994) and entanglement in commercial and recreational fishing gear are other mortality factors for wintering loon populations (McIntyre and Barr 1997). Iron, bismuth, tin and tungsten have received full approval for use in nontoxic shot shells for hunting waterfowl (USFWS 2001); Thomas (2003) indicated the same materials should be able to receive approval for use as components of fishing weights in order to reduce lead mortality to diving waterbirds including common loons and horned grebes.

Oil spills along coastal wintering grounds and pesticide accumulation in their wintering aquatic habitats negatively affect horned grebe populations. Other sources of mortality for the horned grebes include plastics and lead ingestion as well as entanglement in commercial and recreation fishing gear (Kaufman 1996; Handford and Kirschbaum 2001).

Conservation Accomplishments

Research projects have been undertaken to clarify the derivation of mallards and northern pintails migrating to and wintering in South Carolina. Between 2003 and 2004, SCDNR personnel fitted eight female northern pintails and six female mallards with satellite-telemetry transmitters. Most of these ducks were successfully tracked; the research indicated a migration corridor through the Great Lakes and western Quebec-eastern Ontario and a preference for nesting near or on Hudson Bay (Rhodes 2004; Perry et al. 2005). Post-season banding efforts have been redoubled in recent years resulting in an increased dabbling ducks banding; blue-winged teal have been specifically targeted for banding.

Habitat conservation accomplishments for these ducks have been numerous and widespread in South Carolina. Key waterfowl habitats, known locally as focus areas, have been protected in efforts under the NAWMP through Atlantic Coast Joint Venture (ACJV) projects. Over 2.25 million hectares (5.56 million acres) have been identified within focus area boundaries targeted for priority landscape conservation through voluntary easements, gift or fee-title purchase. Approximately 162,000 hectares (400,000 acres) have already been protected in perpetuity through these efforts (USFWS 2003; SCDNR 2003).

Coastal focus areas in South Carolina are part of the South Atlantic Migratory Bird Initiative (SAMBI). Currently, plans written by SAMBI address goals and objectives identified as multi-state/federal/non-governmental conservation priorities. SAMBI seeks to provide a secure future for a wide variety of wetland dependent species including dabbling ducks and migratory diving waterbirds. SAMBI is a mechanism to integrate and coordinate various bird conservation efforts to meet habitat conservation goals as identified for the South Atlantic Coastal Plain.

A thorough database has been maintained for several decades documenting wintering dabbling duck populations that utilize traditional habitats in South Carolina. In many years, these data illustrate that up to 40 percent of the dabbling ducks in the Atlantic Flyway use habitats in South Carolina.

Outreach efforts include establishment of expanded waterfowl information on the agency website. Specific information on satellite-telemetry of mallards and northern pintails is included on the SCDNR website.

Conservation Recommendations

Dabbling Ducks

- Conserve and enhance additional dabbling duck habitat and associated species partnership efforts in concert with the NAWMP and ACJV focus areas.
- Develop and implement expanded mid-winter surveys in non-traditional wintering areas to better document the possible redistribution of wintering dabbling ducks into newly created habitats.
- Continue examining banding data to further determine the migration dynamics of mallards wintering in the state.
- Eradicate invasive species, such as common reed, to protect key dabbling duck habitat.
- Complete comprehensive mapping, monitoring, control and follow-up efforts to evaluate the effects of invasive plant species on dabbling ducks.
- Conduct additional winter banding of priority waterfowl species that utilize habitats in South Carolina in concert with additional spatial analysis of band return data in order to further identify correlations between origin and winter termini.
- Increase public outreach efforts with improved website information, presentations, news releases and special publications.

Common Loons and Horned Grebes

- Explore opportunities to limit the use of toxic materials as fishing sinkers
- Perform baseline investigations to determine life history characteristics for wintering common loons and horned grebes in South Carolina. Topics to include:
 - o winter energetics of common loons or horned grebes
 - o precise wintering distribution and abundance of common loons and horned grebes
 - o ecological requirements and social structure of wintering common loons and horned grebes including winter site preferences, mobility and mortality during winter, effects of winter weather on these species or impacts to these and other diving waterbirds from commercial fishing activities

Measures of Success

Increases in populations of dabbling ducks and allies in concert with the goals provided in the NAWMP, SAMBI and ACJV plans will provide adequate measures of success for proposed conservation actions. Establishment of a reliable MWI to include inventory of newly created waterfowl wintering habitats and production of a comprehensive mapping and monitoring plan would also be noteworthy as additional conservation accomplishments. Finally, establishment of baseline data regarding South Carolina wintering common loons and horned grebes would assist in future management of these species.

Wood Stork

Mycteria americana

Contributor: Thomas M. Murphy

Description

Taxonomy and Basic Description

The wood stork is one of 19 species in the family Ciconiidae and one of four species in the genus *Mycteria*. They are morphologically indistinguishable across the species' range and no subspecies have been proposed. Likewise, genetic studies on 15 nesting colonies in Florida showed little genetic variation (Stangel et al. 1990).

Wood storks are the only stork species and the largest wading bird that breeds in the United States. They are large, long-legged birds with a head to tail length of 85 to 115 cm (33 to 45 inches) and a wingspan of 150 to 165 cm (59 to 65 inches). Adults are white except for their primary and secondary wing and tail feathers, which are black with a greenish sheen. Adults have an unfeathered head and neck with a long, thick black bill. The legs and feet are dark; toes are pink during the breeding season. Subadults are similar except the head and neck have grayish feathers that are gradually lost as the bird matures. Subadults also have a pale yellow bill.

Status

Wood storks were listed as endangered on February 28, 1984, pursuant to the Endangered Species Act of 1973, as amended (U.S. Fish and Wildlife Service 1984). They are also listed as endangered under the South Carolina Nongame and Endangered Species Conservation Act. The South Carolina Heritage Trust Program lists the wood stork as threatened in this state (S1/S2) and uncommon but not rare or apparently secure globally (G4) (NatureServe 2005).

Population Distribution and Size

The United States breeding population of wood storks was listed as endangered after nesting pairs declined from between 15,000 and 20,000 in the 1930's to 2,500 pairs by 1978. The low number in 1978 was a combination of a decrease in the regional population and poor conditions for nesting that particular year (U.S. Fish and Wildlife Service 1996). Historically, wood storks have used South Carolina as a post-nesting foraging area during the summer and fall (Murphy 1995). In 1981, the first successful wood stork nests were documented in South Carolina (11 nests). By 2004, the population had grown to 2,057 nests at 14 sites.

Habitat and Natural Community Requirements

Wood storks typically nest in the upper branches of black gum (*Nyssa biflora*) or cypress (*Taxodium distichum*) trees that are in standing water. Standing water deters mammalian predators and is an essential element of colony sites. Storks require open access to nest trees and are frequently found in trees adjacent to open water areas. Range-wide, there has been a trend towards the use of manmade wetlands as colony sites in recent years as these sites are not totally dependent on rainfall for water (Rodgers 1996). In South Carolina, colony sites are surrounded by extensive wetlands, in particular palustrine forested wetlands (Mitchell 2002).

Wood storks are tactile feeders. They frequently feed in large groups in open wetlands where prey species are available and water depths are less than 50 cm (20 inches). Forested riverine floodplain habitats are frequently used, but a variety of ponds, ditches and diked marsh

impoundments are important habitats. Use of these habitats is enhanced by receding water. Storks also forage around low tide along many coastal tidal creeks.

Challenges

Loss of feeding habitat from alteration of natural hydroperiods has resulted in abandonment of nesting colonies or widespread nesting failures in south Florida. Development, lowered water tables and disturbance also degrade nesting sites. Therefore, as their natural range has become depleted, South Carolina has become an important population source in recent years.

Conservation Accomplishments

Most importantly, standardized surveys of nesting effort have been completed for the southeastern United States. In addition, a regional wood stork working group has been organized to facilitate information exchange and to set research and management priorities. Regional management guidelines for wood stork nesting, feeding and roosting habitats have been developed. A wood stork recovery plan has been completed by the U.S. Fish and Wildlife Service and an information brochure to inform landowners of conservation and management needs of storks has been completed as a joint production of the U.S. Fish and Wildlife Service (USFWS) and the Savannah River Ecology Laboratory. A general information pamphlet for distribution to the public has also been completed by Clemson University, Department of Pesticide Regulation.

Techniques for management of fresh water ponds to enhance stork use have been developed and implemented at the National Audubon Society's Silver Bluff Plantation Sanctuary in Jackson, South Carolina. Finally, artificial nesting platforms have been developed to enhance stork nesting at colony sites with limited vegetation for nest construction. This technique was developed by USFWS- Refuges Division.

Conservation Recommendations

- Determine survivorship of fledgling, immature and adult wood storks.
- Document important wood stork winter habitats and determine if the amount of habitat limits species recovery. This will involve general census and satellite radio tagging.
- Conduct complete ground counts of wood stork nests at colony sites in South Carolina each year.
- Estimate wood stork nesting success by counting chicks in a sample of nests each year.
- Conduct aerial surveys to locate new wood stork nesting colonies.
- Participate in and contribute to the regional wood stork working group.
- Provide technical guidance and assistance to landowners where wood storks occur.
- Develop a South Carolina Department of Natural Resources web page on wood storks for public outreach and information exchange with existing and potential management partners.
- Consider protecting storks and their habitats through an interagency permit review system.

Measures Of Success

Efforts to restore wetlands in south Florida may significantly impact wintering and nesting wood storks in the future. In addition, during the past several decades, wood stork nesting has shifted north and is significantly changing management of the species. Both of these activities will require responsive and adaptive management to reach the recovery goal of 10,000 breeding pairs.

CHAPTER 3: AMPHIBIANS AND REPTILES

American Alligator

Alligator mississippiensis

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

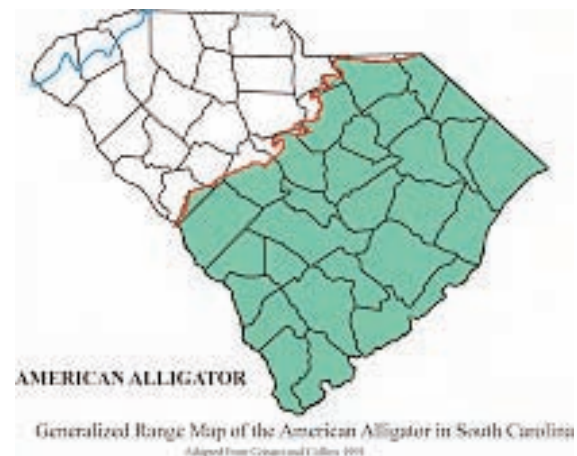
The American alligator is the only crocodilian native to South Carolina. The range of this reptile includes the coastal plain of the Gulf and Atlantic states, ranging as far north as Albemarle Sound in North Carolina and westward to southern Texas. This is a large animal that can reach lengths of 5 meters (16 feet) (Conant and Collins 1991). The American alligator is typically black or dark brown with light yellow-white cross bands on the body. Juvenile alligators have bright yellow bands on the body that fade with age. Alligators differ from the American crocodile, the only other crocodilian native to the United States, in having a broader, rounded snout. The American crocodile (*Crocodylus acutus*) does not occur in South Carolina, as its native distribution is restricted to extreme southern Florida and the Caribbean.

Status

The American alligator is currently listed as federally threatened by similarity of appearance to the American crocodile and as a species in need of management in South Carolina. This species was formerly listed as endangered, both on the federal and state lists. NatureServe (2005) identifies the American alligator as secure both statewide and globally.

Population Distribution and Size

The American alligator is currently common to abundant in coastal South Carolina. Large, protected populations exist on some government-owned lands, such as the Savannah National Wildlife Refuge and Donnelly Wildlife Management Area. This species has recovered from very low population levels in the 1950's and 1960's (Murphy and Wilkinson, 1982) due to protection afforded it by the federal Endangered Species Act from unregulated harvest (Murphy and Wilkinson, 1982).



Habitat and Natural Community Requirements

The American alligator is a resident of large river swamps, lakes, ponds, coastal impoundments, abandoned rice fields and other bodies of water (Conant and Collins 1991; Martof et al. 1980). Alligators are occasionally found in brackish-water marshes and estuarine tidal creeks (Palmer and Braswell, 1995). Juvenile alligators will use seasonal wetlands, such as Carolina bays (Gibbons and Semlitsch, 1991), where they likely feed on abundant amphibians. Alligator nests may superficially resemble muskrat lodges. Nest sites are constructed by the female alligator and consist of muck and aquatic vegetation piled on to a mound. The nests are usually constructed

near freshwater and may be concealed in stands of cattails or other emergent vegetation. The eggs incubate in the rotting vegetation and therefore require exposure to sunlight. Alligators are unique among reptiles because the female will guard and protect the nest from predators, including humans (Ross 1989).

Challenges

The major Challenges facing the American alligator are unregulated harvest and wetland habitat loss due to coastal development (Murphy and Wilkinson 1982). Human/alligator interactions may increase as coastal development continues. Alligators often inhabit golf course ponds as their native wetlands are altered or destroyed. Alligators will habituate to humans who feed them. Education campaigns are necessary because human encounters often result in negative consequences for the alligator.

Alligators, particularly large specimens that live in close proximity to human populations, may pose a threat to human safety. Such animals are deemed “nuisance alligators” and may have to be removed and destroyed. The department has developed a program to handle nuisance alligators that is enabled under SCDNR’s regulatory authority. The nuisance alligator program is managed such that it does not threaten the long-term survival of this species in this state.

Conservation Accomplishments

The American alligator is listed as a species in need of management in South Carolina; therefore all activities regarding this species in our state are regulated. The American alligator has experienced a significant recovery from historically low populations due to listing and the prohibition of unregulated harvest.

Conservation Accomplishments

- Design educational materials, especially signage, that can be erected at sites where human/alligators interactions frequently occur such as golf courses, state parks, natural areas and recreational lakes.
- Develop a plan that delineates proper methods for responding to nuisance alligator problems.
- Develop a plan for a limited harvest of nuisance alligators.
- Determine locations of stable alligator populations in the state. Continue life history studies that provide data necessary for harvest and sustainable use planning.
- Monitor alligator population stability at protected sites and respond to increases or decreases in current populations.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Monitoring of marked populations of alligators on SCDNR properties will provide data on natural population fluctuation over time. Such data can be compared to future surveys on private lands, subject to alligator removal/harvest, to determine the effect of such programs on the local alligator population. Public opinion concerning alligators may be monitored in the future to reveal any shifts in the public perception of this species due to increased educational efforts. Stable populations of this species on public lands will be a measure of success.

Blue Ridge Reptiles and Amphibians Guild

Bog Turtle *Clemmys (Glyptemys) muhlenbergi*

Eastern Milk Snake *Lampropeltis triangulum triangulum*

Timber Rattlesnake *Crotalus horridus* – mountain race

Canebreak Rattlesnake *Crotalus horridus* – coastal plain race

Coal Skink *Eumeces anthracinus*

Seepage Salamander *Desmognathus aeneus*

Shovel-nose Salamander *Desmognathus (Leurognathus) marmoratus*

Green Salamander *Aneides aeneus*

Hellbender *Cryptobranchus alleganiensis*

Wood Frog *Rana sylvatica*

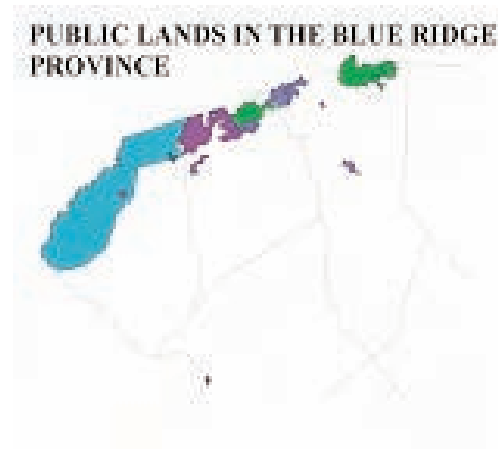
Contributors: Stephen H. Bennett and Kurt Buhlmann

Guild Description

This grouping includes several amphibian and reptile species that are not necessarily related in terms of their life histories or habitat requirements. These species are restricted to or primarily occur in the Blue Ridge Physiographic Province (Southern Appalachian Ecoregion) and upper piedmont (foothills) of South Carolina; some are peripheral to our state. Several members of this group are, in fact, quite common in the core of their geographic ranges to the north of South Carolina. Several large public lands are located within the ranges of these species and those land managers will be responsible for management of these species. These land holdings include Sumter National Forest and the Jocassee Gorges Wildlife Management Area as well as several South Carolina State Parks. Thus, presenting these species together as a “guild” may help land managers develop a holistic, multiple species conservation plan and minimize management conflicts that may occur if the species are treated separately.

The Southern Appalachian Ecoregion (Blue Ridge Province) and upper piedmont of South Carolina support a diverse and rich herpetofauna population. Many species found in this region occur nowhere else in South Carolina with the majority of their geographic range lying to the north of our state. While a number of the species represented in this grouping are relatively common outside of South Carolina, some, such as the bog turtle, are not. Other species, such as the green salamander and coal skink have disjunct ranges and are considered to be of conservation concern in other portions of their range.

Although most of these species are peripheral to South Carolina, we can make a case for their conservation in our state based on the overall rarity of some and the consideration that most species are most vulnerable at the edge of their geographic range. In addition, the edge of a species’ range is often where it experiences the greatest possibility for some evolutionary change, making these populations of potential interest to evolutionary biologists as well as conservation biologists.



Bog Turtle

Description

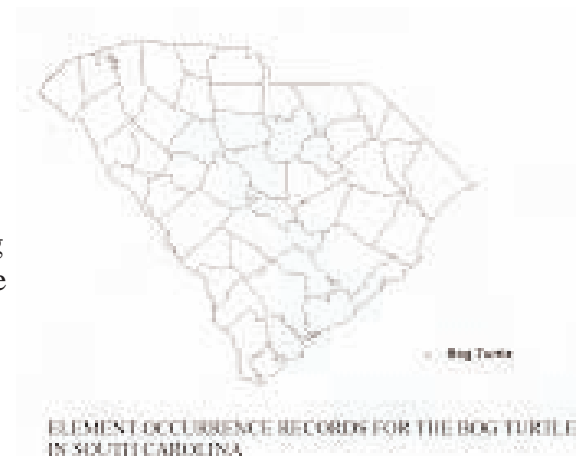
The bog turtle is a small semi-aquatic turtle that can reach 7.5 to 9 cm (2.9 to 3.5 inches) in length; maximum is approximately 11 cm (4.3 inches). Bog turtle shells are typically dark brown with light yellow or red centers on the large scutes. The bog turtle has a distinctive orange or yellow blotch on the head located just behind the eye (Conant and Collins 1991).

Status

The bog turtle is currently listed as threatened in South Carolina with a state rank of S1, critically imperiled, and a global rank of G3, vulnerable (NatureServe 2005). In the Southern Appalachians, the bog turtle population is listed as federally threatened. This species was discovered in South Carolina in the 1980's.

Population Distribution and Size

The bog turtle was first documented in South Carolina in 1988 (SC Heritage Trust Program). To date, only four specimens have been found in this state. All four records from this species came from separate areas or sites. To date no populations of bog turtles have been documented. In South Carolina, the bog turtle is not a truly mountain species, occurring primarily in the foothills region of the state.



Habitat and Natural Community Requirements

The bog turtle is typically found in streamside bogs, seeps, beaver ponds and other wetlands. In South Carolina, the few specimens found have been discovered in streamside bogs or crossing roads adjacent to streams or beaver ponds. Bog turtle wetlands are generally characterized by wet meadow habitats described as open canopies with spring-fed water and deep silts (Palmer and Braswell 1995). In South Carolina, this habitat type is generally found in the upper piedmont and foothills in association with small streams and rivers.

Challenges

The wet meadow habitats in which bog turtles are found are associated with farm areas. As farming has declined, the wet meadow bogs have undergone natural succession to red maple swamps (Buhlmann et al. 1997; Herman and Tryon 1997). As succession occurs, the previously open canopy of a bog closes, limiting light to the ground layer. Canopy closure results in changes to the vegetative composition of the bog and the physical structure of the bog, resulting in degraded habitat for bog turtles.

Eastern Milk Snake

Description

The eastern milk snake is the nominative species for a group of related snakes that includes the more common scarlet kingsnake in South Carolina. The eastern milk snake is a slender, strongly blotched snake that reaches lengths of 61 to 90 cm (24 to 35 inches); maximum length is approximately 132 cm (52 inches) (Conant and Collins 1991; Martof et al. 1980). Milk snakes typically possess reddish-brown blotches or saddles that run the length of the snake's body. In South Carolina, milk snakes from the upstate do not closely resemble the typical eastern milk snake and may resemble an "intergrade" between the eastern milk snake and the scarlet kingsnake. In current field guides, this form is now reported as the "coastal plain milk snake" (Conant and Collins 1991). Further taxonomic research will provide clarity about the relationship between these different forms.

Status

The South Carolina Department of Natural Resources (SCDNR) Heritage Trust Program assigns a state rank of S2 to the upstate (mountain) population of the eastern milk snake, classifying it as imperiled because of rarity or otherwise vulnerable to extirpation. The global rank of the nominate species is G5, secure. Although the milk snake may be widespread and not uncommon in South Carolina's upstate, its taxonomic status is unknown.

Population Distribution and Size

Specimens of this milk snake have been recorded from the Eastatoe Gorge, Bad Creek and Jones Gap areas of South Carolina. This upstate "form" seems to be associated with the area near and above SC Highway 11 (Foothills Trail) in South Carolina. No formal mapping of the range or extent of the milk snake in this area of South Carolina exists.

Habitat and Natural Community Requirements

Little is known about the specific habitat requirements of the milk snake. Specimens have been found in mountain valleys, along streams and in rocky areas. This species is likely to be fossorial much of the year and can be found occasionally under cover objects such as rocks and fallen woody debris (Conant and Collins 1991).

Challenges

Lack of data on the taxonomy and distribution of the milk snake in South Carolina makes conservation planning for this species problematic.

Timber Rattlesnake And Canebrake Rattlesnake

Description

The timber rattlesnake is a large bodied snake that can reach lengths between 90 and 152 cm (35 to 60 inches); maximum length is approximately 189 cm (74 inches) (Conant and Collins 1991; Martof et al. 1980). There are two forms, or phases, of the timber rattlesnake found in South Carolina: the coastal plain form, known colloquially as the canebrake rattlesnake and the mountain form, known as the timber rattlesnake. These two forms were formerly recognized as subspecies of the timber rattlesnake, but recent research has determined that no genetic

evidence supports this classification (Pisani et al 1972). Despite the genetic similarity, there are morphological and ecological differences between the two forms (Brown and Ernst 1986).

The canebrake rattlesnake is typically a tan to flesh colored snake with black chevrons crossing the body and a dark red lateral stripe running the length of the body along the spine. A dark stripe runs diagonally through the eye (Conant and Collins 1991).

Two color phases are known for the timber rattlesnake. In the first color phase, the body is yellow; in the second color phase, the animal is almost solid black. In both phases, dark chevrons cross the body, and the dorsal lateral stripe, if evident, is not red. This form does not typically have an eye stripe (Conant and Collins 1991).

Status

The timber rattlesnake (both the mountain and coastal plain forms) is listed as a species of concern by the South Carolina Heritage Program and has a rank of S?, unknown and G4, apparently secure (NatureServe 2005). Although rattlesnakes are widespread in South Carolina, they are most common in the coastal plain and Blue Ridge and tend to be uncommon or absent in much of the intervening piedmont. In upstate South Carolina, the distribution of the timber rattlesnake is not fully known. Timber rattlesnake specimens from the foothills and upper piedmont more closely resemble the canebrake form of this species. The distribution of the mountain form of the timber rattlesnake is not known, but it is assumed that this form is isolated to areas of higher elevation in our state.

Population Distribution and Size

To date no exhaustive population study exists for the timber rattlesnake and the canebrake rattlesnake in South Carolina.

Habitat and Natural Community Requirements

The mountain form of the timber rattlesnake is generally associated with dry, south-facing slopes at relatively high elevations. In these areas, the timber rattlesnake uses communal den sites in rock outcrops, particularly those with an open south face exposed to the sun. Timber rattlesnakes spend the winter months in these dens; pregnant females give birth to their young in the fall. During the warmer months, timber rattlesnakes may be found in a number of mountain habitats. This species is an ambush predator, feeding primarily on squirrels and other large rodents (Palmer and Braswell 1995).

Challenges

Humans often fear rattlesnakes; snake/human interactions often end with the death of the snake. Populations may be threatened by urban development as the timber rattlesnake's habitat becomes more fragmented by development. Further, additional development is likely to result in increased road mortality.

Coal Skink

Description

The coal skink is a small lizard that reaches lengths of 12 to 17 cm (4.7 to 6.6 inches). This skink has four dorsal lines with the light stripes extending onto the tail. A thick, dark stripe lies between the two light stripes on either side of the body. The body color is bronze to brown,

sometimes with dark brown spot, dashes or lines (Palmer and Braswell 1995). There are no light lines on the head in this species. The heads of males occasionally turn light red during mating season (Conant and Collins 1991; Martof et al. 1980).

Status

The coal skink is listed as endangered in South Carolina with the southern coal skink (*E. a. pluvialis*) ranked S?, unknown G5, secure globally by the SCDNR Heritage Trust Program. The coal skink has only been found at one site, Sassafras Mountain, in South Carolina. This skink is an enigmatic species; it is rarely seen and is never seen in large numbers (Palmer and Braswell 1995).

Population Distribution and Size

To date, no exhaustive population study for the coal skink exists in South Carolina.

Habitat and Natural Community Requirements

The coal skink occurs near small, forested streams. They are found in mesic environments under stones, logs and other sheltering debris (Palmer and Braswell 1995). Little is known about its habitat preferences in South Carolina. In the Appalachians, this species occurs most frequently in forests formerly dominated by chestnut, chestnut oak and yellow poplar (Braswell 1977b).

Seepage Salamander

Description

The seepage salamander belongs to the dusky salamander group. This salamander is small; it typically only reaches lengths from 4.4 to 5.7 cm (1.7 to 2.2 inches) and is very slender. Seepage salamanders typically have a wide dorsal stripe that varies in color from tan to yellow. Some individuals have a dorsal strip that terminates in a “Y” behind the head. The sides of the salamander are dark while the underbelly is pale (Conant and Collins 1991; Martof et al. 1980).

Status

The seepage salamander was only recently reported in South Carolina and has only been found in the Sumter National Forest in Oconee County (Petranka 1998). The seepage salamander is ranked S?, status unknown, in South Carolina and has a global ranking of G3/G4, apparently secure (NatureServe 2005).

Population Distribution and Size

To date, no exhaustive population study for the seepage salamander exists in South Carolina.

Habitat and Natural Community Requirements

The seepage salamander is associated with small streams and wetlands where it may be found beneath leaf litter and debris, especially in seepage areas. The South Carolina population is disjunct from the main geographic range of this species (Petranka 1998).

Shovel-nosed Salamander

Description

The shovel-nosed salamander is totally aquatic relative of dusky salamanders. This species can

reach lengths of 9 to 12.5 cm (3.5 to 4.9 inches) with a maximum length of approximately 14 cm (5.5 inches). The shovel-nosed salamander is variable in coloration, ranging from gray-brown to yellow. Typically, a paired row of lightly colored spots is found on the back (Conant and Collins 1991; Martof et al. 1980). The tail of the shovel-nosed salamander is compressed laterally, an adaptation to its aquatic lifestyle.

Status

The shovel-nose salamander is ranked S2, vulnerable, for the state of South Carolina and G4, apparently secure, globally (NatureServe 2005).

Population Distribution and Size

To date no exhaustive population study for the shovel-nose salamander exists in South Carolina.

Habitat and Natural Community Requirements

The shovel-nosed salamander is a stream dweller, found in fast-flowing, rocky streams. The salamander is typically found under rocks, mostly in second and third order streams below elevations of 1,220 m (below 4,000 feet) (Petranka 1998).

Green Salamander

Description

The green salamander is the only arboreal salamander in South Carolina. This species can reach lengths of between 8 and 12 cm (3.1 to 4.7 inches) with a maximum length of approximately 14 cm (5.5 inches). This salamander is the only species in South Carolina with green coloration. Further, it has a pattern that resembles the lichens and mosses found growing on rocks in the green salamander's habitat (Conant and Collins 1991; Martof et al. 1980). The green salamander is also the only salamander in South Carolina that has toe pads, much like those of a treefrog, to help it climb trees and rocky cliffs (reference).

Status

The green salamander is ranked S1, critically imperiled in South Carolina and G3/G4, vulnerable/apparently secure globally and is listed as a Species of Concern.

Population Distribution and Size

To date no exhaustive population study for the green salamander exists in South Carolina.

Habitat and Natural Community Requirements

The green salamander is occasionally found in the same rocky areas that are used by the timber rattlesnake. This species is a "cliff dweller," residing in moist, but not wet, rocky sites with abundant crevices. Green salamanders are also found using trees that occur adjacent to rock outcrops (Waldron and Humphries, in press).

Hellbender

Description

The hellbender is a large, totally aquatic salamander that can reach lengths between 30 and 50 cm (11.8 to 19.6 inches); it has a maximum length of approximately 68 cm (26.7 inches); it is one of the largest salamanders in North America. The hellbender is typically gray or brown to dark brown in color, occasionally yellow, with a flattened head and a paddle-like tail. Fleishy folds of skin are prominent along both sides of these salamanders (Conant and Collins 1991; Martof et al. 1980). Although this is an aquatic species, adults do not possess external gills; respiration occurs chiefly through the fleshy folds of skin.

Status

There are only two records of the hellbender in South Carolina; fishermen caught both of these salamanders from Lake Tugaloo in Oconee County. South Carolina is well outside the typical range for hellbenders. With the exception of the two individuals discovered in Lake Tugaloo, hellbenders have not been found in any Atlantic drainage streams in the southeast. It is likely that the two South Carolina specimens were introduced. To date, no population of hellbenders has been documented in the state of South Carolina. The hellbender is ranked S?, unknown in South Carolina and G4, apparently secure globally. This species is also listed as a Species of Concern.

Population Distribution and Size

To date no exhaustive population study for the hellbender exists in South Carolina.

Habitat and Natural Community Requirements

The hellbender is a stream dweller found in large, fast-flowing, rocky second and third order streams with abundant flat rocks. Hellbender streams are typically broad and shallow. Hellbenders only survive in flowing, cool, clean, well-oxygenated streams and rivers and do not tolerate sedimentation. (Palmer and Braswell 1995)

Wood Frog

Description

The wood frog is a small member of the true frog family, related to the bullfrog, leopard frog and gopher frog. This species can attain a size of 3.5 to 7 cm (1.3 to 2.7 inches); maximum size is approximately 8 cm (3.1 inches). The body color of the wood frog is highly variable ranging from pink to brown to almost black. The major distinguishing characteristic is the dark patch that extends backward from the eye (Conant and Collins 1991; Martof et al. 1980).

Status

The wood frog is ranked S3, vulnerable in the state of South Carolina and G5, secure globally. This frog is also listed as Species of Concern.

Population Distribution and Size

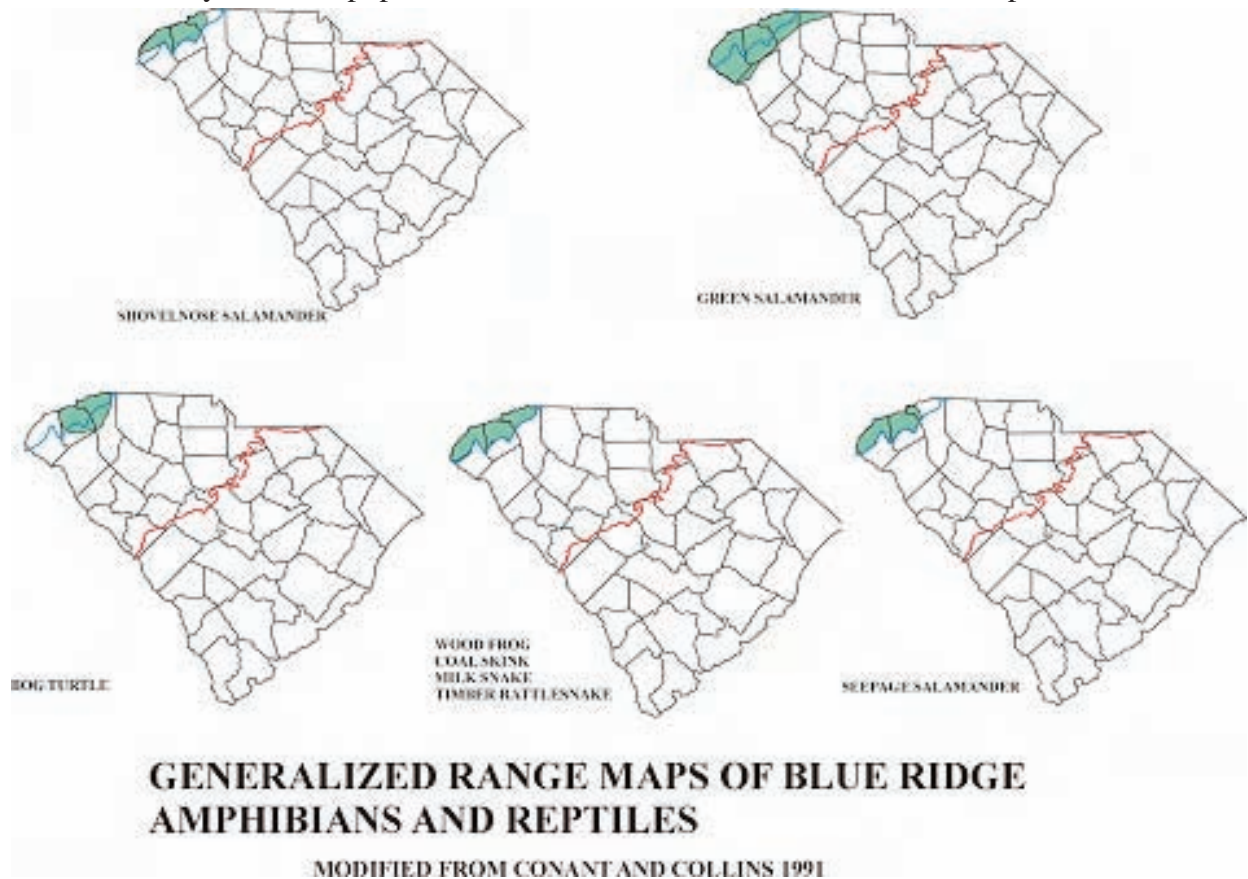
To date no exhaustive population study for the wood frog exists in South Carolina.

Habitat and Natural Community Requirements

The wood frog breeds in small ponds, bogs and other wetlands during late winter and early spring in South Carolina. This species is typically associated with wet or moist areas, but it can be found some distance away from water during the non-breeding season. (Palmer and Braswell 1995).

Challenges

Several large tracts of public land are located in the Southern Appalachian Ecoregion of South Carolina; many of these species occur on one or more of these tracts. Therefore, habitat loss and alteration at a large scale is not as problematic for these species as it is for others in our state. Habitat loss, however, still occurs and is considered a problem, albeit not the most pressing one. The primary problem for these species is habitat fragmentation and degradation, such as drainage of ephemeral wetlands, mining and development on private lands. Collection of salamanders for the bait industry can limit populations or cause declines of some salamander species; 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.” Collection of milk snakes and timber rattlesnakes for the pet trade or venom trade can also limit or reduce populations.

Conservation Accomplishments

Surveys for the bog turtle and the green salamander, funded by the SCDNR, were recently conducted. All records for green salamanders resulting from these surveys are stored in the

Heritage Program database. No occurrences of bog turtles were documented during these surveys.

Approximately 40,500 hectares (100,000 acres) of land is in public ownership in South Carolina's southern Appalachians and vicinity. The majority of this land is in the Sumter National Forest, Andrew Pickens District and the Jocassee Gorges Wildlife Management Area, the latter of these owned and managed by SCDNR. Several other smaller tracts, including Heritage Preserves and State Parks, are also protected in this region. Amphibians and reptiles are not the primary management targets on any of these sites, but these species do benefit from conservation management on most, if not all, of these public lands.

Conservation Accomplishments

- Protect bog turtle habitat through acquisition or conservation easement at all known sites, based on the inventory work. Easements can be implemented through Project Bog Turtle, a non-profit program.
- Educate local landowners who have populations of bog turtles on their properties about the ecological importance of this species.
- Work with private landowners, in conjunction with Project Bog Turtle, and provide bog turtle habitat management recommendations through habitat management guidelines for Southeastern amphibians and reptiles currently being developed by Partners in Amphibian and Reptile Conservation (PARC).
- Implement management techniques for restoring bog turtle habitat. These include cutting shrubs and trees, diking streams, restoring sheet flow to wetlands, burning and use of livestock to mimic native herbivore grazing.
- Consider captive breeding and reintroduction programs if inventory results indicate that bog turtles have been extirpated in South Carolina.
- Re-survey all known historical sites for bog turtles.
- Determine the current extent of bog turtles in South Carolina.
- Conduct research to determine the effectiveness of bog turtle habitat management (scrub clearing and grazing) in South Carolina.
- Monitor bog turtle response to management actions, such as red maple thinning and grazing, designed to improve bog turtle habitat conditions,
- Create or expand existing education programs for public and private land managers about the presence and ecological importance of eastern milk snakes and ways to protect this species.
- Determine the taxonomic differences between eastern milk snakes, coastal plains milk snakes and scarlet kingsnakes.
- Monitor known pet trade collection sites for eastern milk snakes.
- Work with US Forest Service and South Carolina State Park Service (SCSPS) to protect known timber rattlesnake (mountain race) den sites.
- Develop an education program promoting the ecological importance of venomous snakes, including timber rattlesnakes.

- Conduct surveys to identify denning sites of timber rattlesnake populations in the Blue Ridge Mountains.
- Monitor known timber rattlesnake denning sites in Blue Ridge Mountains to assess any potential human impacts.
- Investigate life history requirements for timber rattlesnakes in South Carolina, including adult sex ratios, recruitment and mortality, habitat use and seasonal activity patterns.
- Partner with the US Forest Service and the South Carolina Park Service to make recommendations regarding seepage salamander habitat requirements during preparation of forest plans.
- Conduct baseline research to identify seepage salamander distribution, abundance and specific habitat requirements.
- Consolidate known museum locality data for seepage salamanders. Work with land conservancy groups, the US Forestry Service and the SCSPS to protect watersheds that contain shovel-nose salamanders.
- Include the importance of protecting shovel-nose salamanders in general education materials.
- Regulate collection of shovel-nose salamanders to protect them from over harvest for bait.
- Survey Andrew Pickens National Forest to determine presence of shovel-nose salamanders on that property; monitor any populations discovered.
- Protect sandstone cliffs, the habitat of the green salamander, by eliminating or reducing timber activities that expose these cliffs to drying or allow fragmentation of connective forest habitat.
- Develop an education program highlighting the green salamander as a unique species that illustrates biodiversity in the Blue Ridge Mountains.
- Encourage the USFS to consider avoiding isolation of sandstone cliffs from the forest matrix as a result of timber cutting operations on Andrew Pickens National Forest.
- Survey appropriate habitat for the green salamander, including Andrew Pickens National Forest and South Carolina State Parks in the region; monitor any populations discovered.
- Conduct research to determine dispersal mechanisms for green salamanders through intervening forest habitat.
- Collaborate with land conservation groups, such as The Nature Conservancy, to protect watersheds that contain hellbenders.
- Design posters that request reporting of any hellbender sightings in the Blue Ridge Mountains.
- Determine the true distribution of the poorly known hellbender in South Carolina Blue Ridge Mountain streams.
- Based on inventory, design a monitoring protocol for hellbenders in Blue Ridge Mountain streams.
- Collaborate with public land managers to protect wood frog habitat.

- Include the importance of protecting wood frogs in general education materials.
- Work with USFS and consider the needs of wood frogs when creating wildlife watering ponds in the mountains.
- Inventory appropriate habitat in the Blue Ridge Mountains for presence of wood frogs; monitor any populations discovered.
- Conduct calling frog surveys to determine the presence of wood frogs.
- Monitor successful metamorphosis of larval wood frog tadpoles.

Measures of Success

For many of these species, the first measure of success will be to document basic life history requirements as well as population status and distribution. As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from status surveys will be used to direct future research on life history, ecology and limiting factors for the target species. Such data will also be used to direct future habitat acquisition and management projects. Stable or increasing populations of the primary target species on public lands will be the ultimate measure of success.

Diamondback Terrapin

Malaclemys terrapin

Contributors: DuBose Griffin, David Owens and J. Whitfield Gibbons

Description

Taxonomy and Basic Description

The diamondback terrapin is a small, long-lived estuarine turtle endemic to coastal marshes, estuarine bays, lagoons and creeks ranging from Cape Cod, Massachusetts to the Gulf Coast of Texas. Currently, there are five (Hartsell 2001) or seven (Ernst et al. 1994) subspecies. More recently, Hart (2004) identified six management units. The subspecies found in South Carolina is *Malaclemys terrapin centrata*.

Terrapins have varied coloration from black to spotted patterns on the soft tissue and dark or light-colored scutes with strong concentric layers on the carapace. The hind margin of the carapace curls up instead of flaring. Hind legs are large and toes have extensive webs. These turtles are strong, fast swimmers that feed on a variety of mollusks, crustaceans and other invertebrates. In South Carolina, salt marsh periwinkles (*Littoraria irrorata*) and blue crabs (*Callinectes sapidus*) are among the terrapin's primary food sources (Tucker et al. 1995; Levesque 2000).

Terrapins are sexually dimorphic. Females are much larger than males and reach 15 to 18 cm (6 to 7 inches) in length; males reach 10 to 13 cm (4 to 5 inches) in length. Adult females also have enlarged heads. Terrapins hibernate in the mud during winter and mate in the spring. Eggs are laid May through early August and clutches have 5 to 12 eggs (Pritchard 1979). The number of clutches laid per female in South Carolina is undocumented; however two clutches may be common (David Owens, College of Charleston, pers. comm.).

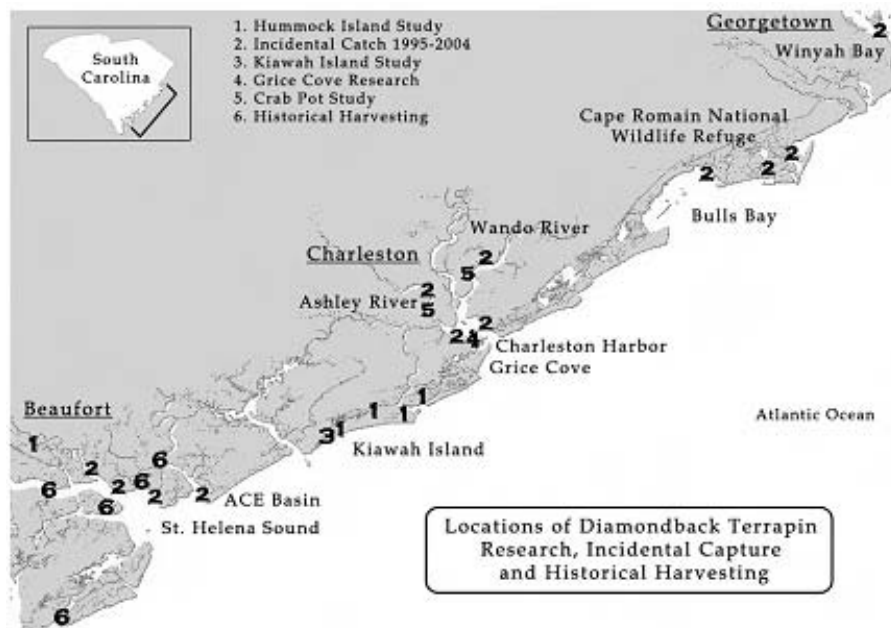
Status

The 2003 International Union for Conservation of Nature and Natural Resources (IUCN) lists terrapins as a species of lower risk/near threatened. In South Carolina since 2000, Chapter 5 Section 50-5-2300 of South Carolina law “authorizes the Department of Natural Resources to grant permits for the harvest and marketing of diamondback terrapins.” However, there have been no permit requests for harvesting terrapins. Currently, permit requests would be considered but not issued (D. Theiling, SCDNR, pers. comm.) because the species’ status is unknown or declining (Seigel and Gibbons 1995). Prior to 2000, the law allowed a harvest season, but this has not been active since the 1970’s (R. Gault, terrapin harvester, pers. comm.). The status of the species is listed as unknown in South Carolina (S?) and apparently secure globally (G4) (NatureServe 2005).

Population Distribution and Size

The current status of most populations of terrapins is unknown or declining (Seigel and Gibbons 1995). The species experienced near extinction in the early 1920’s because of commercial over-harvest. Commercial harvest declined in the late 1920’s and terrapin populations increased (Gibbons et al. 2001). Mr. Robert Gault, the last terrapin harvester in the state, reported catches of nearly 500 turtles in two to three days of net fishing in the Beaufort area in the 1970’s.

Two decades of monitoring terrapins in four creeks adjacent to the Kiawah River has documented a decline since the early 1990s and local extirpation (Gibbons et al. 2001; Tucker et al. 2001). Along the South Carolina coast, incidental catch data from 1995 through 2004 of diamondback terrapins in research trammel nets has remained consistent. Incidental captures north and south of the Charleston Harbor estuary are much less common (Levesque 2000; B. Roumillat and J. Archambeau, SCDNR, pers. comm.).



Genetic studies in North and South Carolina indicate that terrapin populations from these states are not significantly different (Hart 2004; Hauswaldt 2004) and should be treated as one management unit. A previous genetic study using a different genetic marker was unable to detect a difference between the Carolinas and Georgia (Lamb and Avise 1992). The Diamondback Terrapin Working Group (DTWG) was formed in September 2004. Georgia and both Carolinas comprise the southeastern section of this working group.

It should be noted that in 1947, several thousand diamondback terrapins were released into Cape Romain National Wildlife Refuge (CRNWR) waters from the North Carolina Beaufort Fishery

Station (Anonymous 1947). The genetic stock of these terrapins is not known. This should be taken into consideration when determining the genetic stock of diamondback terrapins in South Carolina waters.

Habitat and Natural Community Requirements

Terrapins are endemic to estuarine habitats. They are the only emydid turtle that can survive in a high salinity environment without accessing a freshwater source. Terrapins nest on land and require access to dry soft sand/soil to deposit their eggs. There is also evidence of high site fidelity and low recruitment and/or dispersal among tidal creeks. If a population were extirpated from a tidal creek, recruitment from other creeks would be very slow to repopulate the area. (Gibbons et al. 2001).

Challenges

Major problem for diamondback terrapins include loss or degradation of nesting habitat resulting from coastal development. Nests are destroyed by native (raccoons and mink) and non-native predators (fire ants) as well as erosion and storm events. Vehicle inflicted mortality of females during the nesting season is common where a highway separates nesting sites from tidal creeks. Mortality is also associated with mowing of causeway shoulders (T. Murphy, SCDNR, pers. comm.).

A major source of mortality in the marine environment is the presence of recreational, commercial and abandoned/ghost crab pots. In the Ashley and Wando Rivers, Bishop (1983) estimated that the mean daily terrapin catch per baited crab pot was 0.16 in April and May with 10 percent mortality. A statewide survey in fall 2003 documented nearly 10,000 commercial hard crab pots (M. Maddox, SCDNR, pers. comm.). Other problems include commercial harvesting (if permitted), destruction of food resources, environmental degradation and contamination (through increased sedimentation, nutrient enrichment, oil spills and filling/draining marshes), boat and propeller mortality and the commercial pet trade (D. Owens, College of Charleston, pers. comm.).

Conservation Accomplishments

A Diamondback Terrapin Working Group (DTWG) for the species' entire range has been organized to facilitate information exchange and to set research and management priorities; this group was formed September 2004 (D. Griffin, SCDNR, pers. comm.). In 2000, the South Carolina legislature recognized the value of science-based management of marine resources and has changed commercial access to the South Carolina terrapin resource from a seasonally open fishery to one managed with discretion by the Department of Natural Resources (D. Theiling, SCDNR, pers. comm.).

There have been local research findings and accomplishments throughout South Carolina. Sonic telemetry has been useful in studying site fidelity of terrapins. Genetic studies indicate that high site fidelity is not reflected in population genetic structure; no significant genetic differentiation exists among estuaries in North and South Carolina. Further, terrapins between South Carolina and New York are more similar to those from Texas than to terrapins in Florida, possibly because of intentional mixing (Hauswaldt 2004). Multiple paternity does occur in diamondback terrapins, but at lower frequencies than other species of turtles (Hauswaldt 2004). Genetic management units are not estuary specific; therefore, terrapins within the units defined by Hart (2004) can be translocated to areas where terrapins are extirpated (Hauswaldt 2004).

Diamondback terrapin nesting was apparent on five of 16 hummock islands inventoried during a 2003 through 2004 South Carolina Department of Health and Environmental Control (SCDHEC)/SCDNR preliminary study in South Carolina (W. McCord, SCDNR, pers. comm.). Seasonal reproductive activity of Charleston Harbor estuary terrapin populations has been determined and may be used to reduce anthropogenic threats (Lee 2003). Grice Cove Beach in the Charleston Harbor estuary was identified as an important nesting beach for diamondback terrapins compared with other beaches in this system. Highest nesting activity was early May to mid June (Riollana 2003).

A terrapin population study in four tidal creeks adjacent to the Kiawah River has been ongoing since 1983. There have been 1,336 individual terrapins captured and 1,323 recaptures (Gibbons et al. 2001). Recreational crab pots have been shown to adversely affect diamondback terrapin populations in the Kiawah River (Hoyle and Gibbons 2000). From 1995 to 2004, terrapins have been consistently caught in research trammel nets (Levesque 2000; W. Roumillat and J. Archambeau, SCDNR, pers. comm.). Terrapins play an active role in the salt marsh food chain and are an important predator of salt marsh periwinkles, *L. irrorata* (Levesque 2000).

A diamondback terrapin spring mating aggregation has been identified in Grice Cove in the Charleston Harbor estuary (B. Estep and D. Owens, College of Charleston, pers. comm.). Baseline data on clutch and egg size was documented for Kiawah Island, South Carolina (Zimmerman 1989). Artificial propagation of the diamondback terrapin is a successful management strategy for this species (Hay 1917; Barney 1922; Hildebrand 1929).

Five hundred bycatch reduction devices (BRDs) were made available to Kiawah Island residents, visitors and merchants. BRDs were provided for both commercial and recreational crab pots in the vicinity of Kiawah Island, John's Island and Beaufort (Marilyn Blizard and Elizabeth King, Kiawah Island, pers. comm.). Crab pots with BRDs showed an increase in the number of legal crabs caught (Guillory and Prejean 1998). The Town of Kiawah Island also sponsored a "Save the Diamondback Terrapin" program. Numerous educational materials have also been printed and distributed (M. Blizard and E. King, pers. comm.).

Conservation Accomplishments

- Develop and implement long-term coastwide standardized surveys to estimate the abundance and distribution of South Carolina's terrapin population.
- Quantify anthropogenic sources of terrapin mortality, with focus on life stage and sex specific mortality rates.
- Determine effectiveness of bycatch reduction devices on crab pots to exclude terrapins.
- Identify sites of significant or potential terrapin mortality from vehicles and mowers.
- Determine habitat of one and two-year-old juvenile terrapins.
- Establish several intensive studies to determine population parameters required for evaluating the status of diamondback terrapins, such as mortality rates and nesting effort/success.
- Identify and protect critical diamondback terrapin nesting habitats throughout the state, especially from beach disturbances by visitors, boaters and dogs during the nesting season.
- Develop predator control programs for critical diamondback terrapin nesting beaches.

- Identify and protect critical diamondback terrapin mating aggregations throughout the state.
- Consider the need for a moratorium on commercial harvest and possession of diamondback terrapins without a permit.
- Examine the potential benefits of requiring effective BRDs in recreational and commercial crab pots for reduction of diamondback terrapin mortality.
- Examine the potential benefits of requiring effective degradable panels or panel attachments in recreational and commercial crab pots to reduce diamondback terrapin mortality associated with abandoned crab pots.
- Develop an abandoned/ghost crab pot collection program with partners throughout the state to reduce terrapin mortality in these traps.
- Evaluate the need for changing the status of the terrapin from a harvestable game species to a species “in need of management” under the South Carolina Nongame and Endangered Species Conservation Act.
- Collaborate with the South Carolina Department of Transportation (SCDOT) to negotiate restrictions of causeway mowing during the terrapin nesting season.
- Encourage the salvage of eggs from road-killed female terrapins for an incubation and release program by local animal care groups.
- Educate the public about how they can help conserve the diamondback terrapin and specifically emphasize responsible actions when using crab pots. Produce education materials to be distributed coastwide.
- Erect crossing signs along roadways alerting motorists about crossing diamondback terrapins during the breeding season. Signs should be theft proof or removed each year at the end of the breeding season.
- Develop a South Carolina Department of Natural Resources web page on diamondback terrapins. Web site will enhance collaboration for the southeastern portion of the DTWG.
- Participate in and contribute to the DTWG by attending triennial meetings.
- Collaborate with institutions, partners and nongovernmental organizations on future research and management actions to protect the diamondback terrapin.

Measures of Success

As results from current research and surveys are identified and analyzed, we will initiate projects to address specific needs that arise from these results, with the ultimate measure of success being to stabilize or increase populations of diamondback terrapins.

Florida Green Watersnake

Nerodia floridana

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

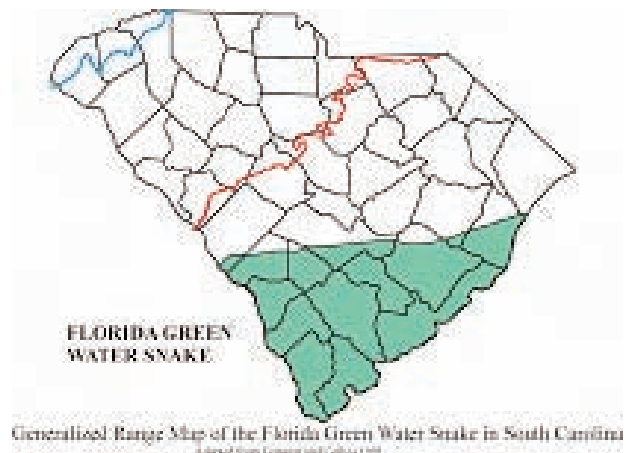
The Florida green watersnake is moderate to large in size, reaching lengths from 76 to 140 cm (30 to 55 inches); maximum length is approximately 188 cm (6.2 feet). (Conant and Collins 1991). It was considered a subspecies of the green watersnake, *Nerodia cyclopion*, until recently when it was determined to be a separate species (Pearson 1966, Lawson 1987, Sanderson 1993). The Florida green watersnake is uniformly green or brown, with crossbars present occasionally (Conant and Collins 1991; Martof et al. 1980) and a plain white or cream-colored belly.

Status

The Florida green watersnake is listed as a species of concern in South Carolina and has a rank of imperiled state-wide (S2). This species is considered secure globally (G5) (NatureServe 2005).

Population Distribution and Size

Little data exists concerning the population biology of the Florida green watersnake in South Carolina. This species occurs on the Savannah River Site (SRS) in Aiken and Barnwell Counties. It has also been found in the Cooper River area of Charleston and Berkeley Counties. There are reports of this species from old rice fields in Georgetown County (Charleston Museum). There are no records from the counties between these two South Carolina population areas, suggesting that two meta-populations of this species may occur in South Carolina. The South Carolina populations of the Florida green watersnake are disjunct from the primary range of this species, which is extreme south Georgia and Florida, by over 300 kilometers (200 miles).



Habitat and Natural Community Requirements

In South Carolina, the Florida green watersnake has been reported from such wetland types as Carolina bays, lakes, old rice fields and reserves and lakes. Sites where the Florida green watersnake has been reported typically have open water with little or no canopy of trees and an abundance of “pad plants” such as water lily, cow lily, lotus and water shield (Gibbons and Dorcas 2004).

Challenges

Draining and filling wetlands may impact this species. The green watersnake is a poor overland disperser and if extirpated from wetlands due to ditching, draining or drought, populations may not easily become re-established (Seigel et al. 1995).

Conservation Accomplishments

Simply identifying populations of the Florida green watersnake is an accomplishment. The species occurs on the Savannah River Site where it is identified as an uncommon to rare species. This species also occurs at the Charleston Naval Weapons Station. Both areas are currently under management, but no specific actions have been implemented for green watersnakes. Awareness of this species among SRS land managers has increased and SRS is restoring Carolina bay wetlands. If we encourage SRS to manage for the broad hydrological array of Carolina bay wetlands on SRS, then green watersnakes will benefit.

Conservation Recommendations

- Encourage SRS to protect known wetland sites that contain Florida green watersnakes.
- Educate fishermen and recreational users about the differences between the venomous cottonmouth and the Florida watersnake. This could be accomplished by posting signs at popular fishing sites and/or boat landings.
- Consider habitat needs of the Florida green watersnake when managing Carolina bays and similar wetland ecosystems.
- Couple conservation of Florida green watersnake with waterfowl management, where appropriate.
- Determine the distribution of the Florida green watersnake in South Carolina, including inventories of known populations. Monitor populations once the inventory is complete.
- Investigate drought responses and re-colonization abilities of the Florida green watersnake.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from basic surveys will be used to develop specific life history and ecology projects and determine limiting factors to population growth and dispersal. Stable or increasing populations on public lands will be a measure of success.

Freshwater Turtles

Yellowbelly Turtle *Trachemys scripta*

River Cooter *Pseudemys concinna*

Florida Cooter *Pseudemys floridana*

Chicken Turtle *Deirochelys reticularia*

Florida Softshell Turtle *Apalone ferox*

Spiny Softshell Turtle *Apalone spinifera*

Common Snapping Turtle *Chelydra serpentina*

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

General Turtle Diversity Introduction

The southeastern United States includes one of the world's richest regions for freshwater turtle diversity. Freshwater turtles are under increasing levels of threat around the world. In particular, two-thirds of the world's turtle species are listed as threatened by the IUCN and many of the

remaining third have not been evaluated (Turtle Conservation Fund 2002). Human exploitation of turtles has resulted in population declines, local extirpations and even extinction of some species (Thorbjarnarson et al. 2000).

Description

Taxonomy and Basic Description

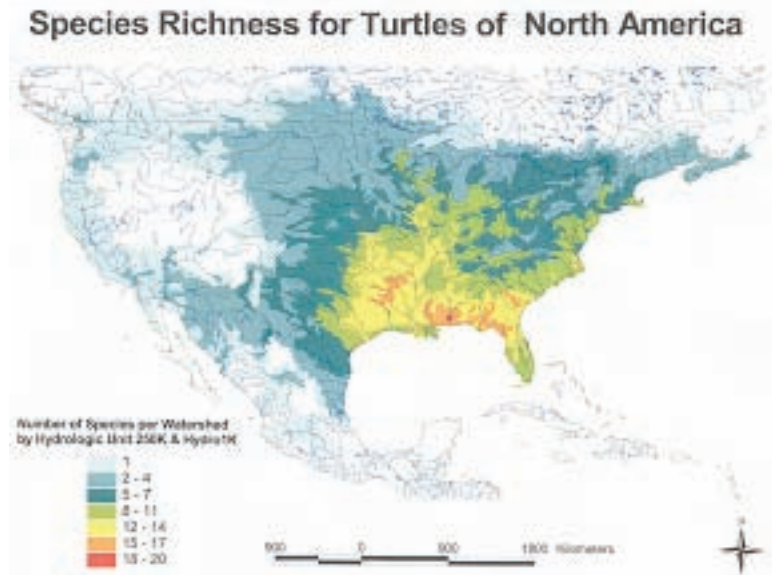
This group comprises a number of freshwater turtles that may be affected by commercial harvest in South Carolina. These species all occur in freshwater habitat in this state and are susceptible to harvest by some form of trapping. Recently, the demand for freshwater turtles from the U.S. has increased dramatically due to the Asian animal markets.

The yellowbelly turtle, river cooter, Florida cooter and chicken turtle are members of the family Emydidae, the semi-aquatic pond turtles (Ernst and Barbour 1989). These species all have hardened carapace (top) and plastron (bottom) shells.

The yellowbelly turtle is large; it reaches lengths from 12.5 to 20.3 cm (4.9 to 7.9 inches). The maximum length for the yellowbelly turtle is approximately 29 cm (11.4 inches). Adults are sexually dimorphic; females reach greater lengths and overall body size than males (Ernst and Barbour 1998). Adults are typically dark with vertical yellow markings on their carapace. The most conspicuous marking is the yellow blotch on the side of the head, just behind the eye (Conant and Collins 1991; Martof et al. 1980). The plastron of these turtles is yellow with round, dark markings along its edge. Older adult yellowbelly turtles can become very dark, obscuring many of their distinguishing marks.

The river cooter and Florida cooter are both large turtles that can reach lengths between 23 and 33 cm (9 to 13 inches); maximum length for these turtles is approximately 39 cm (15.3 inches). Adults of both species have dark carapaces with yellow markings; however, markings on the Florida cooter tend to be vertical stripes while the river cooter has a net-like pattern. The plastron of the Florida cooter is typically plain yellow (Conant and Collins 1991; Martof et al. 1980). The river cooter has dark markings on its plastron. Both cooters have yellow stripes along the sides of their heads. These species are closely related; some taxonomists believe they might be the same species (Seidel 1994). They are typically found in different habitat types, but some overlap does occur and they may hybridize readily in these areas, producing individuals that share traits of both species.

The chicken turtle is small to moderate in size. This turtle reaches lengths from 10 to 15 cm (3.9 to 5.9 inches); maximum length is approximately 25 cm (9.8 inches). This species has a dark black to brown carapace with a light net-like pattern and a very long, striped neck (Conant and Collins 1991; Martof et al. 1980). The plastron is typically plain yellow and patterning on the bridge varies among individuals; the bridge may have a black bar, one or two spots or no



markings at all. Very strong, vertical striping is present on the rear legs. The carapace is longer than wide and is widest toward the rear, appearing somewhat pear-shaped from above. The edges of all marginal scutes are smooth. The species differs from most other North American turtles because it has both a fall to spring nesting season as well as a long incubation period.

The Florida softshell turtle and the spiny softshell turtle are both members of the Family Trionychidae (Ernst and Barbour 1989). Members of this family are semi-aquatic and have cartilaginous shells, rather than hardened shells like other turtles and tortoises. The cartilaginous “shell” of these turtles covers a bony shell in much the same way the scutes of other turtles and tortoises cover a bony shell. Softshell turtles, in general, have very flattened, pancake-like shells.

The Florida softshell turtle is a large species, reaching lengths between 28 and 62 cm (11 to 24 inches); females are significantly larger than males (Conant and Collins 1991; Martof et al. 1980). The shell of this species is typically dark brown to dark green and generally uniform in color. The Florida softshell has an oval shaped shell with numerous bumps on the carapace just behind the head and neck.

The spiny softshell turtle is also a large species, reaching lengths between 18 and 45 cm (7 to 17.7 inches) (Conant and Collins 1991; Martof et al. 1980). Females of this species are significantly larger than males. The spiny softshell turtle has a more rounded shell than the Florida softshell and there are usually two or more dark, broken lines that parallel the curve of the shell at its rear. The carapace of this species also has numerous small blotches or circular marks. The spiny softshell has two stripes along its neck. Both species have extremely long necks and elongated nostrils.

The common snapping turtle is a member of the Family Chelydridae, which includes the snapping and alligator snapping turtles. Members of this family are semi-aquatic and are only found in North America. The common snapping turtle is large; it can reach lengths of 20 to 36 cm (7.8 to 14 inches). The maximum length for this species is approximately 50 cm (19.6 inches) (Conant and Collins 1991; Martof et al. 1980). This species has a “prehistoric” appearance because its long tail looks “saw-toothed” and its dark brown carapace has a jagged rear edge. The plastron of this species is greatly reduced and white. The head of the common snapping turtle is very large and includes a sharp beak-like snout. This species has a nasty disposition and lives up to its name.

Status

None of these species are currently listed either federally or in South Carolina. All of these species were listed as Species in Need of Management in South Carolina, due to a concern over unregulated harvest, from June 2003 until December 2003 under an emergency regulation issued by SCDNR. The Florida softshell turtle is included in this plan because it is peripheral to South Carolina and is currently ranked unknown (S?) in this state (NatureServe 2005).

Each of these turtles is currently relatively common to abundant in South Carolina. However, they are under potential impact from an unregulated harvest. Although South Carolina does not track turtle harvest through a permit system, North Carolina did track turtle harvest. In 2003, North Carolina Department of Environment and Natural Resources (NCDENR) prohibited the commercial harvest of freshwater turtles because that state had experienced a tremendous increase in turtle harvest from 2000 to 2003.

There is concern among resource managers and scientists that freshwater turtle populations

cannot withstand the level of harvest to which they are currently subject in South Carolina. Many of the “target” species are long-lived animals that may not reach sexual maturity until they are 15 years old. Further, these turtles exhibit low survivorship in both the egg and juvenile life stages. It could be possible for one trapper to completely eliminate a population of turtles at a given site within a matter of months.

Turtle Life Histories

Endangerment of many tortoise and freshwater turtles worldwide is directly related to their life history strategies. Turtles are long-lived organisms that can take years to mature; in some species, sexual maturity is not reached until 20 years of age. Turtle life history traits sharply contrast North American wildlife game species. Rabbits, squirrels and white-tailed deer can reproduce at six months to one year of age and may only live to be two or three years old. Even earlier maturing turtle species become reproductive later than do many shorter-lived birds and mammals: diamondback terrapins (*Malaclemys terrapin*) mature at age 6 (Lovich and Gibbons 1990), Florida cooters (*Pseudemys floridana*) at age 6 to 7 (Gibbons and Coker 1977), yellowbelly turtles (*T. scripta*) females at age 8 (Gibbons et al. 1981) and chicken turtles (*Deirochelys reticularia*) at 5 to 6 years of age (Buhlmann 1998). Thus, turtles grow slowly, mature later in life and survive for many years. Consequently, management strategies for turtles should be very different from historical wildlife management approaches for most game species.

When turtles reach sexual maturity, they have a low annual fecundity. In general, few hatchling turtles survive; those that do must harvest resources, grow and survive for years before they become adults. Thus, adult turtles must have high annual survivorship to maintain stable populations (Congdon et al. 1993, 1994). In some species, older females have higher survivorship and produce more offspring than do younger individuals (Gibbons 1990). Many animals eat turtle eggs, hatchlings and juveniles, but adults of many turtle species have few natural enemies except humans (Gibbons 1990). Commercial harvests remove large numbers of adult turtles that are the most important individuals for population stability and persistence.

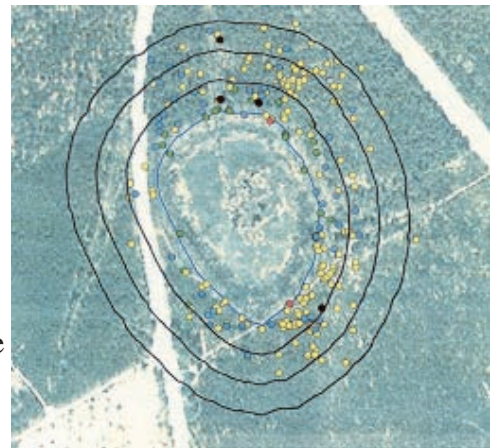
Population Distribution and Size

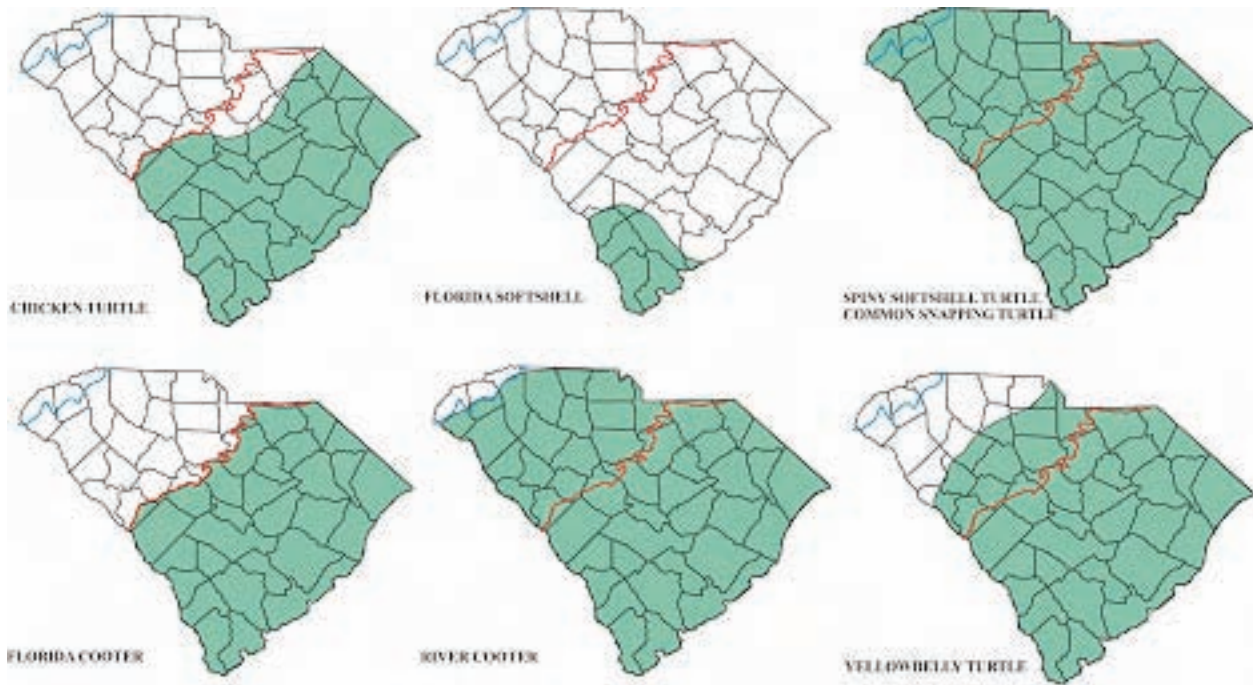
Accurate population estimates do not exist for any of these species. Most, if not all, are considered relatively common to abundant in South Carolina. The Florida softshell is the least common species encountered in this state, primarily due to its restricted range. However, this species is common to abundant in Georgia and Florida.

Habitat and Natural Community Requirements

All of the members of this group inhabit some type of freshwater and/or wetland system in South Carolina. Some species, such as the spiny softshell turtle and the river cooter are restricted to rivers and reservoirs resulting from impounded rivers. The yellowbelly turtle and Florida cooter are most commonly associated with ponds, small lakes and other non-flowing wetlands. The chicken turtle inhabits seasonally fluctuating, fish-free isolated wetlands. The Florida softshell turtle and the common snapping turtle occur in rivers, ponds, lakes and other wetland types.

Chicken turtles also use surrounding upland habitats for





GENERALIZED RANGE MAPS FOR FRESHWATER TURTLES

ADAPTED FROM CONANT AND COLLINS 1991

refugia during periods when wetlands are dry (Buhlmann 1998). These turtles, predominantly juveniles and males, but also several females, can spend September through March wintering 50 to 250 m (164 to 820 feet) from a Carolina bay in South Carolina (Buhlmann and Gibbons 2001). Most often, chicken turtles chose an older live oak and pine forest for wintering habitat; fewer choose clearcut areas. Even the most stringent wetland protection laws do not protect more than 100 feet of adjacent uplands (Burke and Gibbons 1995)..

In contrast to the Florida softshell, spiny softshell turtles live in riverine habitats where they often bask on sandbars and bury in clean sand in the river bottoms.

Challenges

The primary challenge facing these species comes from unregulated harvest. Many turtle ecologists are doubtful that these species can sustain any type of harvest because of their particular life histories. Continuing unregulated harvest in South Carolina could result in drastic population declines for these turtles, which are currently common to abundant.

Alterations to freshwater habitats can result in impacts to all of these species. Specifically, chicken turtles are affected by alterations to freshwater wetlands. These alterations include draining and filling of isolated wetlands. Water quality degradation in these wetlands can also adversely affect these turtles. Chicken turtle populations appear most robust where clusters of seasonal wetlands exist in close proximity in an unfragmented landscape. Roads that pass near seasonal wetlands contribute to chicken turtle population declines through automobile mortality; this mortality results when chicken turtles are moving to upland forests during the dry period.

Timber and logging companies that continue to clear-cut forests to edges of wetlands eliminate the dry season habitat required by chicken turtles. Narrow buffers of forest habitat left to protect water quality are currently insufficient to provide the upland habitat component needed by chicken turtles.

The loss of wetlands has likely reduced suitable habitat for Florida cooters. Mortality also occurs as roads and highways further fragment and isolate wetland habitats.

Population stability of yellowbelly turtles is threatened by hybridization with red-eared sliders (*Trachemys scripta elegans*), a related subspecies from the Mississippi Valley. Red-eared sliders were sold in South Carolina pet stores for many years and continue to be sold through other venues, such as flea markets and exotic animal trade shows. This non-native species is often released in South Carolina by well-meaning, but ill-informed persons, and can survive in our state. The primary issue here is one of genetic integrity as established red-eared sliders interbreed with yellow belly turtles, shifting the genetics of these local populations.

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. Road mortality may be a factor as Florida softshells frequently move overland between lakes and wetlands.

Pollution of rivers and streams may adversely affect spiny softshell turtles at greater rates relative to hard-shelled turtles due to the permeability of the skin and shell. Sandbars used for nesting are also favorite sites for recreational boaters and campers during the summer months. Whether the human use of the sandbars directly and significantly affects nesting and hatching success is unknown; however, raccoon predation likely increases where camping refuse is also found. Fire ants have been observed to colonize river sandbar habitats and likely affect hatchling survival (Buhlmann and Coffman 2001).

Alteration of rivers, through damming and dredging adversely affects river fauna. Dams increase normal summer low flows and thus scours aquatic weed-beds (Petts 1984); these abnormal flows may affect hatchling survival. Bottom-release dams reduce river water temperatures and may adversely affect river cooters. Reservoirs may also allow for hybridization between river cooters and Florida cooters as their habitats coincide.

Establishment of nonnative fire ants in the southeastern U.S. has an adverse impact on freshwater turtles, as they will predate nests and newly hatched turtles. These ants especially affect those species in which the hatchlings exhibit delayed emergence and have evolved to remain in the nest because it provided a safe refuge.

Conservation Accomplishments

The recently issued emergency regulation and several newspaper articles have directed some attention to the threats facing South Carolina's freshwater turtles. To date, no permanent solution to this problem has been enacted.

Conservation Recommendations

- Include the importance of protecting all freshwater turtles and their habitat in general education materials.
- Consider the need to develop a regulatory solution to the problem of unregulated harvest of freshwater turtles. Monitor harvests for these species.

- Consider habitat needs of freshwater turtles in river dredging and dam construction projects.
- Determine locations of viable river cooter populations. Surveys can be conducted via basking surveys during spring and early summer months. These surveys can form the baseline for long-term monitoring.
- Conduct research that determines effects of dams and reservoirs on the exclusively riverine river cooter.
- Conduct research to determine the ecological habitat niche overlap between Florida cooters and river cooters.
- Conduct research on the sustainability of harvest for all freshwater turtles.
- Consider habitat needs of the Florida cooter when managing Carolina bays and floodplain ecosystems.
- Determine locations of viable Florida cooter populations.
- Include chicken turtles in protection plans for coastal plain wetlands. Engage Savannah River Site-U.S. Forest Service and the Savannah River Ecology Lab to manage for metapopulations of chicken turtles and habitat connectivity between Carolina bay wetlands.
- Consider chicken turtle habitat needs when managing Carolina bays and similar wetland ecosystems. Work with SREL, and USFS to develop ecologically meaningful buffers and define core uplands habitat needs for Carolina bay habitats required by this species.
- Determine locations of viable chicken turtle populations and monitor those populations. Priority survey sites should be located in the vicinity of Carolina bay clusters.
- Assess the probable impacts of fire ants on freshwater turtles, particularly on chicken turtles, which spend a greater amount of time in the ground as developing eggs, overwintering hatchlings and terrestrially aestivating adults.
- Complete on-going life-history studies for the chicken turtle.
- Survey for Florida shoftshell turtles and identify possible sites for protection based on results of surveys.
- Consider spiny shoftshell turtle habitat needs in river dredging and dam construction projects.
- Monitor known spiny softshell turtle sites for water quality changes and determine whether changes in water quality adversely affect this species.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from surveys and other research will be used to determine the best means of conserving these species in South Carolina through both habitat management and regulatory means. Stable or increasing populations of these species on public lands and in public waters will be a measure of success.

Gopher Tortoise

Gopherus polyphemus

Contributor: Stephen Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

The gopher tortoise was described by Daudin in 1791. This is the only species of tortoise found in the eastern United States and one of only four tortoise species found in North America.

The gopher tortoise is a large, terrestrial turtle with front legs that are spade-like, an adaptation for digging and hind legs that are elephantine. The carapace of the gopher tortoise can vary from brown to dark gray. Carapace length averages 25.4 to 30.5 cm (10 to 12 inches) for adults; maximum length is approximately 38 cm (15 inches). The carapace of the adult tortoise is generally dull and unmarked. Adult tortoises can weigh up to 4.5 kg (10 pounds). The head of a tortoise is square in profile with a flat, blunt nose (Conant and Collins 1991).

Juvenile tortoises are typically lighter colored than adults, varying from yellow-brown to light gray. Juveniles may have light colored centers on their carapacial scutes, and visible growth annuli. As tortoises grow, their annuli become worn and are seldom apparent on adult specimens (Ernst et al 1994).

Tortoises are herbivorous, feeding primarily on grasses and plants, but they have also been documented to scavenge on carrion and other materials, as available (Conant and Collins 1991, Ernst et al 1994)

The gopher tortoise is a long-lived species, possibly reaching 50 to 60 years, or greater, in age. This species is believed to reach sexual maturity between 12 to 14 years of age and can be reproductively active until death. Tortoises mate in spring and nesting occurs during April through July. Clutch sizes typically number five to seven eggs. Hatchlings emerged in late summer to early autumn (Conant and Collins 1991; Ernst et al 1994).

Status

- The gopher tortoise is legally protected throughout its range as follows:
- Georgia - state listed as threatened
- Florida -state listed as a species of concern
- Mississippi - state listed as endangered; federally listed as threatened
- Alabama - state listed as protected; populations west of the Tombigbee and Mobile Rivers are federally listed as threatened
- Louisiana - state and federally listed as threatened

The gopher tortoise is currently listed as endangered in South Carolina as critically imperiled with a ranking of S1 and is globally considered vulnerable (G3) (NatureServe 2005),

Population Distribution and Size

In South Carolina, gopher tortoise populations currently occur in the sandhills and inner coastal plain ecoregions in three counties: Jasper, Hampton and Aiken. There are additional records of the tortoise in Colleton and Dorchester Counties and an anecdotal record for Bamberg County.

Another additional record for the gopher tortoise came from Allendale County; this is believed to be an introduced population, although it is likely that Allendale County was in the historic range of the tortoise.

The currently accepted (historic) range of the gopher tortoise in South Carolina includes the southern portion of the state. Additional records have added to the range of this tortoise in South Carolina. Based on all of the records for the tortoise, it is reasonable to believe that the gopher tortoise once occurred throughout the southeastern portion of South Carolina.

ELEMENT OCCURRENCE RECORDS FOR THE GOPHER TORTOISE IN SOUTH CAROLINA

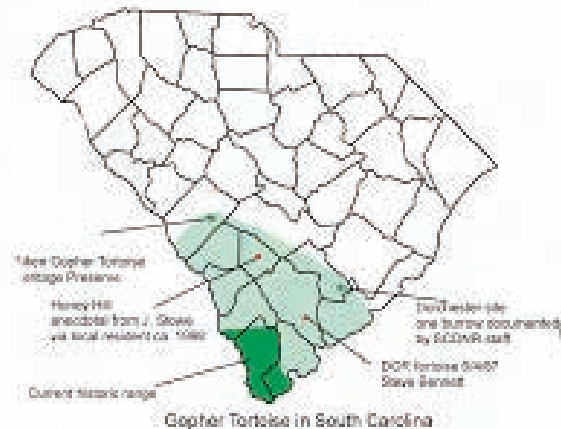


Currently Accepted Range of the Gopher Tortoise

Native, extant, reproducing populations of the gopher tortoise are currently known from three different “metapopulation” areas: 1) the sandhills along the South Edisto River in Aiken County; 2) the sandhills along the Coosawhatchie River in both Jasper and Hampton Counties; and 3) in the Tillman Sand Ridge Heritage Preserve (TSRHP), along the Savannah River in Jasper County.

Little is known about the population status of the gopher tortoise in Aiken County or in the Coosawhatchie region.

Holbrook (1842) noted that gopher tortoises were abundant in the “Edgefield and Barnwell” districts (Tuberville et al. in review). A portion of the Aiken population is protected on the Aiken Gopher Tortoise Heritage Preserve, but this population is believed to be in severe decline, with perhaps no more than 50 individuals contained within the entire region. An experimental translocation project using gopher tortoises is currently entering its fourth year on the Savannah River Site (SRS). Researchers from the University of Georgia’s Savannah River Ecology Laboratory and the U.S. Forest Service-Savannah River worked with South Carolina Department of Natural Resources (SCDNR) and Georgia Department of Natural Resources to obtain tortoises from an industrial development site in Georgia (Tuberville et al. in review).



Three sub-populations of the tortoise occur within the Coosawhatchie region: one near the town of Grays in Jasper County; one near the town of Gillisonville in Jasper County; and one on Buckfield Plantation in Hampton County. The two Jasper County populations are on land owned by the Mead-Westvaco Corporation; SCDNR holds conservation easements from Mead-Westvaco on these two tracts; Mead-Westvaco is managing for the tortoise at these two sites. Buckfield Plantation is currently in private ownership; no management for the tortoise is currently occurring at this site.

The tortoise population at TSRHP has been the subject of past surveys by Franz in 1974/1975 (Auffenberg and Franz 1982) and Wright in 1977/1979 (Wright 1982). Currently, approximately 567 ha (1,400 acres) of the TSRHP are protected. Approximately 121 ha (300 acres) of this preserve supports the xeric sandhill habitat preferred by the tortoise. In 1977 and 1979 Wright surveyed tortoises at TSRHP. In 1998 Tuberville and Dorcas re-surveyed this preserve (Tuberville and Dorcas 2001). The population estimates derived from these surveys indicates a steady decline in the adult population of tortoises at this preserve.

Tuberville and Dorcas (2001) estimate that approximately 163 adult tortoises occur on the TSRHP. This estimate does not account for juveniles and sub-adults. The current estimate indicates that this population is in decline, despite the protection afforded and appropriate management at the site.

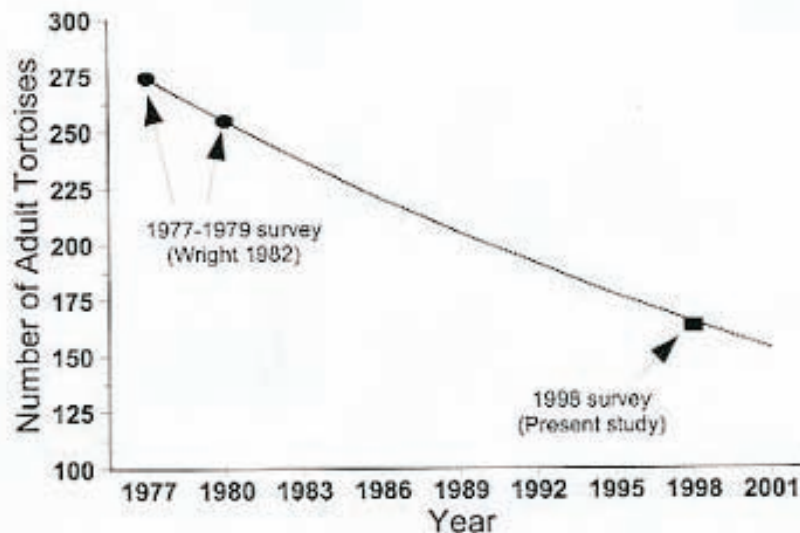


Figure 3. The projected change in adult gopher tortoise population size on the Tillman Sand Ridge Heritage Preserve from 1977 to 2001. The projection assumes an initial population size in 1977 of 274 individuals as estimated by Wright (1982) and an average 2.33% loss per year in the adult population, which was observed by Wright during 1977-79 (indicated by circles), leading to a projected population of 165 individuals in 1998. Based on our 1998 survey, we estimated the maximum adult population size at 163 tortoises (indicated by square).

Recently, SCDNR began a mark-recapture and radio telemetry study of tortoises on the TSRHP. Two sites, one on the TSRHP and another 405 ha (1,000 acres) tract owned by the Public Service Authority (PSA) are currently being studied. This study is in its second year; however, anecdotal evidence suggests that the tortoise population on the PSA tract is also in decline. To date, little evidence of reproduction or recruitment has been found at this site. The population seems to be made up entirely of older, adult tortoises, indicating that it might be a senescent population (data from current SCDNR tortoise project).

Habitat and Natural Community Requirements

The gopher tortoise is a fossorial, burrowing species that primarily inhabits xeric longleaf pine sandhills in South Carolina. The deep, droughty sands of such habitats provide the ideal substrate for the excavation of the tortoise's burrow. Adult tortoises may excavate a burrow that can be from 3 to 9 m (10 to 30 feet) in length; at its deepest point the burrow may be 3 m (10 feet) underground (Ernst et al 1994).

An individual tortoise may excavate several such burrows over its lifetime; it may also take over and utilize burrows excavated by other tortoises. Tortoises typically use more than one burrow during the active period of the year, but typically over-winter in only one burrow (Ernst et al 1994).

The burrow system within a tortoise colony may provide the organization and structure for these social animals. Courtship occurs at burrow mouths and egg deposition typically occurs within 4 m (12 feet) of the burrow (Ernst et al 1994).

Tortoise burrows are not just important to the tortoises but are also a critical resource for many species that are found in sandhill habitats. Over 250 species of vertebrate and invertebrate animals have been documented to use tortoise burrows, whether active or abandoned.

Longleaf pine sandhill habitat is fire adapted, that is, it requires periodic wildfire (historically) or prescribed burning (currently) for establishment, restoration, and maintenance of this vegetative community. This habitat type has declined due to the suppression of fire in the southeast and the conversion of longleaf pine forests to commercial loblolly plantations.

Historical tortoise habitat would consist of longleaf pine in an open, park-like stand with a lush ground cover dominated by wiregrass (*Aristida stricta*). Herbaceous plants such as gopher apple, goat's rue, lupine and other grass species would have also occurred. A sparse understory would have been composed of scrub oaks.

The gopher tortoise shares its sandhill habitat with several other reptile species of concern in South Carolina. These include the Florida pine snake (*Pituophis melanoleucus mugitus*), southern hognose snake (*Heterodon simus*) and eastern diamondback rattlesnake (*Crotalus adamanteus*), all of which have all been documented from areas with active gopher tortoise populations in this state.

Challenges

Tortoise populations have been historically adversely affected by take or harvest. The gopher tortoise was collected for food throughout the southeast prior to its range-wide protection. Illegal take for food still occurs, especially on private lands where little or no management or care-taking occurs. Gopher tortoises have also been confiscated when found for sale as pets. It is often unknown from where these individuals originated.

Currently, the primary challenge to the gopher tortoise is habitat loss, either through direct means, such as type conversion to loblolly plantations, agriculture or development; or through indirect means, such as fire suppression that results in successional changes that render the habitat unsuitable for tortoises.

Direct threats to habitat may cause immediate mortality in tortoises or result in displacement of tortoises into unsuitable habitats. Heavy equipment can collapse burrows; this can result in additional tortoise mortality.

Using fire as a management tool has become increasingly difficult; this is a particularly troubling issue for gopher tortoise management and for longleaf pine ecosystem management, in general. The PSA site in Jasper Country has been managed for hunting by excluding fire and mowing strips between stands of trees. This type of management has allowed scrub oak to obtain dominance over longleaf pine; it has also shaded the understory so that wiregrass and other forbs have declined. On SRS, prescribed fire is used too infrequently due to Department of Energy concerns about facilities and general disruption to highway traffic, personnel, and operations.

Indirect threats to habitat may result in long-term population declines correlated to declines in available food and burrow sites and increases in predators. While adult tortoises have few predators, with the exception of man, juvenile tortoises are predated by a wide array of animals, including foxes, raccoons and snakes. Declining gopher tortoise habitat may favor predators of juvenile tortoises. In addition, armadillos, which have recently established in South Carolina, may pose a threat to tortoise by modifying existing burrows and potentially predating tortoise eggs.

Conservation Accomplishments

Four areas that support gopher tortoise populations have been protected through SCDNR's Heritage Trust Program. Two areas, Tillman Sand Ridge Heritage Preserve and Aiken County Gopher Tortoise Heritage Preserve, are owned and managed by SCDNR. The Aiken preserve is 565 ha (1,395 acres) in size, most of which is suitable tortoise habitat. The Tillman preserve is 576 ha (1,422 acres) in size, approximately 400 acres of which currently contain suitable tortoise habitat. There are approximately 40 ha (100 acres) of potentially suitable habitat at the Tillman preserve that require some restoration.

Two additional gopher tortoise sites on private lands are currently protected under conservation easement with the Mead-Westvaco Corporation. These sites are located near the small communities of Grays and Gillisonville in Jasper County, South Carolina.

In addition to habitat protection efforts, SCDNR is currently conducting a study on the tortoise population at TSRHP. Sixteen tortoises, eight each at two study sites, have been outfitted with telemetry radios and are being tracked to determine home range, habitat use and seasonal movement patterns. In addition, a mark-recapture study of tortoises is ongoing at both sites. To date, twenty tortoises have been captured, measured, weighed, the sex determined and the shell marked at both sites.

Conservation Recommendations

- Inventory known gopher tortoise populations and relict individual localities to determine the extent of the population.
- Protect all gopher tortoise sites identified in the inventory through land acquisition or conservation easement. Monitor these sites to determine stability of known populations.
- Conduct landowner workshops to educate landowners about the importance of gopher tortoises and methods for protecting this species.
- Conduct fire management operations at known gopher tortoise locations on SCDNR properties.
- Encourage other property owners, especially owners/operators of public lands such as SRS, PSA and others to conduct fire management operations to further enhance gopher tortoise populations.
- Continue gopher tortoise life history research.
- Continue gopher tortoise repatriation/relocation technology research.
- Monitor impacts to gopher tortoise burrows from armadillos

Measures of Success

As results from current research and surveys are identified and analyzed, we will initiate projects to address specific needs that arise from these results. Data from ongoing life history and ecology studies will be used to develop specific management plans for the species and its habitat. The maintenance and growth of existing tortoise populations along the Tillman Sand Ridge and recovery of the tortoise population at Aiken Gopher Tortoise Heritage Preserve will serve as two measures of success.

Leatherback turtle

Dermochelys coriacea

Contributors: Sally Murphy and Tom Murphy

Description

Taxonomy

Blainville introduced the generic name *Dermochelys* in 1816. The binomial refers to the distinctive leathery, scaleless skin of the adult turtle. The specific name, *coriacea*, was first used by Vandelli in 1761 and adopted by Linneaus in 1766 (NMFS, USFWS 1992). The leatherback is the largest living turtle and is so distinctive that it is placed in a separate family, Dermochelyidae.

Basic Description

The carapace of the leatherback is distinguished by a rubber-like texture. It is black with white spots and has seven prominent longitudinal ridges, which taper posteriorly to a blunt point. No sharp angle is formed between the carapace and the plastron, resulting in the animal being somewhat barrel-shaped; hence one common name was “trunkback.” The undersurface is mottled, pinkish-white and black and is highly variable. The mean curved carapace length for adult females nesting in the U.S. Caribbean is 155 cm (61 inches) with weights of 262 to 506 kg (578 to 1274 pounds) (NMFS, USFWS 1992).

Leatherback hatchlings are dorsally mostly black and covered with bead-like scales; the flippers are margined in white and rows of white scales appear as stripes along the length of the back. In the U.S. Virgin Islands, hatchlings average 61.3 mm (2.4 inches) in straight carapace length and 45.8 g (91.6 ounces) in weight.

Status

The leatherback turtle is endangered throughout its global range. It was listed as endangered on June 2, 1970 and is included on Appendix I of CITES (Convention on International Trade in Endangered Species).

Population Distribution and Size

Leatherback nesting beaches are distributed circumglobally. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on 28 major surveyed beaches, with a lower limit of about 26,200 and an upper limit of about 42,900 (Spotila et al. 1996). This is less than one third of the 1980 estimate of 115,000 (Spotila et al. 1996). The largest population is in the western Atlantic (Spotila et al. 1996). Leatherback nesting in Florida was once considered extremely rare, but now nests number in the hundreds annually (Meylan 2004). In North America, the northeast coast of Florida was considered the northern limit for leatherback nesting.

In 1981, two confirmed leatherback nests were documented in Georgia on Cumberland and Blackbeard Islands. Today, leatherback nesting has been confirmed in South Carolina and North Carolina as well and, possibly, Maryland (Rabon et al. 2003). Since 1996, four leatherback nests have been documented in South Carolina (SCDNR unpublished data).

Habitat and Natural Community Requirements

Leatherbacks are highly migratory and are the widest ranging of all sea turtles. Habitat requirements for post-hatchling and juvenile leatherbacks are virtually unknown. Their movements are no doubt in response to seasonal abundance of jellyfish, their major food item. An annual migration of adult and subadult leatherbacks from the wider Caribbean to the northwestern Atlantic results in spring and fall concentrations of leatherbacks in South Carolina waters. Nearshore concentrations of leatherbacks can occur from April to June during the northward migration when cannonball jellyfish (*Stomolophus meleagris*) are abundant (Hopkins-Murphy et al. in press). Based on strandings, there is a second, less apparent peak, during the southward migration in October and November.

Nesting females prefer high-energy beaches with deep, unobstructed access that occurs most frequently along continental shorelines.

Challenges

Leatherbacks are still occasionally killed for meat and oil in the Caribbean (NMFS, USFWS 1992). The theft of eggs for local consumption was once a problem in the U.S. Virgin Islands, but has been all but eliminated as a result of nightly patrols and nest protection programs (NMFS, USFWS 1992).

Loss or degradation of nesting habitat from coastal development and beach armoring results in adverse impacts to leatherbacks. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites. Uninformed visitors using flashlights at night can cause females to avoid certain areas and beachfront lighting will disorient hatchlings (NMFS, USFWS 1992). Ghost crabs (*Ocypode quadratus*) and yellow crown night herons (*Nyctanassa violacea*) are common hatchling predators on the beach at night (NMFS, USFWS 1992).

Because of their very large front flippers, leatherbacks become entangled fairly often in longlines, float lines of crab and lobster pots, buoy anchor lines and other ropes and cables. This can lead to serious injuries and/or death by drowning (NMFS, USFWS 1992). Leatherbacks apparently mistake floating plastic bags and sheets for jellyfish and consume these materials. This can cause direct obstruction of the gut or absorption of toxic byproducts and reduced absorption of nutrients across the gut wall. Mrosovsky (1981) reviewed data from leatherback stomach content studies worldwide and concluded that approximately 44 percent of the adults examined had plastic in their stomachs.

The shrimp trawl fishery also captured leatherbacks until Turtle Excluder Devices (TEDs) were enlarged to allow their escape. They are also vulnerable to boat and ship collisions, particularly when inhabiting shallow near shore waters. Lewison et al. (2004) integrated catch data from over 40 nations and bycatch data from 13 international observer programs. They estimate that 50,000 leatherbacks were likely taken as pelagic longline bycatch in 2000.

Conservation Accomplishments

Since 1981, intensive nest survey and protection efforts have been implemented at Sandy Point, St. Croix, U. S. Virgin Islands. In 1984, the U.S. Fish and Wildlife Service purchased the 2.4 km (1.49 mi.) long nesting beach at Sandy Point, which became a National Wildlife Refuge and designated as Critical Habitat under the Endangered Species Act of 1973. In South Carolina, nearshore aerial surveys have documented the density and distribution of leatherbacks since 1993. The leatherback Conservation Zone was established as part of the Contingency Plan in 1995 (60 FR 25260, May 12, 1995; 60 FR 25663, May 12, 1995). Additionally, leatherback-sized Turtle Excluder Devices (TEDs) were required in all shrimp trawls by the National Marine Fishery Service in 2003.

Conservation Recommendations

- Conduct short-term telemetry studies to document residency time of leatherbacks in South Carolina.
- Protect areas of high leatherback concentration from activities that can have a negative impact on leatherbacks such as longlines, set nets and trawl fisheries that do not require effective TEDs.
- Conduct education programs that inform the public about the detrimental impacts of litter on aquatic organisms like the leatherback to assist in reducing the volume of plastics in the marine environment.
- Provide protection from predators and erosion for any nests that are laid on the beaches.
- Ensure a continued food source for leatherbacks by protecting the cannonball jellyfish from commercial over harvest.
- Continue near shore index aerial surveys to document spatial and temporal distribution of leatherbacks in South Carolina.
- Monitor stranded leatherbacks to determine the number, size and distribution of mortalities and the source of tagged individuals.
- Perform post mortem examinations of stranded leatherbacks to document cause of death, food habits, sex ratio, reproductive condition and extent of ingestion of plastics.
- Continue to gain more information on leatherback distribution from the public through the Marine Turtle Conservation Program web site.

Measures of Success

While Pacific populations of leatherbacks are in sharp decline, nesting populations in the Atlantic appear to be either stable or increasing. South Carolina research and monitoring efforts will be an important component to document future population trends in this endangered and unique animal. An increase in numbers of individuals recorded during index aerial surveys and increased numbers of nests may be a considered sign of successful management actions.

Loggerhead turtle

Caretta caretta

Contributors: Sally Murphy and DuBose Griffin

Description

Taxonomy and Basic Description

The loggerhead was described by Linnaeus (1758) and named *Testudo caretta*. Over the next two centuries more than 35 names were applied to the species (Dodd 1988), but there is now general agreement on *Caretta caretta* as the valid name.

The carapace, head scales and dorsal scales of the flippers of adult and juvenile loggerheads are reddish-brown. The plastron, neck, ventral surface of the flippers and margins of the head scales are yellow, but with some variation. Adult loggerheads in the southeastern United States have a mean straight carapace length of 92 cm (36.2 inches) and weigh about 113 kg (249 pounds) (NMFS, USFWS 1991).

Hatchlings lack the reddish tinge and vary from light to dark brown dorsally. Both pairs of flippers are dark brown and have distinct white margins. The plastron and other ventral surfaces are a dull tan. Hatchlings have three dorsal keels and two plastral keels. The mean straight carapace length is about 45 mm (1.8 inches); juvenile loggerheads weight about 20 g (0.7 ounces) (NMFS & USFWS 1991).

Status

The loggerhead is federally listed as threatened. The population nesting in the United States is comprised of four nesting assemblages, or sub-populations. The northern sub-population, which nests from northern Florida to North Carolina, is declining. The southern sub-population, which is ten times larger, is stable or increasing. Status of the two remaining sub-populations is unknown (TEWG 1998; TEWG 2000).

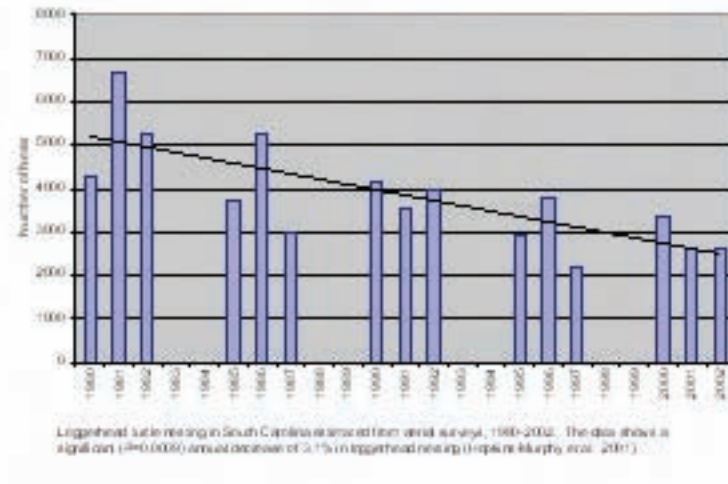
Population Distribution and Size

The Northern sub-population is the second largest in the United States. Annual nesting totals ranged from about 3,629 to 6,642 between 1989 and 1998, representing approximately 1,287 nesting females per year (TEWG 1998). South Carolina nesting effort represents over 65 percent of the northern sub-population. However, the South Carolina nesting population has shown a 60 percent decline since the early 1980's (Hopkins-Murphy et al. 2001; SCDNR unpub. data).

Research by the South Carolina Department of Natural Resources (SCDNR) indicates that juvenile loggerheads in coastal waters off South Carolina, Georgia and northern

Florida are more abundant by an order of magnitude than they were in the late 1970's and early 1980's (Maier et al. 2004). If most of the juveniles are from the southern sub-population, then this increase of juveniles will not be realized in future years in the South Carolina nesting population.





Habitat and Natural Community Requirements

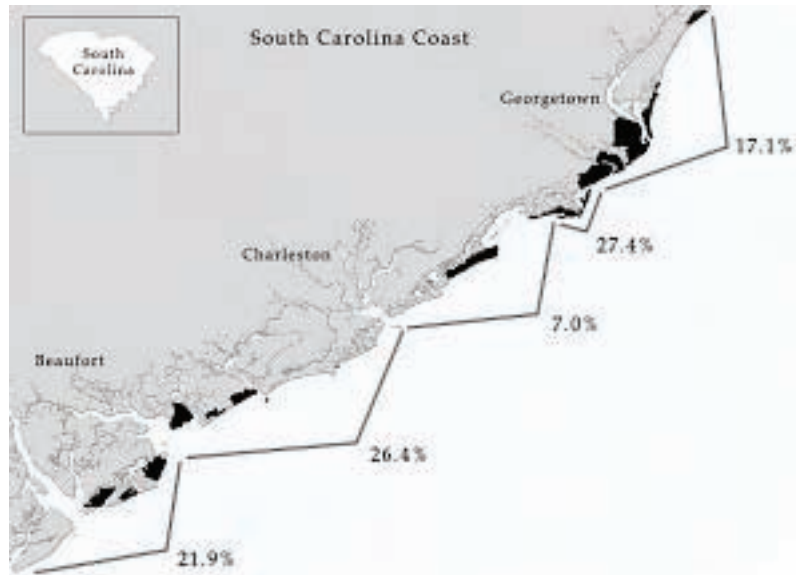
Adult females inhabit coastal waters during the nesting season, from mid May to mid August; during this time, they are not feeding. After nesting, females migrate to foraging areas both north and south of their nesting beaches. The predominate pattern for South Carolina females is to move to the mid Atlantic Bight until November and then return south of Cape

Hatteras during winter. In spring, they return to their same foraging area as the previous season. They repeat this until it is time for their breeding migration back to the nesting beach.

Loggerhead turtles nest on ocean beaches within the continental United States from Texas to Virginia. Major nesting concentrations are found on the coastal islands of North Carolina, South Carolina and Georgia, and on the Atlantic and Gulf coasts of Florida. Nests are typically made between the high tide line and the dune front (NMFS, USFWS 1991).

Darkened areas represent federal, state and private protected nesting beaches.

Percent of nesting for each section of coast from 1995 to 1997 is also shown. Three smaller protected areas, rarely used for nesting, are not included.



Juveniles from the various sub-populations mix on foraging grounds, which include estuarine, neritic and continental shelf waters in the Gulf of Mexico and the eastern seaboard. Juveniles, 40 to 91 cm (15.7 to 35.8 inches) in length are found in South Carolina on a seasonal basis from early April to early November (NMFS, USFWS, 1991).

Challenges

Because of their highly migratory behavior, conservation efforts for loggerhead populations in one country and/or state may be offset by activities in another.

Major Challenges faced by loggerheads include loss or degradation of nesting habitat from coastal development and beach armoring, although beach armoring is no longer allowed in South

Carolina. Of the 303 km (188.3 miles) of coastline in South Carolina, about 70 percent is suitable nesting habitat (Hopkins-Murphy et al. 1999). Of the 30 percent that is not suitable, two-thirds of it is the Grand Strand in Horry County. The other third is a combination of natural eroding beaches and previously built sea walls. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites. 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 loggerhead nesting (R. Westbrooks pers. com.).

Uninformed visitors using flashlights at night can cause females to avoid certain areas and beachfront lighting will disorient hatchlings. Excessive predation by native and non-native predators as well as erosion and storm events, destroy nests (NMFS, USFWS 1991). Feral hogs are reproducing and destroying loggerhead and bird nests, as well as negatively impacting the maritime forest community on some coastal islands (NMFS, USFWS 1991). Killing of adults is rare, but human poaching of turtle nests with clandestine markets for eggs may continue to be a problem (NMFS, USFWS 1991).

Another major impact on all sea turtles results from incidental take from commercial fishing operations. 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). Other trawl fisheries are known to capture sea turtles, but capture rates are currently not available. In South Carolina, these fisheries include: blue crab, whelk and cannonball jellyfish. Although incidental take has decreased in recent years, this continues to be a major problem for sea turtles. The shark longline fishery, which operates all year long off the south Atlantic, may impact loggerheads in the neritic environment (Lewison et al. 2004). Loggerheads have been found entangled in a wide variety of materials including fishing line, rope, onion sacks and discarded netting (NMFS, USFWS 1991). They also ingest many types of marine pollution and debris, resulting in gut blockage (NMFS, USFWS 1991). Watercraft and ship strikes are becoming more prevalent as more and more people move to the coast. Natural mortality factors include predation by large sharks, disease and parasites (NMFS, USFWS 1991).

Degradation of foraging habitat by physical damage occurs when there is trawling over live bottoms. Clam dredges can cause similar damage in the more offshore areas. Over harvesting of prey species, such as horseshoe crabs and whelks can deprive loggerheads of their food resource, resulting in longer remigration intervals between nesting (Bjorndal 1997). Data on the quantity and quality of foraging habitat is scarce.

Conservation Accomplishments

Some Conservation Accomplishments achieved for this species span a regional scale by federal agencies while others were made locally in South Carolina (Hopkins-Murphy 1987). The Sea Turtle Stranding and Salvage Network (STSSN) was established in 1980 to document the number of sea turtle carcasses that wash ashore. Nest protection projects were established along the South Carolina coast from 1981 to the present to increase hatchling productivity (Hopkins-Murphy et al. 1999). Over 70 percent of the nests laid in South Carolina are under nest protection management and achieve at least a 60 percent hatching success (Hopkins-Murphy et al. 1999). Statewide aerial beach surveys began in 1980 to provide a standard index for monitoring the nesting population (Hopkins-Murphy et al. 2001).

The loggerhead turtle was designated the South Carolina State Reptile in 1988 (Act # 588, June 1, 1988). South Carolina became the first state to enact Turtle Excluder Device (TED) regulations in 1988. Federal regulations requiring TEDs in all waters, at all times came into effect in 1991. In 1991, South Carolina also became the first state to require the U.S. Army Corps of Engineers (USACE) to restrict hopper dredge channel maintenance to the winter months. South Carolina became the first state to enlarge TED openings in 2002. Federal regulations requiring larger TED openings came into effect in 2003. The US Fish and Wildlife Service produced and distributed large “Lights Out” signs that were erected on roadways to beaches. Volunteers have also produced numerous articles to inform beach residents and visitors about the necessity to have lights out during the nesting and hatching seasons.

Finally, just this year, through a partnership of resources of NOAA Fisheries, SCDNR’s environmental education program and the South Carolina Department of Education, all public schools in this state have been provided copies of the interactive DVD “Journey of the Loggerhead.”

Currently, Endangered Species Act Section 6 funding from both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service provides program support for the South Carolina marine turtle conservation program.

Conservation Recommendations

- Protect any remaining significant loggerhead nesting beaches that are still threatened with development through fee simple purchase or conservation easement.
- Ensure that important nesting beaches destroyed by storm events are restored. Collaborate with the US Army Corps of Engineers to complete beach restoration projects.
- Reduce feral hogs populations on coastal islands.
- Ensure that predator control is conducted on important loggerhead nesting beaches.
- Consider establishing Marine Protected Areas based on satellite telemetry data of adult female loggerheads on resident foraging areas. This should be done in collaboration with Atlantic States Marine Fisheries Commission, Fisheries Management Councils and relevant states.
- Collaborate with other states in the southeast on projects to determine the cause(s) of the increase in emaciated loggerheads that stranded in recent years.
- Ensure existing surveys that are providing a standardized index to the population are adequately funded.
- Continue to publicize and promote the lights out efforts and enlist the assistance of electric utility companies when necessary.
- Maintain and improve the SCDNR Marine Turtle Conservation Program web page.

Measures of Success

As research and management needs are identified, we will initiate projects to address those needs. This was done previously with TED opening sizes when they were found to be too small. Also, this is being done now with the management of beach vitex through the establishment of a Beach Vitex Task Force using funding from a National Fish and Wildlife Foundation grant.

Because there are multiple threats to loggerheads, both on the nesting beaches and at sea, there

are likewise multiple management strategies being implemented to bring about their recovery. We may not know which ones have been responsible for recovery of the species, should population numbers on nesting beaches begin to increase. The state will work to implement any Recovery Plan Tasks where South Carolina is the Responsible Agency.

Longleaf Pine Reptile Guild

Primary species

Mimic Glass Lizard *Ophisaurus mimicus*

Pine Snake *Pituophis melanoleucus melanoleucus* and *P. m. mugitus*

Southern Hognose Snake *Heterodon simus*

Eastern Diamondback Rattlesnake *Crotalus adamanteus*

Coral Snake *Micrurus fulvius*

Secondary Species

Slender Glass Lizard *Ophisaurus attenuatus*

Pine Woods Snake *Rhadinea flavilata*

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

This guild comprises five primary species and two secondary species. Five of the species are snakes and two are lizards; all of the species are commonly associated with one or more of the natural communities that comprise the longleaf pine ecosystem. Primary species are high priority species that are directly tied to the unifying feature/habitat. Secondary species are priority species that may occur in or be related to the unifying feature at some time in their life.

All of the species in this guild are associated with the longleaf pine ecosystem that was extensive across the southeastern United States at the time of European settlement (Bartram 1791; Guyer and Bailey 1993). The longleaf pine ecosystem has declined to less than ten percent of its original land area (Frost et al. 1986). Much of the previously forested lands are now urban or agricultural (Gibbons and Buhlmann 2001). Those lands that are forested have been planted in pine species other than longleaf and have been managed on shorter rotations, in many cases without prescribed fire and without concern for the diverse herbaceous plant species that once occurred with the longleaf pine. It is not surprising, therefore, that the reptiles associated with this ecosystem are also species of concern.

Taxonomy and Basic Description

The mimic glass lizard is a recently described species that reaches a maximum length of approximately 65 cm (25.6 inches). This is the smallest glass lizard and is generally similar in color and pattern to the slender and island glass lizards, making identification difficult. The mimic glass lizard is typically light brown with dark brown or black longitudinal stripes. A dark mid-dorsal stripe is typically present. All glass lizard species lack limbs and are also known as legless lizards (Conant and Collins 1991; Martof et al. 1980).

There are two subspecies of the pine snake found in South Carolina: the northern pine snake (*P. m. melanoleucus*) and the Florida pine snake (*P. m. mugitus*). The Florida pine snake is generally restricted to the southwestern-most counties of our state, primarily Jasper, Beaufort, Allendale

and Hampton Counties. The northern pine snake occurs throughout the remainder of the state. Along the western border of South Carolina, adjacent to the Savannah River, there is a region of intergradation between the two subspecies, primarily in Barnwell, Aiken and Lexington Counties (Conant and Collins 1991). For purposes of this report we will treat the pine snake at the species level.

The pine snake is a large snake with a maximum length of approximately 228 cm (7.5 feet). The pattern of this species can be variable. The pine snake typically has a light brown to ivory background color with large brown or black blotches down the length of the body. In the Florida subspecies, the anterior blotches are typically not present and the pattern is indistinct. Pine snakes from different regions of South Carolina can be very different in coloration and pattern, ranging from light backgrounds with distinct, dark blotches to dark animals with indistinct patterns; occasionally individuals with red (erythristic) blotches or background colors are found

The southern hognose snake is the smallest of the hognose snakes, a group of snakes that possess a sharply upturned snout, believed to be an adaptation for burrowing (Conant and Collins 1991). This species averages from 36 to 51 cm (14 to 20 inches) in length. The southern hognose snake is typically tan-brown with darker blotches running down the back. The colors of this snake are typically less variable than its more common relative, the eastern hognose (Conant and Collins 1991).

The eastern diamondback rattlesnake is the largest venomous snake in the United States, with a maximum reported length of 243 cm (8 feet). In South Carolina, most adult specimens are typically smaller, averaging approximately 84 to 183 cm (2.75 to 6 feet) in length. Typical of pit vipers, the eastern diamondback is a large-bodied snake, with a very large head and a tail rattle composed of keratinized epidermis. This rattlesnake is usually light brown to dark brown with dark diamond-shaped blotches running the length of the body. These blotches are typically outlined by a single row of yellow-white scales. The eastern diamondback has a distinctive wide, dark stripe across the eye, surrounded on either side by a narrow, light stripe (Conant and Collins 1991; Martof et al. 1980).

The coral snake is the only member of the Family Elapidae found in South Carolina; this family includes cobras and their relatives. This venomous snake is very different from all of South Carolina's other venomous snakes, which are all pit vipers. Instead, this species has short, fixed fangs. The coral snake is a brightly colored species with red, yellow and black annular rings running the length of the body. There are two species of non-venomous snakes that are similarly patterned: the scarlet kingsnake and the scarlet snake. On the coral snake, the red and black bands never touch, whereas on the non-venomous species, the red and yellow bands never touch. In addition, the coral snake has a black head and the non-venomous species have red heads. The coral Snake can reach a maximum length of 120 cm (47 inches); however most specimens are typically in the range of 51 to 76 cm (20 to 30 inches) (Conant and Collins 1991; Martof et al. 1980).

The slender glass lizard is moderately large; this species can reach lengths from 56 to 106 cm (22 to 42 inches) (Conant and Collins 1991). This species is typically brown with dark longitudinal markings that are similar to those of the mimic glass lizard. The slender glass lizard differs from the mimic glass lizard and the island glass lizard, another rare species, in that it has numerous dark markings (dark spots, dashes or lines) below the lateral fold (Palmer and Braswell 1995). There is sufficient variation in the glass lizard species to make casual identification problematic.

The pine woods snake is a small, secretive species that rarely exceeds 33 cm (13 inches) in

length. This species varies from golden brown to light reddish-brown, becoming paler along the sides. There is a dark line through the eye; lip scales are white to yellowish in color (Conant and Collins 1991).

Status

The five primary members of this guild are listed as Species of Concern in South Carolina [by whom?]. A proposal to list the southern hognose snake as State Threatened has been submitted to the South Carolina Department of Natural Resources (SCDNR). The secondary members of the guild are species that have been identified as potentially requiring some Conservation Recommendations in South Carolina. The Heritage Trust Program currently ranks the species as follows: mimic glass lizard, S2/G3; northern pine snake, S3,S4/G4; Florida pine snake, S2/G4; southern hognose, S2/G2; eastern diamondback rattlesnake, not ranked; coral snake, S2/G5; slender glass lizard, not ranked; and pine woods snake, not ranked.

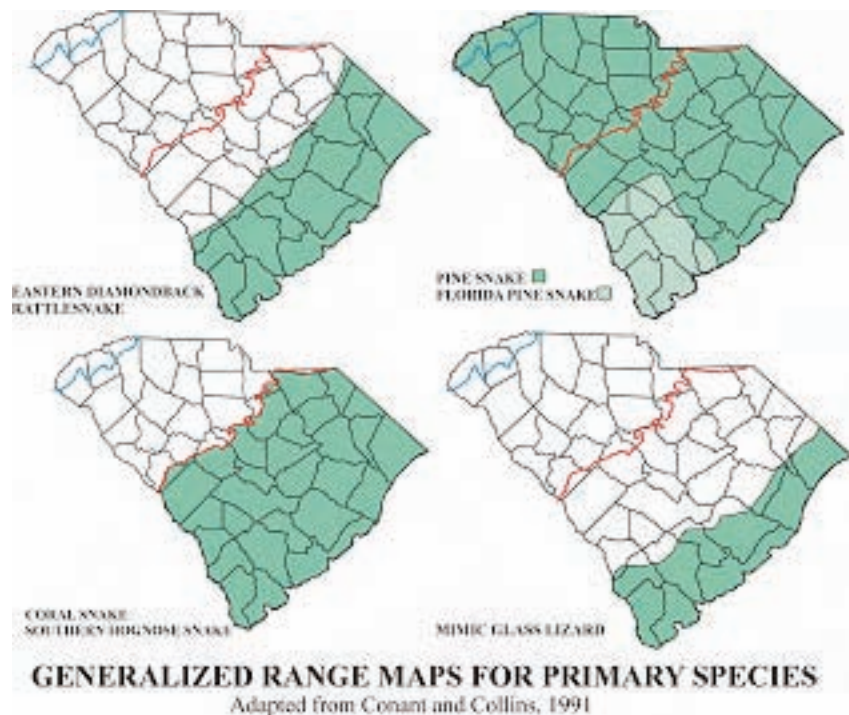
Population Distribution and Size

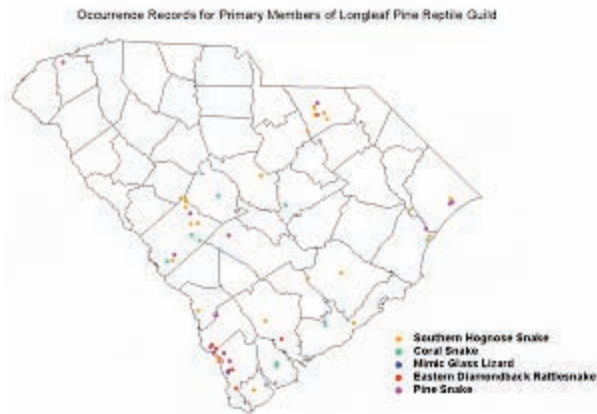
Little is known of the actual population status of any of these guild members. The mimic glass lizard, possibly the most rare guild member, has only been reported once in South Carolina. The slender glass lizard is more widespread and better represented in collections than the mimic glass lizard, but no data exists on its population status. Glass lizards as a group are not well known in terms of their population status, life history or demography.

The pine snake is widespread in South Carolina, but appears to be restricted to several specific habitat types that are either subsets of the longleaf pine ecosystem or share some of the characteristics

of this system, primarily the relatively open canopy and xeric conditions. Pine snakes are not abundant in any particular area of the state, even where they are found with some regularity. There are records of pine snakes from public lands including: the Savannah River Site in Aiken and Barnwell counties; Tillman Sandridge Heritage Preserve in Jasper County; Francis Marion National Forest in Berkeley County; Sandhills National Wildlife Refuge in Chesterfield County; and Lewis Ocean Bay Heritage Preserve in Horry County.

The southern hognose snake has been documented from 15 counties in South Carolina. The species appears to be stable on the Savannah River Site (SRS), where 193 specimens have been captured since the 1950's (Tuberville et al. 1998). In the past 15 years, the species has only been documented in 40 counties across its entire southeastern range; this represents 31.7 percent of its





historical extent (Tuberville et al. 1998). This species is both fossorial and cryptic, making survey efforts difficult. Outside of the SRS, there is no population data for this species, and collections are infrequent.

The eastern diamondback rattlesnake is primarily restricted to the lower terraces of South Carolina's coastal plain. This species was once believed to be common and widespread, but is now thought to be declining range-wide (Martin and Means 2000; Timmerman and Martin 2003). In South Carolina, the species is

still relatively common on large tracts of land in the southern portion of its range; however, this species is uncommon to rare north of the Santee River. Currently, a mark-recapture study of this species is underway at SCDNR's Webb Wildlife Center in Hampton County. The goal of this study is to establish a statistically viable population estimate for the species at this protected site.

The coral snake is one of South Carolina's least known reptile species. This fossorial, secretive species appears to be colonial in distribution. Coral snakes are found with some regularity in a few areas of the state including the Savannah River Site, the Aiken Gopher Tortoise Heritage Preserve in Aiken County, and Lady's Island in Beaufort County. No population data exists for this species and its fossorial habits make it a very difficult species to survey.

Little or no data on the distribution or status of the slender glass lizard and the pine woods snake exists for South Carolina. These species are not necessarily rare, but they are not frequently encountered.

Habitat and Natural Community Requirements

Members of this guild are closely associated with, but not necessarily endemic to, natural communities that are part of the Longleaf Pine Ecosystem. The pine snake, southern hognose snake and coral snake are typically associated with the more xeric longleaf communities and can be found in the same habitat types that support gopher tortoise populations. The eastern diamondback rattlesnake, mimic glass lizard and slender glass lizard are more commonly associated with the mesic longleaf communities, including longleaf pine flatwoods. All species show some overlap in their particular habitat preferences and can be found in habitats other than longleaf.

The eastern diamondback rattlesnake is also found in coastal maritime communities such as maritime grassland and maritime forests, in particular on barrier or estuarine islands. The coral snake has been found in maritime forests and mesic hardwood forests in the coastal plain. The pine snake has been found in dry, rocky areas of South Carolina's Appalachian Mountains; in particular, near the area of Keeowee-Toxaway State Park. In general, these other habitat types share some characteristics in common with the longleaf pine habitats, including sandy soils, xeric conditions, open canopies and underground refugial sites like stump holes and rock crevices.

All members of this guild spend some portion of their life using underground shelters, such as stump holes, rodent burrows, root channels or gopher tortoise burrows. The eastern diamondback rattlesnake is typically found underground during the colder months. This ambush predator can,

however, be found on the surface during warmer seasons. The other species spend far greater amounts of time underground, coming to the surface for only short periods of time.

Longleaf pine habitats provide open canopies with abundant stump holes. These are created when pine trees are blown over by storms or killed by lightning. In the case of lightning killed trees, the root ball is typically burned out by periodic fire, creating underground chambers. In addition to stump holes, this habitat typically features friable, sandy-loam soils that are easily excavated by rodents and other animals. Many reptiles take advantage of these burrows, exploiting the food resource by eating the occupants and then using their burrows for refuge.

Numerous amphibian and reptile species are closely associated with some form of longleaf pine habitat. Several species of conservation concern in South Carolina, other than the primary guild members, would benefit from conservation efforts directed at this habitat type, including species that have been covered either individually or under another guild type. The following species are highly likely to benefit from such conservation efforts: gopher tortoise, flatwoods salamander, gopher frog and tiger salamander.

In addition, numerous species whose status is not fully understood, or are relatively common would also benefit from longleaf pine habitat conservation. Examples of such species include the coachwhip (*Masticophis flagellum*), scarlet kingsnake (*Lampropeltis triangulum elapsoides*), barking treefrog (*Hyla gratiosa*) and Mabee's salamander (*Ambystoma mabeei*).

Challenges

The primary challenge confronting members of this guild is habitat loss. 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 plantation in South Carolina. The loss, or degradation of longleaf pine habitat results in the loss of key components, such as stump holes and open canopy conditions required by the guild members.

Certain guild members, such as the eastern diamondback rattlesnake and pine snake, may be under pressure from collection for the pet trade and venom research. The degree of this threat is unknown but it is believed to be far less than that of habitat destruction.

The large snakes are particularly vulnerable to habitat fragmentation and an increasing road network. Some of the large snakes, particularly pine snakes, are long-lived animals with large home ranges. Maintaining viable populations becomes more difficult when mortality from automobiles further reduces the number of individuals in a population.

Introduction of the nonnative fire ant throughout the southeastern United States has been implicated as a potential reason for the apparent decline of the southern hognose snake (Tuberville and Jensen, in press). Fire ants may also be adversely affecting populations of other fossorial and egg-laying snakes.

Intensive or chronic soil disturbance may also pose a threat to fossorial snake species (Tuberville and Jensen, in press). Fire suppression, stump removal and short timber rotations may limit population numbers by reducing availability of nesting sites and large stump holes for refugia (Tuberville and Mason, in press).

Persecution and direct killing of snakes by humans affects these populations. Many of the large snakes are long-lived species. Loss of individuals through human persecution can reduce population numbers because such losses can significantly affect the ability of these species to reproduce.

Conservation Accomplishments

Several members of this guild have been the focus of research and survey either conducted by SCDNR personnel or funded by SCDNR in the past decade. Surveys for the pine snake, southern hognose snake and mimic glass lizard have been ongoing at several SCDNR owned and managed preserves. The eastern diamondback rattlesnake has been the subject of a mark-recapture study and a radio-telemetry study at SCDNR's Webb Wildlife Center in Hampton County. The goal of this study is to produce a statistically accurate population estimate and understand the population dynamics, demography, activity patterns and habitat use of this species at the site. To date, this research has documented differences in the movement patterns and home range size between male and female rattlesnakes (unpublished data).

Documented occurrences of the eastern diamondback rattlesnake, southern hognose snake, coral snake and pine snake are known from several publicly owned and managed sites including the Sandhills National Wildlife Refuge in Chesterfield County, Francis Marion National Forest in Berkeley and Charleston Counties, the Savannah River Site in Aiken and Barnwell Counties, the Tillman Sandridge Heritage Preserve in Jasper County, and the Webb Wildlife Center in Hampton County.

Conservation Recommendations

- Because the mimic glass and slender glass lizards are frequently mistaken by the public as a snake, these species should be included in general education materials to illustrate the importance of protecting reptiles and their habitats.
- Survey for populations of the mimic glass and slender glass lizards to determine the distribution of this species. Due to their secretive nature, inventory techniques for these glass lizards need to be developed.
- Protect existing pine snake habitat. Large areas with suitable habitat and minimal fragmentation by highways and other roads should be a priority for protection. Collaborate with partners that hold large tracts of such habitat to encourage protection of this species.
- Create a program that encourages the public to report sightings of pine snakes, southern hognose snakes and other members of the longleaf pine guild that will aid biologists in the identification of these animals and areas of suitable habitat.
- Determine the effects of long-term chronic automobile mortality on members of the longleaf pine reptile guild. Collaborate with the South Carolina Department of Transportation (SCDOT) to determine ways to reduce road mortalities of reptiles.
- Determine the effect of fire ants on pine snakes, southern hognose snakes and other fossorial egg-laying species.
- Evaluate and monitor pine snake population in isolated mountain habitats in the Blue Ridge
- Determine taxonomic and potential habitat differences between the northern pine snake and the Florida pine snake.
- Determine the root cause of the decline of southern hognose snakes and monitor all known populations.
- Investigate life history, ecology, habitat requirements and distribution patterns of the southern hognose snake.

- Determine the best method for conservation of this rapidly declining species, including the feasibility of captive breeding should such measures
- Encourage protection of eastern diamondback rattlesnakes on large tracts of public land and private plantations, such as the Webb Wildlife Management Area, Francis Marion National Forest, coastal barrier islands and the Oketee Club.
- Include the importance of protecting all venomous snakes and their habitat in general education materials.
- Encourage restoration of large tracts of longleaf pine and wiregrass ecosystem, managed on long rotations and with large stumps remaining after harvest for underground refugia and hibernation sites. Such restoration would benefit eastern diamondback rattlesnakes, coral snakes and other members of the longleaf pine reptile guild.
- Determine and monitor locations of viable populations of eastern diamondback rattlesnakes in South Carolina.
- Investigate eastern diamondback rattlesnake life history, particularly adult sex ratios, recruitment, mortality and population genetics.
- Conduct more intensive coral snake surveys on SRS, Aiken Gopher Tortoise Heritage Preserve, and, if possible, on the Lady's Island population of these snakes; monitor these populations.
- Develop effective inventory techniques for coral snakes.
- Determine whether the pine woods snake is adversely affected by intensive timber management programs, especially bedding and disking.
- Investigate population abundance, life history and habitat requirements of pine woods snake; monitor populations.

Measures of Success

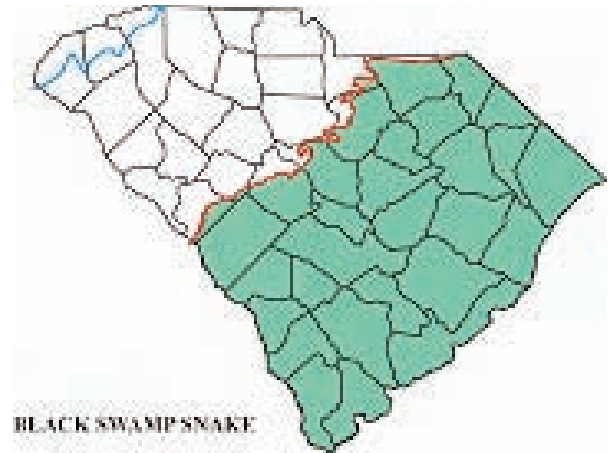
As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. One preliminary result from the rattlesnake study indicates that the eastern diamondback rattlesnake requires a large home range. Habitat protection projects for this species must take this into consideration. Data from surveys will be used to make decisions concerning habitat protection. Protected populations of these species, on managed preserves will be considered a measure of success.

Miscellaneous Amphibians and Reptiles

The following amphibian and reptile species are currently listed as species of concern in South Carolina by The South Carolina Heritage Trust program. These species do not fit logically into any guild or group and are not the highest priority for conservation action in our state simply because we do not know enough about them to make a judgment. Therefore, they are included in this plan because of data deficiencies and the potential risk of overlooking a species in need. For most of these species, the primary conservation objective will be to determine their status through survey in South Carolina.

Black Swamp Snake *Seminatrix pygaea*

The black swamp snake is a semi-aquatic species that inhabits a variety of wetland types. This species is typically associated with wetlands that have abundant aquatic vegetation, including water lilies and other emergent species. The black swamp snake was added to the list of Species of Concern during the first South Carolina Endangered Species Symposium (1978) due to the perception that it was an uncommon species. The current rank is unknown in South Carolina (S?) and stable globally (G5). The black swamp snake is a poor overland disperser and loses body water rapidly (Winne et al. 2001); therefore, this species may be less able to re-colonize habitats once extirpated (Seigel 1995). Recent survey techniques developed to sample semi-aquatic reptiles have revealed that this species is more widespread and more common than previously believed. The species has been documented on the Savannah River Site, Donnelly Wildlife Management Area and Charleston Naval Weapons Station in recent years (SCDNR surveys). The primary conservation objective for this species is to document its distribution in our state and collect data on its life history and demography.

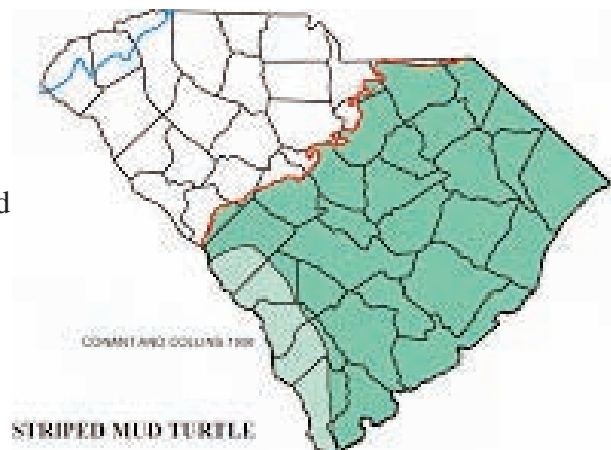
**Island Glass Lizard** *Ophisaurus compressus*

The island glass lizard is virtually unknown in South Carolina, with only two records of occurrence for this state. This species was listed as a species of concern at the 1978 Endangered Species Symposium based on our lack of knowledge. Very little information or data exists for any glass lizard species in our state; this whole group deserves attention regarding taxonomy, distribution and demography. The current rank for the island glass lizard in South Carolina is S1/S2 and globally is G3/G4. The primary conservation objective for the island glass lizard is to better

document its occurrence in South Carolina and determine its distribution in this state.

Striped Mud Turtle *Kinosternon baurii*

The striped mud turtle was first documented to occur in South Carolina in the late 1960's. Since that time, additional surveys have confirmed the occurrence of the species in this state and revealed that it is more widespread than previously believed. It is currently ranked unknown in South Carolina (S?) and secure globally (G5). In the heart of its range (Florida and Georgia), the striped mud turtle has three stripes on its carapace and stripes on the side of its head. In



South Carolina many individuals of this species lack the carapacial and head stripes, making it easy to confuse them with the more common eastern mud turtle. Based on museum searches (Lamb and Lovich 1990), this species occurs throughout the coastal plain of South Carolina and may be relatively common. However, it seems to be found around and in the floodplain swamps of rivers and populations do not appear to occur in isolated wetlands. The primary conservation objective for this species is to determine its distribution in South Carolina and collect data on its life history and demography.

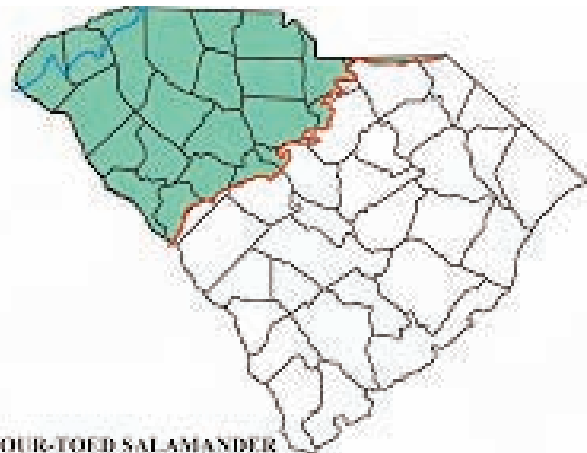
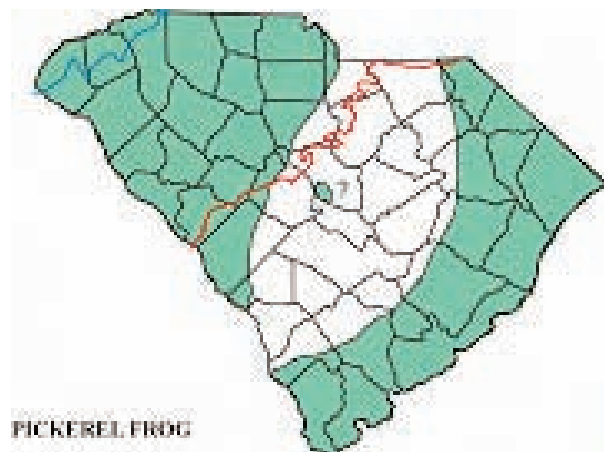
Gulf Coast Mud Salamander *Pseudotriton montanus flavissimus*

The Gulf coast mud salamander was added to the list of species of concern in South Carolina at the 1978 Endangered Species Symposium based on its problematic taxonomic status. The current rank for this species in South Carolina is S3/S4 and is secure globally (G5). This is one of two subspecies of the more widely distributed mud salamander that occur in South Carolina; this subspecies is peripheral in this state. The mud salamanders are difficult to survey. They are fossorial and occur in wetland areas such as cypress-tupelo ponds, floodplain forests and seepage slopes. The primary conservation objective for this subspecies is to document its distribution in South Carolina and resolve any outstanding taxonomic issues.



Four-Toed Salamander *Hemidactylium scutatum*

The four-toed salamander was added to the list of species of concern in South Carolina at the 1978 Endangered Species Symposium based on its apparent rarity in the state. The four-toed salamander occurs around the edges of wetlands and seepage slopes that have abundant *Sphagnum*. Currently, only one recently verified occurrence exists for this species in South Carolina; the single four-toed salamander was found at Kings



Mountain State Park in York County. Several historical sightings remain unverified or the habitat where they occurred has been destroyed by development. The primary conservation objectives for this species are to document its distribution and determine its abundance as well as life history traits in South Carolina.

Pickerel Frog *Rana palustris*

The pickerel frog was added to the list of species

of concern in South Carolina at the 1978 Endangered Species Symposium based on its status as uncommon to rare in South Carolina. The species has a current rank of unknown in South Carolina (S?) and is secure globally (G5). This species may be more widespread and common than once believed. Recent reports of this species have come from the Savannah River Site in Aiken and Barnwell Counties (Gibbons and Semlitsch 1991), the Webb Wildlife Center in Hampton County, the Congaree National Monument in Richland County and the Old Santee Canal Park in Berkeley County. The primary conservation objectives for this species are to document its distribution in our state and collect data on its life history and demography.

Bird-voiced Treefrog *Hyla avivoca*

The bird-voiced treefrog was added to the list of species of concern in South Carolina at the 1978 Endangered Species Symposium based on its status as a peripheral species. Its current ranking is secure both in South Carolina and globally (S5/G5). In South Carolina, the bird-voiced treefrog is only found along the southern portion of the Savannah River floodplain swamp (Gibbons and Semlitsch, 1991). While the species has a very limited distribution in our state, it is common to abundant within its range. The primary conservation objectives for this species are to monitor the populations in South Carolina and collect data on the life history and demography of the species.



Pine Barrens Treefrog

Hyla andersoni

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

The pine barrens treefrog is a small member of the treefrog family, Hylidae. This species reaches lengths of 2.8 to 4.4 cm (1.1 to 1.7 inches); maximum length is approximately 5 cm (1.9 inches) (Conant and Collins 1991). The pine barrens treefrog is green with a broad lavender stripe on either side of the body. This stripe has a thin, white outline. The concealed portions of the legs and inner thigh are bright orange with numerous yellow dots (Martof et al. 1980).

Status

The pine barrens treefrog is listed as a Species in Need of Management in South Carolina with a rank of (S2/S3) statewide and apparently secure (G4) globally (NatureServe 2005).

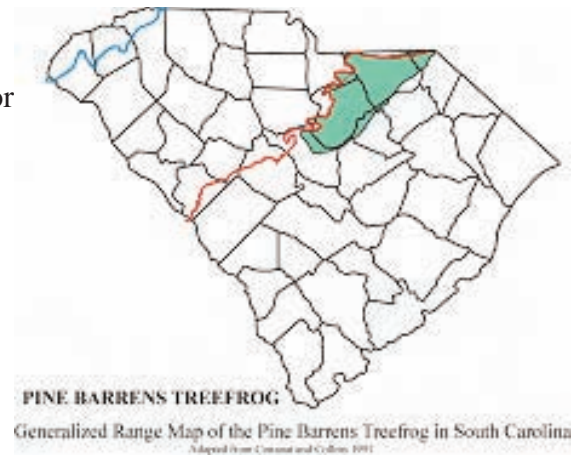
Population Distribution and Size

The pine barrens treefrog is found in the upper (northern) portion of South Carolina's coastal plain in the Sandhills (fall-line) Ecoregion. Between 1979 and 1982, Cely and Sorrow (1982) surveyed 222 potential treefrog sites in this region, and found that approximately 50 of them (23 percent) supported pine barrens treefrog colonies. Colony size ranged from a few frogs to several

dozen, but larger colonies were difficult to estimate. During this study, the researchers used a mark-recapture method to develop a population estimate for one large colony. The estimate for this colony of 159 frogs was much higher than the 25 to 50 individuals originally estimated by call counts. The researchers concluded that estimates of pine barrens treefrog populations, based on call counts, would typically underestimate the actual population size.

The pine barrens treefrog was found to be more widespread in South Carolina than previously believed. Based on their findings, Cely and Sorrow recommended that the status of the frog be changed from endangered to threatened and considered a species in need of management in South Carolina.

Currently, no valid estimate exists for the number of extant pine barrens treefrog colonies in South Carolina or estimates for population size at any colony. The pine barrens treefrog has been found on two significant tracts of public property in Chesterfield County: the Sandhills National Wildlife Refuge (NWR) and the Sandhills State Forest. Garton and Sill (1977) found pine barrens treefrogs at 18 locations on the Carolina Sandhills NWR in 1977.



Element Occurrence Records for the Pine Barrens Treefrog in South Carolina



Habitat and Natural Community Requirements

In South Carolina, the pine barrens treefrog occurs in herb shrub bogs, pocosins and other related communities in the sandhills (Cely and Sorrow 1982; Conant and Collins 1991; Martof et al. 1980). Typical pine barrens treefrog habitat is found in transition zones on the down slopes of sandhills where water percolates out of the soil in some sort of seepage zone. Historically, these habitats would burn periodically, until European settlement in the southeast prompted exclusion of fire. Fire maintains an open character to the seepage bogs. Pitcher plants, sundews and terrestrial orchids are species that typify this habitat type and also require the acidic, open conditions of these bogs. Pine barrens treefrogs live in the thick, pocosin vegetation that often surrounds this habitat, but they also require the open, slow-flowing seeps as breeding habitat (Cely and Sorrow 1982).

Currently, several pine barrens treefrog colonies exist along power line and gas line rights-of-way, where mechanical vegetation control (mowing) keeps the vegetation low, maintaining the open habitat required by the species.

Challenges

The primary challenge facing this species is habitat loss due to fire suppression and other inappropriate management activities such as herbicide application in power line rights-of-way, in the preferred herb-shrub bog habitat.

Ditching and drainage of small, hillside wetlands or other alteration of these wetlands is a potential threat to pine barrens treefrog populations.

Conservation Accomplishments

Several pine barrens treefrog populations occur on the Sandhills National Wildlife Refuge; managers are aware of these populations and the status of this species. The South Carolina Department of Natural Resources Heritage Trust Program has protected a population of the pine barrens treefrog through registration of a gas line rights-of-way in Kershaw County.

Conservation Recommendations

- Acquire or obtain easement for private lands that contain populations of the pine barrens treefrog.
- Encourage public land managers to use the unique pine barrens treefrog to promote conservation of biodiversity in Carolina Sandhills NWR.
- Investigate the positive effects of an active fire management regime on the pine barrens treefrog on Carolina Sandhills NWR.
- Identify specific breeding populations of pine barrens treefrogs in South Carolina, including populations on Carolina Sandhills NWR. Monitor any populations identified during surveys.
- Investigate pine barrens treefrog life history to determine the status of protected populations.
- Advise SCDNR Environmental Review biologists about known or potential populations of the treefrog that occur in areas slated for draining or filling.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from continued surveys will be used to develop site-specific management plans for this species. Stable or increasing populations at protected sites will be considered a measure of success.

Pond-breeding Amphibian Guild

Primary Species

Flatwoods Salamander *Ambystoma cingulatum*

Carolina Gopher Frog *Rana capito capito*

Broad-Striped Dwarf Siren *Pseudobranchius striatus striatus*

Tiger Salamander *Ambystoma tigrinum*

Secondary Species

Upland Chorus Frog *Pseudacris triseriata* coastal plain only

Northern Cricket Frog *Acris crepitans* coastal plain only

Contributors: Stephen Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Descriptions

This guild contains four primary species, flatwoods salamander, Carolina gopher frog, dwarf siren and tiger salamander and two secondary species, upland chorus frog and northern cricket frog. Primary species are high priority species that are directly tied to a unifying feature or habitat. Secondary species are priority species that may occur in or be related to the unifying feature at some time in their life.

The flatwoods salamander and tiger salamander are members of the family Ambystomatidae, the mole salamanders. Both species are large; the tiger salamander is the largest terrestrial salamander in the eastern United States. The flatwoods salamander can reach lengths of 9 to 12 cm (3.5 to 4.7 inches) as an adult. This species is dark, ranging from black to dark brown with

The tiger salamander can reach lengths of 18 to 20 cm (7.1 to 7.9 inches) as an adult; maximum size is approximately 30 cm (11.8 inches). This species has a dark background, typically black, with bright, yellow-orange irregular markings (Conant and Collins 1991; Martof et al. 1980).

The broad-striped dwarf siren is a member of the family Sirenidae, a family of salamanders that consists of both dwarf sirens and sirens. These are totally aquatic species that retain larval characteristics into adulthood. The dwarf siren is small; it reaches 10 to 15 cm (3.9-5.9 inches) in length and is an eel-like salamander that lacks hind limbs and has external gills. Dwarf sirens are typically brown in color with dark-brown longitudinal stripes flanking a broad, light -brown

The Carolina gopher frog is a member of the family Ranidae, the true frogs. Its closest relatives include the bullfrog, leopard frog and bronze frog. This species can reach sizes of 6 to 9 cm (2.4 to 3.5 inches). It has the body shape of a typical frog, but is a little plumper than other frogs with proportionately shorter legs. Gopher frogs are typically light to dark brown with heavy blotching and numerous warts (Conant and Collins 1991; Martof et al. 1980). In fact, while a true frog, the gopher frog does somewhat resemble a toad in appearance, due to the presence of the warts. This trait, as with the toad, is evidence of a more terrestrial lifestyle.

Three of these species, the flatwoods salamander, gopher frog and tiger salamander spend their adult lives in terrestrial habitats as fossorial species, inhabiting crayfish holes, root channels, rodent burrows and other subterranean structures. Adults move to breeding ponds where they deposit eggs. Flatwoods salamanders move during autumn (Anderson and Williamson 1976) while tiger salamanders and gopher frogs move in late winter (Braswell 1993). The aquatic larva of these species may spend several months in a pond before metamorphosis to the adult form occurs. Newly metamorphosed individuals move away from breeding ponds; they only return to these ponds when they become reproductively mature adults (Petranka 1998).

The upland chorus frog and the northern cricket frog are both small frogs; they reach lengths of 1 to 3 cm (0.3 to 1.2 inches). These frogs are in the family Hylidae and are related to treefrogs. The color pattern of the upland chorus frog can be variable; they are typically light brown with dorsal striping that is broken at the posterior. The northern cricket frog is also a highly variable species in terms of coloration; it ranges from red-brown to green (Conant and Collins 1991; Martof et al. 1980). Both species are common throughout most of their range, which, in South Carolina, is primarily the Southern Appalachian and piedmont ecoregions. These species both have populations in the coastal plain, disjunct from their typical range; it is these populations that are of conservation concern.

Status

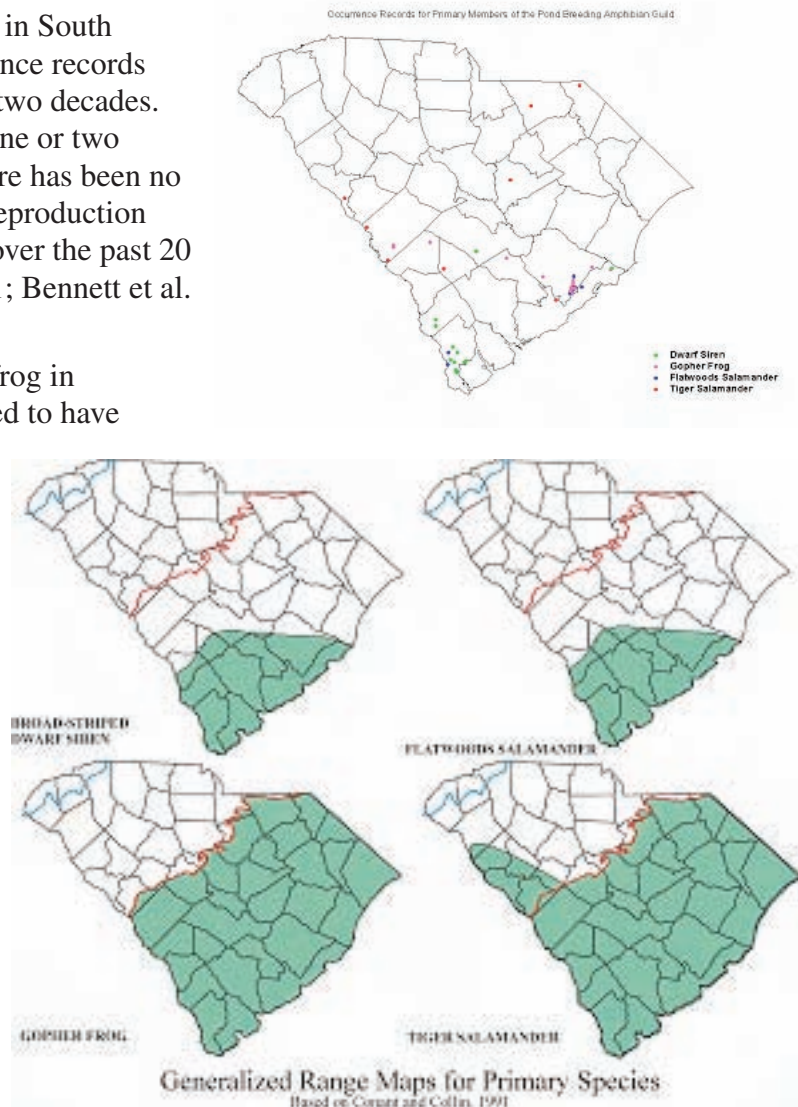
The flatwoods salamander is currently listed as endangered in South Carolina and is given a

natural heritage rank of S1 (NatureServe 2005). With a federal ranking of G2/G3, the flatwoods salamander is federally listed as a threatened (NatureServe 2005). The Carolina gopher frog is currently listed as an endangered in South Carolina with a natural heritage rank of S1 (NatureServe 2005). The gopher frog was previously considered a federal candidate for listing and is currently considered a species of concern, G3/G4 (NatureServe 2005). The dwarf siren is currently considered a species in need of management in South Carolina and ranked S2; it has a federal ranking of G5, secure (NatureServe 2005). The tiger salamander is currently a species of concern in South Carolina and is ranked S2/S3; it has a federal ranking of G5, secure globally (NatureServe 2005). The coastal plain populations of the upland chorus frog are ranked S3/S4, apparently secure statewide, and G5, secure globally (NatureServe 2005). The northern cricket frog is considered secure, both federally and in South Carolina with rankings of G5/S5 (NatureServe 2005).

Population Distribution and Size

Historically, the flatwoods salamander was known from Orangeburg, Jasper, Berkeley and Charleston Counties. In the past decade, this species has only been documented in Jasper and Berkeley Counties. This species has been the object of intense survey efforts in South Carolina and no additional occurrence records have been documented in the past two decades. Recent records have consisted of one or two individuals at breeding ponds. There has been no documentation of any significant reproduction for this species in South Carolina over the past 20 years (Moulis 1987; Harrison 2001; Bennett et al. 2002).

The range of the Carolina gopher frog in South Carolina is generally believed to have included the entire coastal plain. Currently, the gopher frog is only known to occur in Aiken, Barnwell, Charleston and Berkeley Counties, although historic records include Aiken, Barnwell, Bamberg, Orangeburg, Dorchester, Hampton, Berkeley and Charleston Counties. Recent records indicate that gopher frogs are only present on large, public properties. Such properties include: the Savannah River Site, owned by the U.S. Department of Energy and managed by the U.S. Forest Service; Francis Marion National Forest, owned and managed by the U.S. Forest



Service; and the Santee Coastal Reserve, owned and managed by the South Carolina Department of Natural Resources (SCDNR). Gopher frog breeding has been documented within the last decade at these sites, with evidence of successful reproduction at both the Savannah River Site and Santee Coastal Reserve.

The gopher frog has been the object of significant survey effort by the SCDNR in recent years. Efforts to relocate historic breeding ponds outside of the previously mentioned public lands have met with little success. All of these historic ponds have been altered, drained or the surrounding habitat has been significantly altered

Currently the broad-striped dwarf siren only occurs in Jasper, Hampton, Orangeburg and Charleston counties in South Carolina. SCDNR documented this species from several new sites in Jasper and Hampton Counties in the early 1990's. Extensive surveys for this species have not been conducted throughout the general range; it is likely that previously undocumented populations exist.

There are historic records for the tiger salamander from McCormick, Aiken, Barnwell, Bamberg, and Charleston Counties. Additionally, there are recent reports of this species from Sumter, Marlboro and Chesterfield Counties. The tiger salamander has not been the object of a range-wide survey in South Carolina. Little is known about the population biology of this species in this state.

The coastal plain populations of the upland chorus frog and northern cricket frog are both located near Charleston, South Carolina. These two species are common to relatively abundant throughout the piedmont and Southern Appalachian ecoregions of South Carolina. The presence of these disjunct populations in the coastal plain is of scientific and conservation interest.

Habitat and Natural Community Requirements

Aquatic (Breeding) Habitat

The primary species in this guild typically breed, or live in isolated, temporary freshwater wetlands, referred to as breeding ponds. Examples of these naturally occurring ponds include Carolina Bays, limesinks, flatwoods ponds and other such related features. While these ponds may differ in their geologic origin and geomorphology, they share certain characteristics in common. Typical breeding ponds are isolated from flowing streams, particularly any inflows. Occasionally such ponds will have an outflow "stream" that only flows when exceptionally heavy rains fill the pond above full pool (Bennett and Nelson 1991).

Due to the lack of stream-fed water, these ponds typically fill and dry with rainfall cycles. Most, if not all, of these ponds represent perched water tables, holding rainwater and runoff "perched" above the normal water table. The perching mechanism generally consists of an impermeable layer, such as clay, underlying the pond basin. Typical breeding ponds fill during the late autumn and winter and dry, due to evaporation and evapotranspiration, during the mid to late summer.

Breeding ponds may exhibit a diversity of vegetative communities including open-shallow water, grass-sedge prairie (depression meadow), pond cypress savanna, and tupelo gum pond (non-alluvial swamp forest). The primary amphibian guild members tend to favor ponds with an open canopy and abundant grasses and sedges. The clumped-bases of these plants provide refuge and habitat structure for many species of amphibian larvae. Hydroperiod, defined as the duration and seasonality in which a pond holds water, ultimately determines the suitability of a pond for specific amphibian species. Tiger salamanders and gopher frogs require ponds that fill by mid-

winter; further, they need to hold water continuously until May or June for successful larval metamorphosis to occur (Buhlmann et al. 1999; Mitchell and Buhlmann, 1999). Several ponds with a variety of hydroperiods located in proximity within a landscape yields a high diversity of pond-breeding amphibian species.

Fish species, which may prey on amphibian larvae, are typically absent from these ponds, due to their cyclical hydrology. Certain fish species, such as pigmy sunfish, do colonize ponds in low-lying areas that have connection to other water bodies during flooding. Large, predatory fish, such as pickerel and sunfish may invade these ponds at times of abundant rainfall and high water, using deer trails, other natural channels and man-made ditches and firebreaks to move from areas of permanent water into ponds. However, in general, high quality amphibian breeding sites for members of this guild are free of fish.

Terrestrial (Non-breeding) Habitat

The primary species comprising this guild are typically found in the coastal plain in natural communities associated with the longleaf pine ecosystem, including longleaf pine flatwoods, longleaf pine savanna and xeric longleaf pine sandhills. Breeding ponds are nested within the upland longleaf pine matrix of these communities.

In South Carolina, the flatwoods salamander is closely associated with the longleaf pine savannas of the lower coast. These communities typically exhibit a sparse canopy of longleaf pine with a rich herbaceous layer. The water table in such habitat is usually close to the surface and small isolated ponds may be numerous.

The tiger salamander and gopher frog may occur in a wider array of longleaf pine habitats, including the savanna. These species also occur in longleaf pine flatwoods, which typically have a lower water table and a denser canopy, and xeric sandhills, which have a very low water table and deep, droughty sands. Ponds are generally less common in these two habitat types.

Other Habitats

The dwarf siren has been documented from small coastal plain streams that exhibit little or no flow and have muck bottoms. Such streams are typically too small to have established populations of predatory fish such as pickerel and sunfish. All of the members of this guild have been found to occasionally breed in man-made wetlands such as borrow-pits and ditches, when they occur within the appropriate terrestrial habitat. Long-term breeding success in these habitats is currently unknown; therefore, artificial habitats should not be considered as replacements for the destruction of natural wetlands.

Challenges

The requirement for both suitable aquatic (breeding) habitat and terrestrial (non-breeding) habitat has made these species susceptible to alterations in either one of these habitats. The following activities have been suggested as reasons for the perceived decline of the primary species:

- Drainage of temporary wetlands
- Alteration of wetland hydroperiod
- Filling of wetlands
- Conversion of wetlands to other uses such as agriculture or development
- Exclusion of fire in longleaf pine forests

- Conversion of longleaf forest to loblolly pine plantations
- Commercial and residential development
- Conversion of longleaf forest to agriculture

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 isolated wetlands that still exist are now unsuitable for breeding by amphibian species of this guild because they have been left isolated in the landscape as a result of farming or timber operations. Such land management likely causes local extinctions of amphibian populations because the surrounding upland forests are removed, thus eliminating the terrestrial habitat required by these species when they are not breeding in the ponds (Gibbons and Buhlmann 2001; Semlitsch 1998; Semlitsch and Bodie 1998).

Isolated, temporary ponds provide critical habitat for numerous amphibian and reptile species in addition to the primary and secondary species listed for this guild. The following species are known to inhabit or use temporary ponds for some period of time, and have been identified as possible future species of conservation concern, or at least in need of further research and survey to determine their status in South Carolina:

Many-Lined Salamander (*Stereochilus marginatus*)

Black Swamp Snake (*Seminatrix pygaea*)

Glossy Crayfish Snake (*Regina rigida*)

Conservation Accomplishments

The primary species comprising this guild have been documented on four public properties in South Carolina: the Savannah River Site (SRS), Francis Marion National Forest (FMNF), Santee Coastal Reserve (SCR) and the Carolina Sandhills National Wildlife Refuge (SHNWR).

The gopher frog and tiger salamander are present on the SRS have been identified as species of research and conservation interest. Some of the breeding ponds used by these species on the SRS are part of the Department of Energy (DOE) Set Aside Program; as such, these areas have some protection status.

The gopher frog and flatwoods salamander are present on the FMNF. Surveys for the salamander in the forest have been ongoing for several years. Further, the needs of this species are considered in management operations on the forest lands.

The gopher frog, flatwoods salamander and dwarf siren have been documented to occur at the SCR, which is owned and managed by SCDNR. The breeding pond used by the flatwoods salamander and gopher frog is registered as a significant Natural Area with the department's Heritage Trust Program; this pond is managed for these species.

The tiger salamander has been documented to occur at the SHNWR. However, only one specimen has been collected from this site. Little is known about the distribution or status of the species on the SHNWR.

Research and survey efforts on pond breeding amphibians by SCDNR personnel, have been supported in the past by USFWS Section 6 funds, Endangered Wildlife funds (state income tax

check-off) and WCRP funds. The primary focus of past work has been survey efforts to verify historic populations and document new populations. Little data exists on the demography, population dynamics or conservation requirements for these species.

Conservation Accomplishments

- Inventory flatwoods salamander breeding sites; protect these sites and surrounding uplands. Monitor the success of flatwoods salamanders at previously identified breeding locations.
- Meet with public and private land managers to discuss the imperilment of the flatwoods salamander and methods to ensure its protection.
- Develop positive working relationships with key South Carolina landowners to allow for inventory to proceed on private lands and plantations.
- Investigate the potential to establish a captive breeding program for flatwoods salamanders and the possibility of translocating animals into appropriately managed, protected habitats.
- Protect all known Carolina gopher frog population sites. Consult with SRS, USFS, the Savannah River Ecology Laboratory, DOE to formulate and enact management plans that include this species.
- Include the importance of protecting all pond breeding amphibians and their habitat in general education materials.
- Inventory sites that have historically contained Carolina gopher frogs. Monitor these sites for continued population by this species.
- Research the effects of fire management on wetland breeding habitat for both Carolina gopher frogs and tiger salamanders.
- investigate Carolina gopher frog life history to determine the status of "protected" populations and to address habitat requirements, seasonal activity, adult sex ratios, recruitment, mortality and longevity.
- Investigate the feasibility of a captive breeding program or rearing of metamorphic frogs in semi-wild enclosures to help assure the availability of breeding adults..
- Consider broad-striped dwarf siren habitat needs when managing Carolina bays and similar wetland ecosystems.
- Inventory appropriate broad-striped dwarf siren habitat, primarily Carolina bays, for this poorly known species to determine actual distribution in South Carolina.
- Once identified, protect and monitor habitat for broad-striped dwarf sirens.
- Collaborate with appropriate partners to identify, protect and monitor sites that contain tiger salamanders.
- Determine distribution of the tiger salamander in South Carolina.
- Conduct surveys for the upland chorus frog in the coastal plain, particularly in Francis Marion National Forest, to determine if the species is still present and if so, the status of this disjunct population.
- Collaborate with the USFWS and USFW to inventory historic sites for presence of northern cricket frogs in order to collect baseline data for this species in South Carolina. Protect and monitor these sites once they have been determined

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from surveys will be used to identify and develop appropriate life history and ecology research projects to detail causes of decline and limiting factors to population. Stable or growing populations of the primary target species, on protected lands in particular, will be a measure of success.

Resident Juvenile Sea Turtle Guild

Kemp's Ridley Turtle *Lepidochelys kempii*

Green Turtle *Chelonia mydas*

Hawksbill Turtle *Eretmochelys imbricata*

Contributor: Sally Murphy

Description

Taxonomy

Samuel Garman first described the Kemp's ridley in 1880 as *Thalassochelys kempii*. It was named for Richard M. Kemp, a fisherman interested in natural history who submitted the type specimen from Key West, Florida (USFWS and NMFS 1992). Later *kempii* was allocated to the genus, *Lepidochelys*, when it was realized by Baur in 1890 that the Kemp's ridley and Indo-Pacific olive ridley were congener. Others considered *L. kempii* as a sub-species of *L. olivacea*. A review by Pritchard justified their status as a full, separate species and this determination is accepted by most authors (USFWS and NMFS 1992).

Linnaeus described the green turtle in 1758 as *Testudo mydas*. Schweigger first applied the binomial, *Chelonia mydas*, in 1812. Although trinomials have been applied to various populations in the past, they are generally not in use today (NMFS and USFWS, 1991).

The hawksbill was originally named *Testudo imbricata* by Linnaeus in 1766. Two subspecies (*Eretmochelys imbricata imbricata* in the Atlantic Ocean and *Eretmochelys i. bissa* in the Pacific and Indian oceans) are recognized. However, a complex pattern of phenotypic variation exists.

Basic Description

The Kemp's ridley turtle is one of the smallest sea turtles; it has an adult straight carapace length of approximately 65 cm (26 inches) and weighs less than 45 kg (99 pounds). Adults have an almost round carapace that is sometimes wider than it is long. The coloration changes significantly during development from the almost black hatchlings to the lighter, grey-olive carapace and cream-white or yellowish plastron of adults. There are four inframarginal scutes, each of which contains a pore. Hatchlings generally range from 42 to 48 mm (1.7 to 1.9 inches) straight carapace length and weigh between 15 and 20 g (0.5 and 0.7 ounces) (USFWS and NMFS 1992).

Green turtles are the largest of the hard-shelled sea turtles with adults reaching a meter (3.3 feet) in carapace length and 150 kg (330 pounds) in weight. They have a smooth carapace with four pairs of lateral scutes and a single pair of elongated prefrontal scales between the eyes. The plastron remains a yellowish white, but the carapace changes color from solid black to a variety of shades of grey, green, brown and black in starburst or irregular patterns. Green turtle

hatchlings are about 50 mm (2.0 inches) long and weight about 25 g (0.88 ounces).

Adult hawksbills are usually larger than ridleys, but smaller than other sea turtles. Shell length for nesting females varies between 62.5 and 95 cm (25.0 and 37.0 inches) in the Atlantic. The turtle has four pairs of overlapping scutes; a long neck compared to other sea turtles and the adult shell is usually amber with streaks of red-brown, black-brown and/or yellow. The plastron is whitish yellow and may have some black spots.

Status

Kemp's ridleys were listed as endangered throughout their range (Federal Register, December 2, 1970) and are the most seriously endangered of the sea turtles.

Green turtles were listed as threatened under the U.S. Endangered Species Act of 1973. Breeding populations in Florida and on the Pacific coast of Mexico were listed as endangered.

Hawksbills were listed as endangered in 1973. They are also listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN) and are listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Kemp's ridleys and green turtles use South Carolina waters as developmental foraging grounds. Hawksbills are rarely seen in South Carolina waters¹. Since all of these species are juveniles, not nesting turtles, the conservation objective focus on the marine environment.

Population Distribution and Size

In 1947, over 42,000 nesting Kemp's ridleys were estimated in a single day's arribada (mass nesting) (Hildebrand 1963). Their numbers have precipitously declined since then. The nesting population produced a low of 702 nests in 1985 (Ross et al. 1989). This initial decline was brought about by decades of harvesting females and the exploitation of eggs. Exploitation was brought under control in 1976 when Mexican marines and biologists began protecting nesting females and their nests. In 1978, the program expanded into an international effort with the assistance of U.S. biologists (Ross et al. 1989). Since the mid-1980's, the number of nests laid in a season has been increasing primarily due to nest protection efforts and implementation of TED regulations for shrimp trawlers. During the 2002 and 2003 nesting season, more than 6,436 and 8,288 nests, respectively, were deposited on nesting beaches in Mexico.

In U.S. Atlantic waters, green turtles nest in small numbers in the U.S. Virgin Islands and Puerto Rico; they nest in larger numbers along the east coast of Florida. Nesting in Florida has been on the increase, although the annual nesting effort fluctuates by a factor of ten. On high years, annual nesting is in the low thousands. In the past, green turtles were fished commercially in Florida and Texas (Hildebrand 1982).

Female hawksbills are solitary nesters with nests laid quickly and hidden under vegetation (NMFS and USFWS, 1993). Therefore, the hawksbill is a difficult turtle to census by aerial surveys. Because of the general lack of intensive effort needed to survey hawksbill populations, reliable estimates for the population size are available for only a few localities. The species is recorded in the continental U.S. from all the Gulf States and from along the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare (NMFS and USFWS 1993).

Habitat and Natural Community Requirements

The major foraging habitat for Kemp's ridleys is the nearshore and inshore waters of the northern

Gulf of Mexico as well as the Gulf of Campeche in the southern Gulf of Mexico. Kemp's ridleys are often found in salt marsh habitats. This turtle nests primarily on a beach near Rancho Nuevo in Tamaulipas, Mexico. This locale is the only place in the world where large nesting aggregations of the species are known to occur (TEWG 2000). Recently, nesting has been documented along the coast of Texas (Shaver and Caillouet 1998); it occurs as a very rare event in the Carolinas and Florida (Bowen et al. 1994).

When they reach a carapace length of about 20 to 25 cm (7.9 to 9.8 inches), green turtles leave oceanic habitats and become benthic herbivores. Feeding grounds are relatively shallow, sheltered waters. Most commonly, these foraging habitats are pastures of seagrasses and/or algae. Some feeding grounds only support certain size classes of green turtles; in South Carolina, green turtle size class ranges from 28 to 38 cm (11 to 15 inches) (unpublished data, SCDNR).

Hawksbills are a circumtropical species, preferring warm shallow water areas such as coral reefs, lagoons, shoals and bays. They are omnivorous and eat plants and animals such as algae, sea grasses, soft corals and jellyfish, but sponges are the principal diet of hawksbills once they enter shallow coastal waters and begin feeding on the bottom (NMFS and USFWS 1993).

Challenges

Although green turtles probably have always been an important source of protein for coastal dwellers, the commercial exploitation from the 16th to 18th centuries decimated stocks (Mager 1985). There are only four recorded nesting records for green turtles and only one nesting record for Kemp's ridley in South Carolina (Hopkins-Murphy et al. 1999). There are no records of hawksbill nesting in South Carolina. Should nesting of these species increase, the following threats would also affect these species.

Loss or degradation of nesting habitat from coastal development and beach armoring could adversely affect these nesting turtles. Of the 303 km of coastline, about 70 percent is suitable nesting habitat. Of the 30 percent that is not suitable, two-thirds of it is the Grand Strand in Horry County. The other third is a combination of natural eroding beaches and previously built sea walls. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites. 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 nesting.

Uninformed visitors using flashlights at night can cause females to avoid certain areas and beachfront lighting will disorient hatchlings. Excessive predation by native and non-native predators as well as erosion and storm events, destroy nests. Killing of adults is rare, but human poaching of turtle nests with clandestine markets for eggs continues to be a problem (NMFS and USFWS, 1991).

Major Challenges are associated with incidental take from commercial fishing operations. Additionally, the shark longline fishery, which operates all year long off the south Atlantic, may impact sea turtles in the neritic environment. Sea turtles can become entangled in a wide variety of materials including fishing line, rope, onion sacks and discarded netting. They also ingest many types of marine pollution and debris, resulting in gut blockage. Watercraft and ship strikes are becoming more prevalent as more and more people move to the coast. Natural mortality factors include predation by large sharks, disease and parasites (NRC 1990).

Green turtles appear to reside in the more sheltered estuarine creeks and marshes and are thus not

exposed to the threat of incidental catch in shrimp trawlers. While Kemp's ridley are the second highest species recorded as stranded carcasses, the green turtle rarely strands, even though we know they occupy state waters during the warmer months of the year (unpublished data, SCDNR).

Green turtles also develop lobulated tumors (fibropapilloma) on their skin, scales, scutes, eyes (including surrounding tissues), oral cavities and viscera. The cause of this disease is unknown, but it has increased to epidemic proportions in areas as far apart as Florida and Hawaii (Balazs and Pooley 1991). None of the live captures or stranded carcasses in South Carolina have shown signs of this disease.

The main cause of depletion of hawksbill populations is the exploitation of eggs, meat, shell and whole young animals that are stuffed and sold as curios to tourists (NMFS and USFWS 1993). However, the greatest challenge for this species is the continuing demand for "tortoise shell" or the carapace and plastral scutes of the animal. These are reworked to produce hairpins, broaches, fans, inlaid furniture, eyeglass frames and numerous other items (Mager 1985). Another threat in the marine environment is to the coral reef habitat upon which hawksbill depend. Anchors and anchor chains of cruise ships and yachts are destroying portions of the reefs, and some ships run aground, causing widespread damage (NMFS and USFWS 1993).

Conservation Accomplishments

Kemp's ridley nesting beach protection at Rancho Nuevo was significantly increased over the past two decades; there has also been an increase in the number of Kemp's ridley nests documented at Rancho Nuevo since 1985 (Márquez-M. et al. 2005). Also, increasing number of Kemp's ridley nests are being laid annually on the Texas coast, some of which are "head-started" turtles (Fontaine and Shaver 2005).

Green turtle nesting is increasing in Florida (A. Meylan, pers. comm.) Research into the cause of fibropapilloma in green turtles is progressing and field studies have documented cases of natural remission of the disease (Hirama and Ehrhart 2002). This is encouraging since there was no known treatment or cure.

Japan ended import of hawksbill shell in 1993 and dropped its CITES reservation on sea turtles in 1994. Because Japan is the largest importer of hawksbill shells in the world, this should diminish the demand for the species (NMFS and USFWS 1993). The two most important hawksbill nesting beaches in the U.S. Caribbean are now fully protected (NMFS and USFWS, 1993).

The U.S. ratified Optional Annex V of the MARPOL Protocol in 1987, which prohibits dumping of all plastics and fishing gear from all ships at sea (O'Hara et al. 1988).

Conservation Recommendations

- Ensure that live bottoms and marine algae habitats are protected from dredging and dredge spoil dumping through coordination with the U.S. Army Corps of Engineers.
- Map the location of juvenile sea turtle foraging areas for inclusion in protected areas.
- Increase number of estuarine sample areas conducted by SCDNR's Marine Resources Division to discover new foraging areas for juvenile sea turtles.
- Monitor all known juvenile sea turtle foraging areas to document changes in habitat condition, species composition, abundance and size classes in coordination with SCDNR's

Marine Resources Division.

- Collaborate with other institutions, such as the South Carolina Aquarium and the College of Charleston to protect juvenile sea turtles.

Measures of Success

As new Recovery Plans are updated and Status Reviews are completed, we will review the needs of the species and implement research and/or management as indicated. If green turtle nesting should increase in South Carolina as it has in Florida, management actions to protect nests, as is done for the loggerhead, should be implemented.

Seepage Slope Amphibians

Primary Species

Chamberlain's Dwarf Salamander *Eurycea chamberlainii*

Secondary Species

Southern Dusky Salamander *Desmognathus auriculatus*

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

This small group comprises two salamander species that are closely associated with or possibly endemic to seepage slope habitats in the upper coastal plain and piedmont ecoregions. Primary species are high priority species that are directly tied to a unifying feature or habitat. Secondary species are priority species that may occur in or be related to a unifying feature at some time in their life.

Chamberlain's dwarf salamander is a newly described species that was recently recognized as distinct from the more common, dwarf salamander (*Eurycea quadridigittata*) (Harrison and Guttman 2003). Chamberlain's dwarf salamander is lighter in color than the dwarf salamander and has a yellow underside that lacks any markings. Chamberlain's dwarf salamander is very small, averaging approximately 2.5 cm (0.9 inches) in total length (Harrison and Guttman 2003).

The southern dusky salamander is moderately sized, ranging from 7.5 to 12.5 cm (2.9 to 4.9 inches) in length; maximum length is approximately 16 cm (6.2 inches) (Conant and Collins 1991). This is a dark salamander with a row of white or reddish spots along each side of the tail. The belly of this species is black; the dorsal coloration is highly variable.

Status

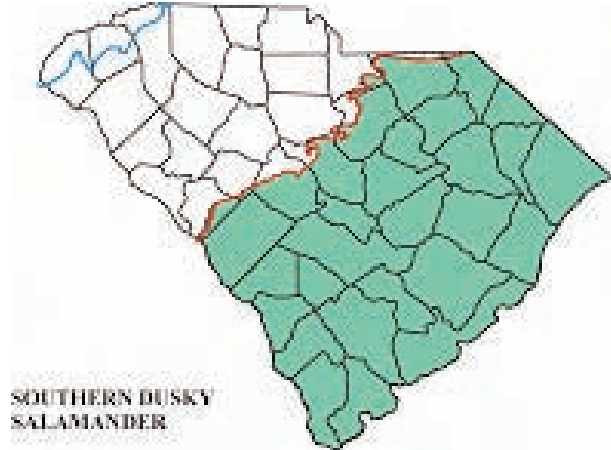
Chamberlain's dwarf salamander was previously considered a color variation of the dwarf salamander, a more common species. At this time, the new species has no official status designation, but qualifies for special concern status because of data deficiencies. The southern dusky salamander is a species that was previously thought to be common in South Carolina. It is now believed by some researchers (Harrison pers. com.), to have disappeared from areas where it was previously common. This species is not listed, but has been recommended as a species that merits some conservation attention.

Population Distribution and Size

Little data exists on the population status of either species. Chamberlain's dwarf salamander has been found in Barnwell, Allendale and Pickens Counties in South Carolina. Further, this species is located on the Savannah River Site (Harrison and Guttman 2003). The southern dusky salamander is restricted to the coastal plain in South Carolina (Conant and Collins 1991).

Habitat and Natural Community Requirements

Both species are found in wet areas, particularly seepages near cypress ponds, small streams and other wetland types. These species are most typically found under leaf litter and small debris in these habitats (Conant and Collins 1991; Petranks 1998; Martof et al. 1980; Harrison and Guttman 2003). The general community types preferred by these species appear to be mesic forests with relatively closed canopies, in particular bottomland forests, in the coastal plain.



Challenges

Little is known about the specific life histories of these species, but they could be threatened by habitat loss and alteration. In particular, forestry practices that alter the canopy structure of their habitat could affect these species.

Both species lay eggs in aquatic habitats such as springs, seeps and small streams. Therefore any alteration or drainage of these habitats could adversely affect the species.

Conservation Accomplishments

None known at this time.

Conservation Recommendations

- Determine actual distribution and occurrences of Chamberlain's dwarf and southern dusky salamanders through inventory. Protect and monitor any populations discovered.
- Include the importance of protecting Chamberlain's dwarf and southern dusky salamanders and their habitat in general education materials.
- Consider the habitat needs of both Chamberlain's dwarf and southern dusky salamanders when managing Carolina bays and similar wetland ecosystems.
- Conduct museum research to correctly assign historic records the new designation of *E. quadridigitata*, where appropriate.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from surveys will be used to identify and develop life history and ecology projects aimed at determining limiting

factors for these species. Stable or growing populations of these species, located on protected properties will be considered a measure of success.

Spotted Turtle

Clemmys guttata

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

The spotted turtle is a small, reaching lengths of 9 to 11 cm (3.5 to 4.3 inches); maximum size is approximately 12 cm (4.7 inches) (Conant and Collins 1991). This species is often called the polka dot turtle as its black carapace is sprinkled with numerous orange-yellow dots. The head and neck of this species also has orange-yellow blotches. The carapacial spots of juveniles are sometimes reduced or absent (Martof et al. 1980).

Status

The spotted turtle was listed as a species of concern until 2001 when its status was changed to Species in Need of Management (threatened). The South Carolina Department of Natural Resources Heritage Trust Program currently ranks this species as secure, both in South Carolina and globally (S5/G5). This change in status was based on the growing popularity and price of the spotted turtle in the pet trade and the fact that most of South Carolina's neighboring states already protect this species. This change in status made South Carolina particularly vulnerable to commercial spotted turtle collectors.

Population Distribution and Size

The spotted turtle is not an abundant species in South Carolina, but it can be common in appropriate habitat throughout the coastal plain. Little data exists on the status of the spotted turtle in South Carolina. This species is known to occur on several tracts of public land in the state including the Savannah River Site, Francis Marion National Forest, Webb Wildlife Center and the Carolina Sandhills National Wildlife Refuge (Garton and Sill 1977; Gibbons and Semlitsch 1991; Lovich 1990).

Habitat and Natural Community Requirements

The spotted turtle is a semi-aquatic species that inhabits a variety of wetland types including small ponds, small streams, swamps, flooded forests and other shallow bodies of water (Conant and Collins 1991; Martof et al. 1980; Ernst and Barbour 1989). Spotted turtles are most active during early spring when they can be observed occasionally basking on logs and other objects. Individuals, in particular males, will wander some distance from wetlands, especially during the spring. This species is difficult to find during the summer months and may undergo a period of summer

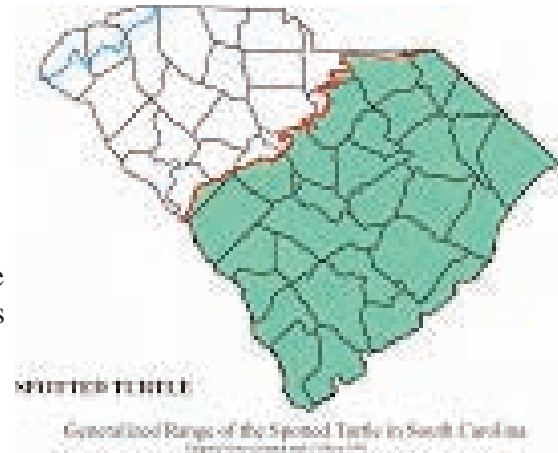
Element Occurrence Records for the Spotted Turtle in South Carolina



dormancy (aestivation) in some areas.

Challenges

The primary challenge facing the spotted turtle is collection for the pet trade; a skilled trapper may be able to eliminate or greatly reduce a local population. Habitat loss or alteration is another threat. Draining and filling isolated wetlands, a preferred habitat of the spotted turtles, has reduced the number of populations and continues to impact this species. Small shallow ponds, Carolina bays and other related wetlands have recently lost protection under the revised Clean Water Act. According to the revised act, isolated wetlands (those not contiguous with any permanently flowing water) may be drained and altered without any permits.



Conservation Accomplishments

The spotted turtle was listed as a species in need of management in 2001. As such, a set of regulations was adopted that now controls the take and possession of spotted turtles in South Carolina. Effective July 1, 2002, anyone possessing spotted turtles in South Carolina must have applied for a free permit to possess these animals. The limit for wild-caught spotted turtles for a permitted individual is nine turtles. There is no limit on the number of captive-born spotted turtles an individual may possess, but all births must be reported as part of the annual permit renewal process. SCDNR will allow persons who possess more than nine wild-caught spotted turtles to apply for a one-time designation exemption for these animals; this application needed to be filed prior to September 30, 2002. The exemption was granted upon the condition that every individual spotted turtle in the applicant's possession was made available for a photograph to document the animal. These photographs are kept on file, in digital format, by SCDNR and may be used in the future to identify these specimens. Applicants for this exemption were not allowed to collect additional wild-caught adult spotted turtles and they were not permitted to replace exempt animals with wild caught animals if the animals were lost due to mortality unless the total number of spotted turtles in their possession fell below nine. SCDNR reserves the right to verify spotted turtle mortality by requiring the carcass or shell of the dead spotted turtle to match against the file photo.

Conservation Recommendations

- Consider spotted turtle habitat needs when managing Carolina bays and floodplain ecosystems.
- Work with SRS-DOE, SR-USFS, and SREL to protect spotted turtle habitat on the Crackerneck Wildlife Management Area on SRS.
- Include the importance of protecting spotted turtles and their habitat in general education materials.
- Enforce regulations that limit spotted turtle personal possessions to levels that allow possession but do not adversely affect populations.
- Prohibit commercial trade of the spotted turtle.

- Work with SRS to design a habitat management plan for Crackerneck WMA on their property for spotted turtles.
- Identify locations of viable spotted turtle populations by conducting early spring surveys when basking turtles are easily seen.
- Continue research on life history of this species, focusing on recruitment, mortality and habitat requirements.
- Monitor known spotted turtle sites determine poaching for the pet trade.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Stable or growing populations of this species on protected lands will be considered a measure of success.

Webster's Salamander

Plethodon websteri

Contributors: Stephen H. Bennett and Kurt A. Buhlmann

Description

Taxonomy and Basic Description

Webster's salamander is a small member of the woodland salamander family. This species reaches lengths of 7 to 8.2 cm (2.7 to 3.2 inches) (Conant and Collins 1991). Both striped and unstriped individuals of this species may be found. Striped individuals typically have a wavy yellowish brown to orange red dorsal stripe extending from the head to the tail tip (Petranka 1998). Unstriped individuals are usually uniform in color, ranging from brown to reddish-orange. The belly of the salamander is mottled with black, white and reddish-orange (Martof et al 1980). This is a relatively non-descript salamander but is typically the only salamander of its size and coloration within its limited range in South Carolina.

This species was originally considered to be *Plethodon dorsalis*, the zigzag salamander.

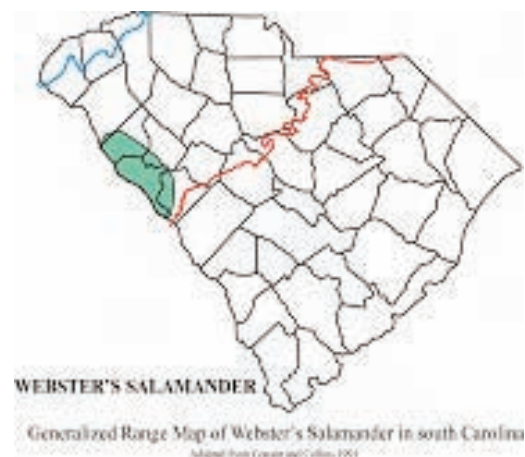
Plethodon websteri was split from that species based on molecular genetics (Highton 1979).

Status

Webster's salamander is listed as endangered in South Carolina with a ranking of imperiled (S2) and is considered vulnerable globally with a ranking of G3 (NatureServe 2005).

Population Distribution and Size

Webster's salamander occurs across the southeast in several disjunct populations. The majority of the species' range is in western Georgia and eastern Alabama in the lower piedmont. In South Carolina, the species is restricted to several counties along the Savannah River in the lower piedmont. Semlitsch and West (1983) surveyed this region of the state and found several new populations of this species. Little data exists on the size of the

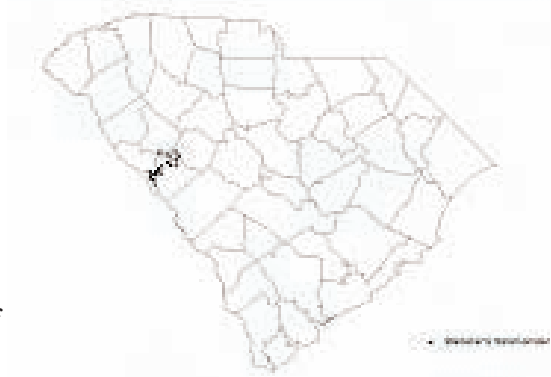


Webster's salamander populations in South Carolina; however, this salamander is abundant at Turkey Creek in the Long Cane district of Sumter National Forest. Webster's salamanders were also found in the Lickfork Lake area (Metts and Gibbons 2003).

Habitat and Natural Community Requirements

Webster's salamander is found in moist, mixed hardwood forests on steep north-facing slopes (Martof et al. 1980). Optimal habitat for this species has a rocky substrate with abundant coarse, woody debris (Petranka 1998). This species is typically associated with forests with a relatively dense canopy that prevents drying of the forest floor substrate.

Historic Occurrence Records for Webster's Salamander in South Carolina



Challenges

The primary challenge to Webster's salamander is habitat loss or alteration due to forestry practices, conversion to agriculture or development. Loss of the dense hardwood forest canopy this species prefers can lead to drying of the habitat and an elevation of soil temperatures, making the habitat unsuitable for the salamander.

Conservation Accomplishments

Stevens' Creek Heritage Preserve in McCormick County protects a population of Webster's salamander. In the 1980's the South Carolina Department of Natural Resources (SCDNR) Nongame and Heritage Trust Program funded a survey of the Webster's salamander (Semlitsch and West 1983) that led to the discovery of several new locales for this species. Several of these locations are on the Sumter National Forest; Forest Service biologists have been made aware of these sites.

Conservation Recommendations

- Encourage land managers to use Webster's salamander to promote conservation of biodiversity in South Carolina.
- Encourage the US Forest Service to protect Webster's salamanders to ensure biodiversity in South Carolina.
- Determine whether Webster's salamander is still present at historic sites and monitor populations discovered.
- Investigate basic life history research on public lands to determine the status of protected populations.

Measures of Success

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Development of site-specific management plans and stable or growing populations of this species on protected Land will be considered a measure of success.

CHAPTER 4: DIADROMOUS FISH

Alosines

American Shad *Alosa sapidissima*

Hickory Shad *Alosa mediocris*

Blueback Herring *Alosa aestivalis*

Contributor: John W. McCord

Description

Taxonomy and Basic Description

The American shad, *Alosa sapidissima* (Wilson 1811), belongs to the herring family, Clupeidae. It is the largest Atlantic Coast member of the family, with females in South Carolina reaching about 66 cm (26 inches) total length (TL). Sexually mature female American shad, often called roe shad because of the large, highly prized ovaries, rarely attain more than 3 kg (7 pounds). Mature male shad, or bucks, are generally smaller than females, rarely exceeding 2 kg (4.5 pounds). American shad, like other alosines and most members of the Clupeidae, are laterally compressed, with relatively large scales. Scales on the midline of the underside form sharp scutes that produce a saw-toothed ridge. Coloration is dark bluish, greenish or bronze on the back, silvery on the sides and white below, and varies depending on color and turbidity of water. The mouth is near the midline of the snout, and a series of several dark spots usually extends backward to below the dorsal fin from near the operculum and pectoral fin. The fins are dark and without spines and the tail is deeply forked.

Most shad spawning in South Carolina are between three and six years old, with males averaging about a year less than females. Shad migrate several hundred miles or kilometers inland in large river basins and arrive in South Carolina from mid-January through mid-May. Peak spawning activity is water temperature dependent, but generally occurs during March and April. Shad are sequential or batch spawners, with groups of eggs released as the fish move upriver. Eggs are semi-buoyant and drift in the water column when flows and depth are appropriate. Eggs usually hatch within a few days into tiny larvae that soon transform into juveniles. Juveniles closely resemble adults, but are generally more silvery, typically reaching only 10 to 12 cm (4 to 5 inches) TL before they move toward the ocean to complete growth and maturation, usually after about one year of development in the rivers, sounds and bays. However, some juveniles remain within the Santee-Cooper Lakes at least until the summer of their second year, presumably because of difficulties in using out-migration options, some of which are not functional when outflows are limited due to low lake levels (D. Cooke, SCDNR, pers. comm., 2005).

Juvenile American shad feed primarily on small invertebrates, including insect larvae and zooplankton. Adult shad prefer larger zooplankton and rarely feed while in freshwater as they are thought to die after their initial spawning run. Both outmigrating juveniles and adults that survive spawning generally move into the Atlantic and migrate into coastal areas of Maine and southern Canada, where they mingle with shad from all Atlantic populations and prey primarily on abundant zooplankton. By fall, the vast conglomerate population migrates south and overwinters off the Mid-Atlantic States. Sexually mature fish then disperse up or down the coast to their respective rivers as late winter and spring water temperatures moderate and become ideal for spawning (Neves and Depres 1979; McCord et al. 1987).

The hickory shad, *Alosa mediocris* (Mitchill 1814), also belongs to the herring family, Clupeidae. It is smaller than the American shad, with females in South Carolina reaching about 55 cm (22 inches) TL. Sexually mature female hickory shad, often called roe jacks, also carry highly prized ovaries, but rarely attain more than 2 kg (4.5 pounds). Adult male hickory shad are usually smaller than females, rarely exceeding 1 kg (2.2 pounds). Hickory shad are shaped much like American shad and also have large scales. General coloration is greenish or bronze on the back, silvery on the sides and white below. A small, indistinct spot can usually be seen beneath each lateral scale. The mouth is nearer the top of the snout than in American shad. Several dark spots usually extend backward to below the dorsal fin from near the operculum and pectoral fins. The fins are dark and spineless and the tail is deeply forked. Juvenile hickory shad resemble adults, but are less distinctively marked. Juveniles usually emigrate from inland habitats by early winter at approximately 15 cm (6 inches) TL. Larval and smaller juvenile fishes are primary dietary items for juvenile hickory shad.

Adult hickory shad migrate and spawn earlier than American shad and blueback herring; hickory shad move inland from December through mid-April. Peak spawning for hickory shad in South Carolina is during February and early March. Hickory shad typically spawn along channel edges of tidally influenced freshwater river reaches, usually within 80 km (50 miles) of the ocean. Otherwise, the general life cycle is similar to the American shad. However, most hickory shad are believed to survive after spawning, presumably because they feed primarily on small fishes that are generally available in inland habitats. Hickory shad apparently concentrate farther south, principally from Delaware Bay to New England coastal inlets, where they feed primarily on small fishes (ASMFC 1999).

The blueback herring, *Alosa aestivalis* (Mitchill 1814), is the smallest alosine in the Southeast. Adult female blueback herring in South Carolina reach about 31 cm (12 inches) TL and weigh 0.3 kg (0.7 pounds); while the slightly smaller mature males approach 28 cm (11 inches) TL and weigh 0.27 kg (0.6 pounds). Adult blueback herring are shaped and marked much like American shad. Juveniles, which usually emigrate to the ocean by mid-winter, resemble tiny adults and are about 10 cm (4 inches) TL.

Timing of inland migration, spawning and development of blueback herring closely follows patterns for American shad. However, blueback herring typically spawn in freshwater marshlands or small tributaries. Small zooplankton constitute much of the juvenile diet. Post-spawning survival rates are not well known for blueback herring, but probably exceed those for American shad. Migratory routes and timing of blueback herring are similar to those for American shad. During the spawning migration, herring move inland at distances intermediate to characteristics described for hickory and American shad. The distance that herring move upriver may be partly dependent upon the availability of habitats with suitable substrates for egg adhesion nearer the coast (Loesch and Lund 1977; J.W. McCord, SCDNR, pers. obs.).

During all life stages, alosines contribute greatly to the dynamics of food chains in freshwater, estuarine or marine habitats (Facey et al. 1986; MacKenzie et al. 1985; Weiss-Glanz et al. 1986). While at sea, alosines are prey for many species including sharks, tunas, mackerel and marine mammals, including porpoises and dolphin (ASMFC 1999; Weiss-Glanz et al. 1986). In fresh and brackish waters, both adult and juvenile alosines are consumed by American eel and striped bass (Facey et al. 1896; Mansueti and Kolb 1953; Savoy and Crecco 1995; Walburg and Nichols 1967). Juvenile herring are high quality prey for largemouth bass (*Micropterus salmoides*); accelerated growth of young bass occurs when herring consumption is high (Yako et al. 2000).

Tissues taken from predatory fish in tidal freshwaters following the residency of migrating alosines had between 35 and 84 percent of their carbon-biomass derived from marine sources (Garman and Macko 1998; MacAvoy et al. 2000). East Coast alosines, particularly populations in the southeast where post-spawning mortality is highest, likely provide nutrients and carbon into riverine systems, similar to nutrient dynamics provided by salmon in the Pacific Northwest (Freeman et al. 2003). For example, the James River, Virginia may have received annual biomass input from alosines of 155 kg/ha (138 pounds/acre) before dams blocked migrations above the fall line (Garman 1992).

More than 40 species of birds and mammals congregate to feed on migrating anadromous fish in southeastern Alaska (Willson and Halupka 1995; Willson et al. 1998). Similar relationships likely occur between East Coast alosines and birds and mammals. Fish-eating birds like osprey (*Pandion haliaetus*) and bald eagle (*Haliaeetus leucocephalus*), prey upon alosines (pers. obs.) and may have evolved their late winter and spring nesting strategies in response to the availability of food resources supplied by pre and post-spawning alosines. In addition, nutrients released from carcasses of post-spawning alosines can substantially subsidize aquatic food webs by stimulating productivity of bacteria and aquatic vegetation (Kline et al. 1993; Richey et al. 1975), thereby stimulating the assimilation of marine-derived nutrients into aquatic invertebrates and fish (Bilby et al. 1996).

Status

American shad, hickory shad and blueback herring are experiencing coastwide reductions in all stocks compared to historical populations (ASMFC 1985; ASMFC 1999). Current spawning runs of east coast North American shad populations have been reduced to 10 percent of historical sizes and have been extirpated from over 4,000 km (2,500 miles) of riverine habitat (Limburg et al. 2003). Several alosine stocks (riverine populations) are of unknown status because no directed studies have been conducted. Hickory shad population status is very poorly known for South Carolina and historical data are virtually absent. The species is apparently not plentiful anywhere within South Carolina. Populations of blueback herring in the Waccamaw-Pee Dee and Santee-Cooper are presumably secure, though undoubtedly reduced from historical levels predating dams. Blueback herring populations for other drainages are perceived to be of poorer status, and perhaps absent.

Population Distribution and Size

American shad occurs along the Atlantic coast from Bay of Fundy, Canada to St. Johns River, Florida. The historical range of hickory shad is very similar, from Bay of Fundy, Canada to Tacoma River, Florida, but current distribution is uncertain with known occurrence as far north as Connecticut (ASMFC 1999). Blueback herring are distributed from Nova Scotia to northern Florida, though they are most abundant from the Chesapeake Bay and south (Scott and Scott 1988). In South Carolina, all three species are presumed to occur as unique populations by coastal river system with a minimum of eight populations (presumably for all three species): Waccamaw-Pee Dee, Santee-Cooper, Ashley, Edisto, Ashepoo, Combahee, Coosawhatchie and Savannah drainage basins. Relatively unique populations likely occur in the major tributaries within the Waccamaw – Pee Dee basin, including Waccamaw, Little Pee Dee, Great Pee Dee, Lynches, Black and Sampit Rivers.

Historical population estimates are nonexistent, but historical distribution records (USFWS 2001) and anecdotal information on abundance strongly indicates that all populations of alosines

in South Carolina are reduced compared to historical levels (early 20th century and earlier). American shad and, to a lesser extent, blueback herring historically ascended large river basins of the state (Waccamaw-Pee Dee, Santee and Savannah) well inland of the fall line and into North Carolina and Georgia (USFWS 2001).

Trends in American shad stocks have been primarily monitored by observations in commercial gill-net fishery catch rates since 1979. Based on these trends, American shad populations in Waccamaw-Pee Dee Basin and Savannah River have remained relatively stable and healthy over the past 25 years, though almost certainly below levels of a century past (McCord 2003). Fortunately, the lowermost dams on both Savannah and Waccamaw-Pee Dee Basins are approximately 320-river km (200 mi) from the ocean. However, historical alosine spawning migrations in these basins extended beyond the point of these dams (USFWS 2001). Anecdotal information indicates that both blueback herring and hickory shad occur in the Savannah in small populations. Dam-locked populations of blueback herring now occur in several reservoirs, including Lakes Jocassee and Hartwell. Hickory shad may have also become dam-locked in Savannah Basin reservoirs, but spawning has not been recorded (D. Cooke, SCDNR, pers. comm. 2005).

Among the ACE Basin rivers, Edisto River's shad populations apparently declined dramatically through the early 1990s, with overfishing indicated as a primary cause (McCord and Ulrich 1991). Directed management through restrictive commercial fishery regulations enacted in 1993 and a decline in the number commercial fishers has apparently promoted an increased population as indicated by improved catch rates for gill-net fishers (McCord 2003). However, this stock is considered to be in guarded condition until additional monitoring can better indicate stock status (McCord 2003). The Combahee River shad population was categorized as substantially declined in the late 1990s, presumably from an extended period of overfishing (McCord and Ulrich 1994; McCord 2003). Restrictive commercial fishery guidelines were established in 2000 and should allow for growth of this stock. The status of the American shad population in Ashepoo River, the smallest of the ACE Basin rivers, is unknown. Relatively few records exist for either hickory shad or blueback herring in the ACE Basin. Both species are presumed to occur in very small populations.

Both Ashley and Coosawhatchie Rivers are small, coastal plain drainages that historically supported limited commercial American shad fisheries. The current status of these populations is also unknown. Commercial fishing activity has been restricted substantially for the Ashley and banned for the Coosawhatchie since fishery laws were revised in 2000 in accordance with Act #245 of the 2000 South Carolina General Assembly. The status of alosine stocks in these small rivers, including whether any hickory shad and blueback herring are present, is unknown.

The Santee-Copper American shad population has grown substantially since 1985 and is among the largest on the Atlantic coast, with the population likely approaching one million adults annually (McCord 2003). The blueback herring population was estimated to average over six million in the five years following the redirection of flows (Cooke and Leach 2003) and may be larger now following almost 20 years of increased flows and fish passage. Both American shad and blueback herring populations in the Santee-Cooper Basin have responded well to existing fish passage protocols and increased flows.

Hickory shad population status is poorly understood; however, based on anecdotal observations, the Santee-Cooper population is among the largest in the state, despite very low passage numbers recorded at St. Stephen Dam (Cooke and Leach 2001). All three alosines are thought to occur as secure stocks in the Waccamaw-Pee Dee Basin.

Habitat and Natural Community Requirements

Because of the highly migratory nature of alosines, these fishes require access to an expansive variety of high quality freshwater and marine habitats. Within state waters, adults migrate through nearshore Atlantic shelf waters and enter coastal sounds, bays and inlets to access the river basins in which they spawn. Eggs of American shad and hickory shad require adequate flows (generally 0.15 to 0.9 m/second or 0.5 to 3.0 feet/second) and sufficiently low sediment loads to keep eggs adrift until hatching (ASMFC 1985; Mansueti 1962; Williams and Bruger 1972). In river reaches where flows and/or water depth are not sufficient to keep eggs suspended, the semi-buoyant eggs sink to the bottom and roll or bounce on hard substrates but may be suffocated in areas with siltation (Massmann 1951; Williams and Bruger 1972). Successful spawning of blueback herring is partly dependent upon the availability of relatively clean vegetation and other substrates outside and at the periphery of river channels for egg adhesion and development with relatively low turbidity or suspended sediments (Christie et al. 1981). Christie et al. (1981) found high utilization of tidal, freshwater breached impoundments or relict rice-fields as blueback herring spawning habitat in the Cooper River basin.

American shad require high, but stable flows of high quality water for spawning and early nursery habitats (Crecco and Savoy 1987). Nursery habitats for American and hickory shad include all channel and adjacent out-of channel submerged habitats from a few kilometers or miles seaward to estuarine sounds and bays of river basin deltas. Larval and early juvenile blueback herring are associated more with the floodplain small tributaries and marshlands where spawning occurs, but older juveniles move into the same riverine and estuarine habitats used by American and hickory shad. Where fish passage venues provide access into reservoirs, juveniles of all three species apparently successfully utilize artificial lake habitats as nursery areas (D. Cooke, SCDNR, pers. comm. 2005).

Abundant sloughs and flats with submerged vegetation are generally available in reservoirs, providing excellent spawning habitat for blueback herring. During fall and winter, juvenile American shad and blueback herring tend to co-occur predominantly in deeper, channel habitats of estuarine systems, while hickory shad juveniles are more frequently encountered in shallow expanses of sounds and bays (pers. obs.). These variant distributions are likely reflective of differences in food preferences, as small crustaceans used by American shad and blueback herring are generally abundant near the bottom in estuarine channels and small fishes preferred by hickory shad are likely more numerous in shallower habitats adjacent to marshlands.

Challenges

Obstructed access to a diversity of habitats may limit basin-specific alosine populations. Dams prevent upstream migration of alosines and other species (ASMFC 1985; ASMFC 1999; USFWS 2001). Atlantic streams from Maine to Florida have undergone a restriction or loss of access for migratory fishes to about 84 percent of stream habitat within historic ranges from dams alone (USFWS 2001, Busch et al. 1998). The Waccamaw-Pee Dee, Santee-Cooper and Savannah basins in South Carolina are impacted by dams that restrict migrations of alosines into historical habitats (USFWS 2001). Dams and other impediments to migration have eliminated alosines from many historical habitats in South Carolina (USFWS 2001); the result being a general reduction in alosine populations even in currently accessible river reaches. The ecosystem effects of this loss are difficult to identify (Power et al. 1996), but ecological roles for alosines may be greatly diminished (Garman and Macko 1998). For example, many freshwater mussels are

dependent upon migratory fishes as hosts for their parasitic larvae and are presently among the most imperiled freshwater fauna (Neves et al. 1997; Vaughn and Taylor 1999), with 29 species of conservation concern in South Carolina.

The Santee Basin has the second largest drainage area and total discharge (only the Susquehanna is larger) of all river systems on the east coast of the U.S. (Hughes 1994). However, this large watershed has been adversely affected by damming to a greater extent than most basins on the Atlantic Coast of North America, with nearly 45 dams in the South Carolina portions of the basin alone (USFWS 2001). The original Santee-Cooper diversion project, completed in 1942, shifted approximately 88 percent of the historical Santee River flow into the Cooper River, changing the average Cooper River flow rate from 2 cms (cubic meters per second) or approximately 7 cfs (cubic feet per second) to 442 cms (1,560 cfs) (Kjerfve 1976). Prior to rediversion in 1985, water releases at Pinopolis Dam on the Cooper River were generally continuous. A weekly average flow of 122 cms (430 cfs) has been maintained in the Cooper River since rediversion to protect water supplies (Orlando et al. 1994), but generation time has been restricted to as little as 10 hours per day. Tidal freshwater marshes along the Cooper River (many of which are relic rice impoundments with breached or eroded dikes), which were used extensively as spawning habitat by blueback herring prior to rediversion of flows into the Santee River (Christie et al. 1981), are less extensive under reduced flows, and many are now partly dewatered or influenced by brackish water. Available fish passage and commercial fishery data indicate that the herring population has declined dramatically since flows were rediverted, presumably because of a reduction in the amount, and perhaps quality, of spawning and nursery habitat (Cooke and Eversole 1994). The original diversion of Santee River historical flows into the Cooper River caused average freshwater flow in the Santee River seaward of Wilson Dam to drop from 525 to 74 cms (1,850 to 260 cfs), and allowed saltwater intrusion (Kjerfve and Greer 1978). The Santee-Cooper Rediversion Project returned about 70 percent of the Cooper River flow to the Santee, increasing average flow to approximately 367 cms (1,290 cfs) and reducing salinity in the lower Santee (Orlando et al. 1994). However, there is no minimum flow requirement at St. Stephen Dam on the Rediversion Canal (D. Cooke, SCDNR, per. comm., 2005) and the average daily flow from Wilson Dam is only about 18 cms (63 cfs) (Orlando et al. 1994). During periods of low inflow into the Santee-Cooper Lakes, water releases can be discontinued at St. Stephen Dam (D. Cooke, SCDNR, per. comm., 2005). In contrast, the average daily discharge from Wilson Dam can approximate 500 cms (1760 cfs) during flood-control releases (Orlando et al. 1994). The resulting flow regimens in both the Cooper and Santee Rivers is typically in highs and lows (with more abrupt changes from peaked power generation and flood releases) than are characteristic of more gradual river flow changes that occur in open rivers where waters expand into, and withdraw from, floodplains.

With the construction of the Santee-Cooper lakes (Moultrie and Marion) in the 1940s, the vast majority of the Santee was closed to migratory fishes (USFWS 2001). Both the Pinopolis navigational lock and St. Stephen fish passage facility are currently used for alosine passage. Passageways at both facilities provide passage for blueback herring and American shad (Timko et al. 2003). The efficiency of passage at St. Stephen Dam for blueback herring is low (Cooke and Leach 2001) and has yet to be determined for American shad.

Fish passage designs and flow protocols currently used at dams on the lower Santee-Cooper Basin were initially designed for passing blueback herring into the lakes for forage and do not maximize passage efficiency for alosines in either direction (Cooke and Leach 2001; D. Cooke,

SCDNR, pers. comm. 2005). Dams on the Santee-Cooper Basin that currently incorporate passage for alosines, do not employ methodologies that accommodate timely outmigration and maximized survival of post-spawning adults or emigrating juveniles. Delayed outmigration of juvenile alosines, as occurs in the Santee-Cooper Lakes, may result in increased mortality of juveniles from artificially high predation and from potential capture for bait since fish become concentrated near dams for an extended period of up to several months. In open rivers, juveniles gradually move seaward in groups that are likely spaced according to the spatial separation of spawning and nursery grounds (Limburg 1996; J.W. McCord, SCDNR, pers. obs.) Delayed outmigration not only concentrates juvenile alosines, but extends their stay in freshwater areas until moderating water temperatures of late spring and early summer induce more active feeding behavior for many freshwater piscivores. Delayed outmigration may also increase vulnerability of juveniles to marine predators that would otherwise be absent from coastal waters if juveniles were able to adhere to natural migration patterns. According to the ASMFC IFMP and Amendment 1 to the IFMP, a fish passage program for alosines is only legitimate if downstream passage is an integral part of such operations (ASMFC 1985, 1999).

Dams, and particularly hydropower dams, often produce flow regimens that are not reflective of natural seasonal flows. Pulse flows used for peaking hydropower production can disrupt natural productivity and availability of zooplankton needed for larval and early juvenile forage (Crecco and Savoy 1987; Limburg 1996), can displace eggs and/or larvae from otherwise highly productive habitats, and can disrupt both upstream and downstream migration patterns for adult and juvenile alosines (ASMFC 1985; ASMFC 1999; Limburg 1996; USFWS 2001). Dams may also reduce minimum flows, potentially dewatering otherwise productive habitats, causing increased water temperature, or contributing to or exacerbating poor water quality such as reduced dissolved oxygen (ASMFC 1985; ASMFC 1999; NMFS 1998; USFWS 2001). Water releases from deep reservoirs may be poorly oxygenated and/or of below normal seasonal water temperature, thereby causing loss of suitable spawning or nursery habitat in otherwise suitable river reaches (ASMFC 1985; ASMFC 1999; NMFS 1998; USFWS 2001). Further, impounded marshlands in freshwater river reaches prevent access of blueback herring to potential spawning and early nursery habitat.

Large concentrations of double-crested cormorants (*Phalacrocorax auritus*) occur immediately below dams, particularly below those with fish passage and during the winter-spring season of alosine passage (J.W. McCord, SCDNR, pers. obs.). The cormorant population has increased dramatically over the past decade (Wires et al 2001) and these birds have been shown to feed heavily on alosines (Johnson et al. 1999). Small alosines can comprise up to 64.5 percent of the cormorant's diet (Johnson et al. 2000). Although the impact of cormorant predation on alosine populations has not been quantified, it appears that cormorants have the potential to negatively impact both upstream passage success for blueback herring and out-of-lake passage for all juvenile alosines.

Competition and predation from non-native species, in particular flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*), may be additive to 'more natural' sources of mortality and may be particularly problematic below dams where catfish density is often high (J.W. McCord, SCDNR, pers. obs.). Even adult American shad have been observed in the diet of large flathead catfish (D. Allen, SCDNR, pers. comm.), and both non-native catfishes are presumed to be problematic to alosines as both competitors and predators (NMFS 1998).

Dredging can also negatively affect alosine populations by producing suspended sediments

(Reine et al. 1998). Behaviorally, chronic turbidity from frequent or prolonged dredging can also affect fish migration, spawning, conspecific interactions, and foraging (Coen 1995). Migrating alosines are known to avoid waters of high sediment load (ASMFC 1985; Reine et al. 1998). Suspended sediments have been linked to a variety of lethal and sublethal responses in juvenile and adult fishes that are consistent with oxygen deprivation due to gill clogging (Sherk et al. 1975; Sherk et al. 1974). Filter-feeding fishes such as alosines are particularly susceptible to negative impacts of suspended sediments on gill tissues (Cronin et al. 1970). Siltation from dredging and from agricultural, silvicultural and other land use practices can reduce spawning success by causing mortality of eggs or by coating substrates needed for attachment of adhesive eggs (NMFS 1998). Suspended sediments, whether caused by dredging or by erosion from land use practices, can also cause reduced feeding success in larval or juvenile fishes that rely on visual cues for plankton feeding (Kortschal et al. 1991). Larval striped bass (*Morone saxatilis*) consumed 40 percent less prey when suspended solids exceeded 200 mg/l (milligrams per liter) (Breitbart 1988). Survival of larval alosines decreases as turbidity or suspended sediments increases above 50 mg/l (Auld and Schubel 1978).

Dredging may negatively impact prey availability by removing benthic invertebrates within sediments, by increasing suspended sediments, or by producing changes in salinity or dissolved oxygen regimens (ASMFC 1990). Sediment resuspension from dredging can cause increased turbidity and localized depletion of dissolved oxygen, as well as increased bioavailability of any contaminants that may be bound to the sediments (Clarke and Wilber 2000). The eggs and larvae of estuarine and coastal fishes appear to be among the most sensitive to suspended sediment exposures of all the taxa and life history stages for which data are available (Clarke and Wilber 2000). High concentrations of suspended sediments, as well as relatively low concentrations sustained for several days, have been shown to cause direct mortality, impaired hatching success, reduced larval feeding, and diminished larval growth in several species of estuarine and anadromous fishes (Clarke and Wilber 2000). Waters with high suspended sediment are unproductive for primary and secondary portions of the food pyramid on which juvenile alosines feed, and changes in salinity regimens can dramatically impact prey distribution (ASMFC 1990).

Pollution from point and non-point sources is a primary cause of reduced habitat quality and aquatic species viability in tidal systems. Land use practices such as agriculture and logging, as well as residential, commercial and industrial development, greatly influence the input of chemicals and nutrients into waterways, and are the primary sources of increased siltation. All of these factors contribute to eutrophication and a general decline in water quality, including a reduction in dissolved oxygen as mentioned previously. Sediments and pesticides most commonly enter coastal waters in run-off from agricultural and silvicultural lands, and agricultural and silvicultural practices alone can significantly decrease the quality of water discharges into coastal habitats, thereby causing drastic adverse impacts on aquatic life (Butler 1968). In addition to sediments, run-off from uplands includes nitrates, phosphates, herbicides, pesticides, silt and other chemicals, any of which either acting alone or in combination with other pollutants can be lethal to aquatic life, and particularly to larval forms (Matthews et al. 1980). Chemicals and heavy metals from industrial and other sources that do not cause acute toxicity can be assimilated through the food-chain and can produce sub-lethal effects including behavioral and reproductive abnormalities (Matthews et al. 1980). Pollution can directly produce mortality from contaminants such as pesticides, can lower pH that may reduce egg and larval survival (Klauda 1994) and can contribute to reduced oxygen levels. All of the potential impacts

of sediment resuspension and increased turbidity due to dredging (described in detail above) would also apply to sediments derived from upland sources.

Deforestation of swamp forest potentially leads initially to increased soil and water temperature (Aust and Lea 1991; Perison et al. 1993), siltation from increased erosion and runoff (Aust et al. 1997), decreased DO (Lockaby et al. 1997), disturbance of food-web relationships in adjacent and downstream waterways (Batzer et al. 2005). Forestry BMPs for bottomland forests are voluntary. When BMPs are not used, braided streams may be obstructed by plant material and disturbed soils, excessive ruts may channel eroded sediments into streams, and 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.). Siltation from agricultural, silvicultural and other land use practices can reduce spawning success by causing entrapment and mortality of semi-buoyant eggs and adhesive eggs by coating substrates needed for attachment of adhesive eggs (Mansueti 1961). Siltation also causes increased water temperature and reduced DO, and can result in reduced productivity beginning at lower levels of food-chain relationships on which juvenile alosines are dependent (Mansueti 1961).

Siltation, from erosion due to land use practices or from dredging, physically covers and kills some aquatic life, including submerged aquatic vegetation (SAV) and thereby increases biological oxygen demand (BOD). SAV provides important ecological functions in freshwater habitats. SAV improves water quality (Rybicki and Hammerschlag) and provides habitat for predator avoidance, foraging and nursery development for many macro-invertebrates and resident and migratory fishes (Maldeis 1970; Killgore et al. 1989; Monk 1988). SAV can also provide important spawning habitat or substrate for blueback herring (Christie et al. 1981). SAV is adversely affected by suspended sediments less than 15 mg/l (Funderburk et al. 1991) and by deposition of excessive sediments (Valdes-Murtha and Price 1998).

Dewatering of freshwater streams from irrigation and other water removal projects decreases instream flows and decreases the quantity of both spawning and nursery habitat. Dewatering can result in reduced water quality from the impacts of more concentrated pollutants and/or increased water temperature (ASMFC 1985). Density dependent impacts such as predation and competition may also increase. Further, mortality of eggs, larvae and/or juvenile alosines can occur due to impingement and entrainment in water intakes at water removal projects and in turbines in dams (ASMFC 1985).

By-catch from 'non-game' gill-nets may exert excessive mortality on hickory shad. Participants in this late winter fishery have reported that numerous hickory shad are caught in these nets (J.W. McCord, SCDNR, pers. obs.). Further, hickory shad are not generally segregated from American shad in commercial catches nor are they easily differentiated in fish passage counts. These factors prevent the collection of reliable fishery-dependent and fishery-independent data collection as needed to properly manage hickory shad populations. Mortality from directed fisheries and/or from by-catch in other fisheries outside of state jurisdiction, including fisheries within the Exclusive Economic Zone (that portion of the Atlantic Ocean under federal jurisdiction from 3 to 200 miles offshore) and within Canadian waters, may negatively impact South Carolina stocks of alosines (ASMFC 1985; ASMFC 1999).

Conservation Accomplishments

The first river-specific restrictive commercial gill-net fishery regulations (Act # 343 of the 1992 South Carolina General Assembly) were enacted in 1993 for the Edisto River after SCDNR

studies indicated overfishing as major contributor to a perceived trend of population decline (McCord and Ulrich 1991). In 2000, laws and regulations were revised to be more responsive to individual perceived population status by drainage basin or river system (Act #245 of the 2000 South Carolina General Assembly). The Coosawhatchie River shad population received the most protection, as the river was closed to commercial gill-nets (Act #245 of the 2000 South Carolina General Assembly). The amount of potential gill-net fishery effort was substantially reduced for other small, more imperiled stocks, including those in Combahee, Ashepoo and Ashley Rivers (Act #245 of the 2000 South Carolina General Assembly).

An interstate fisheries management plan (IFMP) has been developed for the alosines under the auspices of the Atlantic States Marine Fisheries Commission (ASMFC 1998). The original ASMFC IFMP for Shad and River Herring was completed in 1985 and was amended in 1999. The 1999 Amendment 1 to the ASMFC IFMP required all member states to close directed fisheries for American shad in coastal Atlantic Ocean waters by 2005 through a phase-out process initiated in 2000 (ASMFC 1999). Addenda to the IFMP were also approved in 2000 and 2002 (ASMFC 2000; ASMFC 2002). The Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) of 1993 requires states to adopt management guidelines as mandated by approved ASMFC IFMPs, including the conduct of surveys in selected South Carolina rivers and the monitoring of catch and effort for commercial and recreational fisheries for alosines (ASMFC 1999).

The ASMFC IFMP also required states to limit recreational harvest through the establishment of possession limit not to exceed an aggregate of 10 American and hickory shad per angler per day by 2000. Through legislative action, South Carolina established a 10-fish limit in 2000 for all State waters, except for Santee River, where a 20-fish limit was allowed under a conservation equivalency adjustment.

Many dams in South Carolina are currently, or soon to be, undergoing FERC (Federal Energy Regulatory Commission) re-licensing processes; these processes will include considerations for improved access and migration of aquatic species. Passage at all types of dams and other barriers to migration is strongly recommended by the ASMFC IFMP. Existing passage systems and protocols have apparently contributed to observed increases in American shad and blueback herring populations in the Santee River.

The Santee-Cooper Rediversion Project enhanced year-around flows and average late winter and spring water levels in the Santee River, primarily seaward of the Rediversion Canal. These improved flow regimens have likely produced increases in the quantity and quality of alosine spawning and nursery habitat seaward of St. Stephen Dam and the Rediversion Canal.

Conservation Recommendations

- Conduct statewide surveys of alosine distribution and population size, particularly for small rivers where stock status is unknown or perceived as poor, in order to make prioritized decisions for restoration and passage.
- Determine passage and outmigration efficiency for all alosines at existing facilities so potential changes in protocols or designs can be identified.
- Inventory sources of mortality, including existing outlets providing outmigration through dams and bycatch in commercial fisheries; formulate remedies where practical.
- Improve quality and scope of coverage for mandatory catch and effort records, for both recreational and commercial fisheries.

- Determine how often hickory shad is misidentified as American shad or blueback herring.
- Investigate impacts of logging in swamp forests on water quality and habitat, especially as related to blueback herring.
- Determine impacts of dewatering of freshwater streams to aquatic species.
- Conduct studies on the energetics and nutrient dynamics related to food-chain relationships and spawning migrations of alosines.
- Investigate potential success for fish passage at various dams by evaluating upstream habitats for value as spawning and nursery habitat
- Determine genetic relationships, or extent of homing, of alosines relative to tributary streams (particularly in Waccamaw-Pee Dee Basin).
- Determine impacts of competition and predation from non-native species, particularly below dams where alosines passing through existing outmigration routes may become stunned or disoriented, exacerbating predation impacts. To the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Partner with federal authorities to create on-board observer programs to investigate by-catch of alosines by out-of-state jurisdictional fisheries.
- Partner with appropriate agencies to evaluate state water quality standards and Best Management Practices (BMP) that may impact wetlands to ensure that guidelines are stringent enough to protect alosine habitat.
- Determine impacts of pollution and siltation on life history stages of alosines.
- Determine biotic effects of alosine stocking in habitats where access was previously restricted or absent.
- Determine the relationships of alosines to freshwater mussels on the South Carolina Species of Concern list.
- Determine impacts of biotic and abiotic factors on egg, larval and juvenile survival and development and how such factors relate to spawning stock recruitment.
- Survey non-gamefish winter gill-net fisheries to determine potential impacts on alosines, particularly on hickory shad.
- Determine potential impacts of double-crested cormorant predation on passage of adult blueback herring and on all juvenile alosines, particularly at St. Stephen Dam.
- Participate in FERC-relicensing evaluations and partner with appropriate agencies to ensure that cost-effective and efficient designs for providing both upstream and downstream passage of alosines are installed in dams blocking access to suitable spawning and nursery habitats.
- Partner with appropriate entities to improve access to a full diversity of habitats by including fish passage designs, or improving existing designs, at facilities not under FERC jurisdiction.
- Impediments to migration, such as nonfunctional dams, dikes or causeways should be identified. Investigate the feasibility for these structures to ultimately be removed, breeched or bypassed through partnerships with the appropriate authorities.

- Build partnerships with NGOs, permitting authorities, and county and local governments to improve and/or implement the use of Best Management Practices (BMPs) in agriculture, silviculture and urban development activities to reduce siltation and contaminant input.
- Partner with the appropriate agencies to determine water removal guidelines for agricultural, civil or industrial purposes that include considerations for migratory fishes.
- Partner with appropriate entities to limit deforestation of river floodplains and swamp forests.
- Partner with appropriate permitting authorities to design dredging protocols that consider the timing of alosine migration.
- Partner with other coastal states to promote protection of the alosines in the EEZ and in Canadian coastal waters.
- Form an alliance with other state and federal agencies as well as NGOs to implement range wide conservation and management of alosines as described in the ASMFC IFMP.
- Build partnerships with natural resource agencies in Georgia and North Carolina to manage alosine populations that transcend individual state jurisdictions, specifically populations in the Savannah River and Waccamaw-Pee Dee Basin, respectively.
- Partner with NGOs and other state and/or federal agencies to promote changes in water release protocols for dams that will restore or approximate natural flow regimens and increase minimum flows.
- Partner with appropriate agencies and NGOs to develop or revise river basin plans to identify habitats areas of particular concern (HAPCs), to identify degraded or threatened habitats, and to identify preventative or mitigation actions.
- Partner with appropriate agencies to designate critical coastal areas.
- Develop Memoranda of Understanding (MOUS) with other state agencies for joint review of projects and planning activities to ensure that habitats, particularly HAPCs, are sufficiently protected.
- Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs about critical habitat needs, threats, and potential conservation actions related to alosines.

Measures of Success

One measure of success would be to develop sound survey and monitoring programs and estimate trends in alosine populations. Once status has been determined, management plans can be developed to manage for stable to increasing alosine populations in South Carolina.

American Eel

Anguilla rostrata

Contributor: John W. McCord

Description:

Taxonomy and Basic Description

The American eel, *Anguilla rostrata* (Lesueur 1817), belongs to the freshwater eel family, Anguillidae. Related species occur throughout the world, but the American eel is the only North American anguillid eel. Eels are snake-shaped and covered with a mucous layer that renders them slimy to the touch despite the presence of minute scales. A continuous, low fin runs from the middle of the back, around the tail, and ends behind the vent. Relatively small pectoral fins originate near the animal's midline and immediately posterior to the head and gill-covers. Coloration varies with stage of maturity and habitat, but eels are generally dark olive, yellowish or slate-gray above and light below. Eels from dark, tannic acid streams are darker while those from clear streams and estuaries are lighter (pers. obs.).

The American eel is catadromous; it spawns in oceanic waters but uses freshwater, brackish and estuarine systems for most of its developmental life. Sexually mature adults, called silver eels, migrate from freshwater to the sea in fall. Their destination for spawning is the Sargasso Sea, an expansive portion of the central North Atlantic Ocean, east of the Bahamas and south of Bermuda. Adults are thought to die after spawning. The largest females produce nearly 20 million eggs (Barbin and McCleave 1997). Mature females in the southern portion of the eel's range are generally smaller and carry as few as 400,000 eggs (Wenner and Musick 1974). Eggs hatch into a brief pre-larval stage before transformation into the active leptocephalus stage. Leptocephali primarily drift with ocean currents for about a year before metamorphosing into the glass eel stage (Sheldon 1974). Glass eels are shaped like adults, but are transparent and smaller, reaching lengths of 5 to 7 cm (2 to 3 inches) (Hardy 1978). Glass eels actively migrate across the continental shelf and move into estuaries and tidal river reaches in late winter and early spring, apparently by detecting temperature gradients and the scents associated with freshwater (Facey and Van Den Avyle 1987). Glass eels feed little or not at all, but within weeks of entering estuaries and tidal rivers the small eels begin to feed and become pigmented, at which time they are called elvers and resemble miniature adults in coloration and other physical features. While some elvers move far into inland habitats, others remain in brackish and estuarine areas. Both glass eels and elvers migrate primarily at night and are able to move beyond obstacles that prevent passage of most aquatic species. Small eels can climb vertical walls, including low dams, as long as surfaces are damp and textured. The final inland resident stage is called the yellow eel and includes all eels greater than 10 cm (4 inches). Yellow eels may gradually move upstream over many years, with most movement occurring during spring and fall when water temperatures are moderate. However, larger yellow eels may settle in specific areas and have been found to occupy distinct home ranges (Gunning and Shoop 1962). Adult females are larger than males and may grow to lengths of nearly 1.0 m (40 inches), but most adults are 0.6 m (24 inches) or less. Maturation occurs from 3 to 24 years of age (ASMFC 2000), with males generally maturing at a younger age and smaller size than females. Eels as old as age 15 have been recorded in South Carolina (Harrell and Loyacano 1980).

American eels are opportunistic carnivores, feeding on a vast array of animal life depending on the size of the eel and the availability of prey within a given habitat. Larger eels feed primarily on small fishes and benthic invertebrates, including crustaceans, aquatic insects, worms and mollusks. Elvers and small yellow eels feed primarily on aquatic insects, small crustaceans and worms. Elvers collected from Cooper River consumed mostly midge larvae, cladocerans (zooplankton), amphipods (small crustaceans) and fish parts (McCord 1977). Adults taken from the same study area fed primarily on fish parts, elvers (eels can be highly cannibalistic) and terrestrial isopods (McCord 1977). In estuaries, eels often feed on blue crab (*Callinectes sapidus*)

and polychaete worms (Wenner and Musick 1975). Both blue crab and horseshoe crab (*Limulus polyphemus*) are used as bait in trap fisheries for American eel in Chesapeake Bay and elsewhere.

Elvers are not only preyed upon by larger eels but are also eaten by many fishes, both game and non-game species. Small yellow eels up to 46 cm (18 inches) in length are used as bait for striped bass and cobia. Eels are also consumed by other predatory fishes such as largemouth bass (*Micropterus salmoides*) and bowfin (*Amia calva*) (pers. obs.) and are likely preyed upon by opportunistic predatory fish like non-native flathead catfish (*Pylodictis olivaris*). American eels are also included in the diets of fish-eating birds and mammals, such as mink (*Mustela vison*) (Sinha and Jones 1967, Seymour 1974). American eels are a valuable part of the many ecosystems they inhabit during various growth stages. Dams and other impediments to migration have eliminated the American eel from many historical habitats in South Carolina (USFWS 2001). The effects of the loss of American eels from aquatic food webs, though not quantified, may be substantial (Freeman et al. 2003).

Status

The American eel currently has no special status under state or federal regulations; however, a petition was filed in late 2004 with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to have the American eel listed as an endangered species. The Atlantic States Marine Fisheries Commission (ASMFC) has published a management plan for the conservation of this species in response to perceived declines (ASMFC 2000).

Population Distribution and Size

One genetically similar population is thought to occur along the Atlantic coast (Williams and Koehn 1984). However, eels become resident as sub-populations in drainage basins throughout the range of the species until they become sexually mature. Accordingly, many sub-populations by drainage basin and region collectively comprise the North American population. The complex life cycle contributes to the difficulty in determining the population status of this species. Furthermore, the American eel has been poorly studied through much of its range. Historical data are scant for most areas of the Atlantic coast; no such information exists for South Carolina. Long-term data sets collected the northeastern United States and southeastern Canada indicate declines in both recruitment of juveniles and in adult populations (ASMFC 2000). Directed fisheries for silver eels have shown precipitous declines in catch per unit of effort (ASMFC 2000). Long-term data for elvers at Conowingo Dam fish lift on the Susquehanna River, Maryland indicate a declining trend from 1974 through 1996 (ASMFC 2000). Eel migration data from 1984 to 1995 indicate significant negative trends for yellow and/or silver eels in Ontario, Quebec, New York and Virginia (Richkus and Whalen 2000). Since there is likely a single genetic stock throughout the range, sub-population declines in any region or drainage basin can impact the entire population. The largest declines have been indicated over the past two decades. Dramatic declines in the northern portion of the American eel's range are important since sub-populations in this region carry the highest reproductive potential (Casselman 2003).

The American eel occurs along the Atlantic coast from Canada to Central and South America. Within South Carolina, eels occur from estuaries to the headwaters of coastal streams and at least as far inland as the fall line in longer river basins, including the Savannah, Santee and Pee Dee. Although the American eel is capable of traversing obstacles that may completely restrict dispersal of other fishes, both eel distribution and population size may be limited by dams and

other impediments to migration. Historical records show that American eels occur in the Santee basin well inland of the fall line and into North Carolina (USFWS 2001). Similar historical distributions occurred for the Waccamaw–Pee Dee Basin and are likely to be present in the Savannah River basin.

American eel populations within the Santee-Cooper River watershed inland of Pinopolis, St. Stephen and Wilson Dams are likely well below numbers present prior to impoundment of the Santee-Cooper lakes in the 1940s. Observations from St. Stephen Dam indicate rather poor passage success for the American eel (D. Cooke, SCDNR, pers. comm., 2004). Fish passage at Pinopolis Dam on Cooper River is provided by navigational lock. Such passage systems are not considered to be particularly effective for American eels because of great fluctuations in water flow that occur during lock operations (Lary and Busch 1997). Dams on the Savannah and Waccamaw-Pee Dee drainages are well inland and probably do not significantly restrict eel distribution.

Habitat and Natural Community Requirements

The American eel is widely distributed in many aquatic habitats including estuarine, brackish and freshwater tidal channels; tidal creeks; coastal impoundments; ponds; lakes and nearly all accessible freshwater habitats associated within river basins as far inland as the fall-line and beyond. Males are generally restricted to estuarine and brackish habitats while females are found more often in freshwaters. Among freshwater habitats, eels seem to be most abundant in streams, but occupy all habitats having sufficient food resources and well-oxygenated water. A high density of yellow eels has been observed in the upper South Edisto River, where single channels branch into a braided or intertwined network of small creeks within swamp forest. Yellow eels are also present in high densities in the middle Savannah River in relatively shallow, non-navigable reaches characterized by riffles and pools with rocks and submerged aquatic vegetation (pers. obs.). American eels are dependent upon access to such diverse habitats for growth and maturation, as well as free downstream passage for spawning migration. Sexually mature adults are dependent upon the vast expanses of the North Atlantic Ocean and the Sargasso Sea.

Challenges

Because of its complicated life cycle, the American eel population faces a broad range of challenges, some of which are specific to a particular growth stage. Since males and females largely utilize separate habitats, impacts in a given region may affect the sex ratio of the eel population. Dams and causeways obstruct access to a diversity of habitats, which may limit basin-specific and statewide populations. The Pee Dee, Edisto, and Santee coastal drainages have suffered an 83 percent reduction in unobstructed stream habitat (Busch et al 1998). Impingement (entrapment) and entrainment (carried through) in water intakes and turbines are sources of mortality on seaward-migrating eels.

The American eel is sensitive to low dissolved oxygen levels (Hill 1969, Sheldon 1974) in water typically found below dams. Logging in swamp forests may also cause lowered dissolved oxygen by increasing siltation and water temperature. Contaminants such as heavy metals, dioxin, chlordane and polychlorinated biphenyls (PCBs) can bioaccumulate and cause acute toxicity or reduced productivity (Hodson et al. 1994).

Dredging can result in many negative affects to American eels. Physical injury or mortality may result from entrainment of seaward-migrating adults. Increased turbidity or suspended sediments

may negatively affect migration of adults, glass eels and elvers. Dredging may also cause changes in salinity regimens that could impact eel distribution and prey availability.

Spawning habitat may be adversely affected due to seaweed (*Sargassum* sp.) harvest in the Sargasso Sea. Spawning habitat and success is also likely to be affected by pollution like oil spills.

Dewatering freshwater streams for irrigation and other water removal projects decreases habitat availability for American eels and exacerbates any existing areas of poor water quality. Nonpoint source runoff from residential areas, roads and golf courses can have a negative impact on floodplain ecosystems and impact water quality. Potential overfishing or excessive harvest of juveniles (glass eels and elvers) could negatively impact localized populations. Competition and predation from non-native species, particularly flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*) is also a problem for American eels. Both of these catfish are piscivorous and opportunistic; they will feed on any fish that can fit in their mouths. Because both of these species are found in habitats frequented by elvers (pers. obs.), predation on eels by these catfish is a concern. Additionally, non-indigenous pathogens or parasites such as the Asian swimbladder nematode (*Anguillicola crassus*), has been shown to have significant negative impacts on the European eel (*Anguilla anguilla*) and on captive American eels in South Carolina and Texas (ASMFC 2000).

Changes in oceanographic conditions may alter oceanic currents, thereby potentially altering larval transport and recruitment of juveniles across the continental shelf. The cause of these changes is unknown, but global warming may play a part (ASMFC 2000).

Conservation Accomplishments

An interstate fisheries management plan (IFMP) has been developed for the American eel under the auspices of the ASMFC. The original IFMP for the American eel was completed in 2000 and is currently in the process of being amended. The plan established a framework of recommendations for protecting or enhancing eel sub-populations by state and region.

The IFMP required the states to control and limit directed effort in both bait and commercial eel fisheries in South Carolina. Beginning in 2001, states were required to collect and monitor catch and effort statistics for American eel commercial fisheries and to limit effort at levels achieved in 2000. As a result, SCDNR capped participation at 10 license holders and capped gear use as well. The permitting system that emerged from the IFMP mandate has greatly enhanced SCDNR's ability to initiate proactive controls over American eel fisheries. In addition, the plan required states to limit recreational harvest through the establishment of several regulations: the possession limit is not to exceed 50 eels; the minimum size limit is 15 cm (6 inches); and sale of American eels is prohibited without a license.

Many dams in South Carolina are currently, or are soon to be, undergoing Federal Energy Regulatory Commission (FERC) re-licensing, which includes considerations for improved access and migration of aquatic species. Therefore, increasing opportunities for passage are possible in the future.

Conservation Recommendations

- Conduct statewide eel distribution and population surveys to make prioritized decisions for restoration and passage.

- Inventory sources of American eel mortality and formulate remedies where practical.
- Determine contaminant levels in eel tissues and relate those to mortality and reproductive success.
- Investigate impacts of logging in swamp forests on water quality and habitat. Work with municipalities and landowners to direct forestry activities away from floodplain areas.
- Determine impacts to American eel populations of dewatering freshwater streams.
- Determine size, sex, and age structures for each sub-population of American eels.
- Determine potential presence and distribution of the Asian swimbladder nematode (*Anguillicola crassus*).
- Determine potential impacts to American eels from competition and predation by non-native species and, to the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Determine the scope and impact of American eel harvest on sub-populations and revise South Carolina eel regulations to limit harvest of any eel life stage or sub-population.
- Conduct genetics studies to document sub-populations by region or river basin.
- Investigate opportunities to provide passage at dams and other obstructions that are not under FERC authority and develop more cost-effective and efficient techniques for providing both upstream and downstream passage of American eels at migration barriers. Partner with NMFS, USFWS, United States Army Corps of Engineers and non-governmental organizations (NGOs) to promote the inclusion of fish passage designs, wherever prescribed, that can successfully provide two-way passage of American eel.
- Build partnerships with NGOs, permitting authorities and county and local governments to improve and implement the use of Best Management Practices (BMPs) in agriculture and urban development activities to reduce siltation and contaminant input.
- Partner with the Department of Health and Environmental Control to develop or improve water removal guidelines for agricultural, civil or industrial purposes that protect American eels.
- Work with the United States Army Corps of Engineers to identify dredging protocols that consider the timing of eel migration.
- Form an alliance with other state and federal agencies as well as NGOs to implement range wide conservation and management of American eel as described in the ASMFC IFMP.
- Partner with the South Atlantic Fishery Management Council (SAFMC) to promote implementation of the Fishery Management Plan for Pelagic Sargassum Habitat of the South Atlantic Region.
- Promote changes in water release protocols for dams that will restore or approximate natural flow regimens and increase minimum flows.
- Institute permitting protocols for aquaculture and pet fish industries that require certification of the absence of diseases and parasites for all *Anguilla* species.
- Participate in interstate research examining the effects of oceanic changes on distribution of larval American eel and how these changes may be related to global warming.

- Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs about critical habitat needs, threats and potential conservation actions for the American eel.

Measures of Success

One measure of success would be to expand SCDNR's American eel monitoring program to more areas over a more appropriate time period (as outlined in ASMFC plans) to document distribution and population trends. Another measure of success would be to document stable to increasing American eel population trends in response to improved conditions in aquatic ecosystems and improved access to suitable habitats, as outlined in the 'recommendations' section.

Sturgeons

Atlantic Sturgeon *Acipenser oxyrinchus*

Shortnose Sturgeon *Acipenser brevirostrum*

Contributor: John W. McCord

Description

Taxonomy and Basic Description

The Atlantic sturgeon, *Acipenser oxyrinchus* (Mitchell 1815) belongs to the sturgeon family, Acipenseridae. Atlantic sturgeon are among the longest-lived fish, with a life span approaching 50 years or greater. Sexual maturity is not obtained until age 8 to 20, with males maturing younger than females (ASMFC 1990 and 1998). The Atlantic sturgeon is also the largest fish inhabiting freshwaters on the Atlantic Coast, with females in South Carolina reaching about 2.5 m (8 feet) TL. Sexually mature female Atlantic sturgeon, often called 'cows,' may weigh several hundred kilograms or pounds. Mature male Atlantic sturgeons, or 'bucks,' are generally smaller than females, rarely exceeding 1.8 m (6 feet) TL and 45 kg (100 pounds).

Atlantic sturgeons, like other sturgeons, are shaped like sharks and have a deeply forked tail in which the upper lobe is longer than the lower. A single, small dorsal fin is located far back toward the tail and a single anal fin is directly beneath on the underside. Paired pectoral and pelvic fins originate immediately rear of the bony operculum and vent, respectively. The head extends forward into a snout that is pointed in juveniles and blunt and rounded in adults. The protrusible mouth is underneath and at the rear of the snout, and is preceded by a row of four barbels similar to those on catfishes. The mouth, the width of which is about one half the distance between the eyes, does not bear teeth, but bony plates in the throat are used to crush food items if necessary (Gilbert 1989; Vladykov and Greeley 1963). The skeleton is partly cartilaginous, with the skull and leading edges of the pectoral fins among the boniest structures. Structural support and protection are provided by thick, tough skin with three rows of bony plates or scutes and much smaller scale-like 'scutelets.' The skin is generally rough, and gritty, not unlike that of a shark. Coloration is dark bronze to brownish above, lighter on the sides and white below (Gilbert 1989; J.W. McCord, SCDNR, pers. obs.).

The shortnose sturgeon, *Acipenser brevirostrum* (Lesueur 1818) is also classified in the Acipenseridae family. Adults are much smaller than adult Atlantic sturgeon, with 'cows' reaching 1.2 m (47 inches) TL and reaching a maximum weight of perhaps 18 kg (40 pounds). Mature 'bucks' are generally smaller than females, rarely exceeding 0.8 m (32 inches) TL and 7 kg (15

pounds). The shortnose sturgeon is similar in shape and physical characteristics to the Atlantic sturgeon. The snout is pointed only in young juveniles, and is broad, blunt and rounded in adults. The mouth is nearly as wide (70 percent) as is the distance between the eyes, and wider than for Atlantic sturgeon of similar size (Gilbert 1989). The body is also protected by three rows of scutes, but compared to those of Atlantic sturgeon, the bony plates collectively cover less surface area and ‘scutelets’ are small and sparse. The skin, though thick and tough, is less rigid than that of Atlantic sturgeon and is much smoother and often slimy or mucous-covered (J.W. McCord, SCDNR, pers. obs.). Coloration is generally brownish above with pinkish or salmon tones, lighter on the sides, and white below. Because of this coloration, commercial fishers often refer to this species as ‘salmon sturgeon.’ Shortnose sturgeon are also long-lived fish, reaching age 55 (Dadswell 1979), but this species reaches sexual maturity at an earlier age than Atlantic sturgeon. In the South, males may mature as soon as age two and females at age six (Dadswell et al. 1984).

As indicated by the orientation of the mouth, both species of sturgeon are benthic feeders that primarily prey on invertebrates. Aquatic insects such as mayfly and midge larvae and small crustaceans predominate the juvenile shortnose sturgeon diets (Dadswell et al. 1984; Carlson and Simpson 1987), whereas mayfly larvae, amphipods and earthworms are most frequently consumed by juvenile Atlantic sturgeon. Adults of both species consume mollusks, snails and amphipods (Van Den Avyle 1984; Dadswell et al. 1984; Haley 1998). Amphipods are particularly abundant in the lower Edisto River near the fresh-brackish interface (J.W. McCord, SCDNR, pers. obs.); preliminary evidence indicates amphipods and polychaetes as prevalent dietary items for sturgeons in similar habitat in the Savannah River (B. Post, SCDNR, pers. comm., 2005).

Status

Both the Atlantic and shortnose sturgeons are identified with rankings of G3 and S3 (NatureServe 2005), meaning that populations for both species are “vulnerable,” both globally and in South Carolina. In general, populations of both species of sturgeon along the entire Atlantic Coast are reduced from historical levels for at least the past half-century (ASMFC 1990; ASMFC 1998; NMFS 1998). The Atlantic sturgeon was considered for listing under the Endangered Species Act (ESA) in 1998, but the National Marine Fisheries Service (NMFS) determined that listing was unwarranted. However, the gulf sturgeon (*Acipenser oxyrinchus desotoi*), a subspecies of the Atlantic sturgeon restricted to rivers and adjacent waters of the Gulf of Mexico, remains on the candidate list and is currently listed as “threatened” under the ESA. The shortnose sturgeon has been listed as “endangered” under the ESA since 1967 and the American Fisheries Society deemed it “threatened” in 1989.

Population Distribution and Size

Atlantic sturgeon historically ranged along the Atlantic coast from Labrador, Canada to the St. Lucie River, Florida (ASMFC 1990). The historical range of the shortnose sturgeon is very similar, from the St. John River, Canada to the St. Johns River, Florida (Vladykov and Greeley 1963). Currently, both species are thought to be either very rare or extirpated from the extreme southern portion of their ranges.

In South Carolina, Atlantic sturgeon and shortnose sturgeon both occur as relatively distinct populations by river system, as typical for anadromous fishes (Quattro et al. 2002; Wirgin et al. 2000). There is a minimum of five populations (presumably for both species) in South Carolina: the Waccamaw-Pee Dee, Santee, Cooper, ACE Basin (Ashepoo, Combahee and Edisto Rivers) and Savannah River drainage basins. In addition, historical records indicate that Atlantic sturgeon

occurred in the Coosawhatchie River (Smith et al. 1984), but current status is unknown. Since historical data relative to individual stock status are absent and current information is incomplete, the status of all stocks is poorly understood.

In general, shortnose sturgeon stocks are more genetically isolated and dissimilar than are Atlantic sturgeon stocks, presumably because shortnose sturgeon are freshwater amphidromous, largely confined within each river basin (Kynard 1997; NMFS 1998) while Atlantic sturgeon are truly anadromous and intermingle (Quattro et al. 2002).

Historical data that relate directly to population size for South Carolina stocks are nonexistent, but historical distribution records and anecdotal information on abundance strongly indicate that all populations of sturgeons in South Carolina are reduced from early 20th century and previous levels (USFWS 2001). The current status and trends in stock status over the past 25 years for both sturgeons in South Carolina are based primarily on anecdotal information and short-term datasets. Collectively, stock status of Atlantic sturgeon throughout the state was considered in decline based on trends of commercial landings in the early 1980s (Smith et al. 1984).

Waccamaw-Pee Dee Basin: This large basin may currently provide sturgeon access to the vast majority of their historical range of spawning and early nursery habitat, which was identified by Mills (1826); low falls near the fall-line may have prevented further inland access except under high flows. Presumably, spawning of both Atlantic and shortnose sturgeon presently occurs over more than 200 km (100 mi) of river mainstem in suitable channel habitats. Available data indicate the presence of spawning stocks of both sturgeons in the basin, but the extent of basin-wide distribution and habitat utilization is largely unknown. Furthermore, relationships of individual tributary-specific sub-populations, should such exist, are unknown. Presumably fishery impacts are below levels present through 1984, and current conditions should allow populations of both species to recuperate.

Santee Basin: The Santee basin has the second largest drainage area and total discharge of all river systems on the east coast of the United States (Hughes 1994). This large watershed has been impacted by damming to a greater extent than most basins on the Atlantic coast of North America, with 88 percent of the river's annual flow diverted into the Cooper River from 1942 through 1985 (Kjerfve and Greer 1978). With the construction of the Santee-Cooper lakes (Moultrie and Marion) in the 1940's, the vast majority of the Santee was closed to migratory fishes. The navigational lock at Pinopolis Dam has been shown to be ineffective at passing shortnose sturgeon (Cooke et al. 2002; Timko et al. 2003). Fish passed at St. Stephen Dam are recorded on videotape, and only four sturgeons have been passed at the St. Stephen Dam since 1985 (D. Cooke, SCDNR, pers. comm., 2004). During the approximately 40 years since the impoundment of the Santee River, average flows in the Santee River seaward of Wilson Dam have been greatly reduced from historical levels (Kjerfve and Greer 1978). Stocks of both sturgeons were undoubtedly severely impacted over the four decades of generally low flows. Surveys have recorded both adult shortnose sturgeon and juvenile Atlantic sturgeon in rather low numbers through 2001 (Collins and Smith 1996; Cooke and Leach 2004a).

A dam-locked population of shortnose sturgeon is present in the Santee-Cooper Lakes, with spawning apparently occurring at least into the Congaree River below Columbia (Collins et al. 2003). Fish passage observations indicate that this population receives little genetic influx from either river. Sustainability of the population within the lakes is unknown, but dam-locked shortnose sturgeon populations tend to be in poorer conditions than open river populations

(Collins et al. 2003). The relationship of animals from this population to those in the Cooper and Santee Rivers is not yet clear, though a preliminary study shows animals within the lakes and in the Cooper River to be genetically similar (Collins et al. 2003).

The Cooper River: Several hundred adults are believed to inhabit the Cooper River and fertilized eggs have been collected below Pinopolis Dam (Cooke and Leach 2002). However, neither larvae nor juveniles have been collected and successful reproduction has not been confirmed (Cooke and Leach 2004b). The status and viability of sturgeon populations in the Cooper River remains poorly understood, particularly for Atlantic sturgeon.

The ACE Basin: The rivers that make up the pristine ACE basin remain unimpounded. Atlantic sturgeon likely spawn in both the Edisto and Combahee Rivers (Collins et al. 2000). No records exist for adult Atlantic sturgeon in Ashepoo River. Prior to 1994, there were very few authenticated records of shortnose sturgeon in the ACE basin and only one record in the lower Ashepoo River (Collins and Smith 1996; McCord 2003). The Savannah and Edisto River shortnose sturgeon populations are similar genetically (Quattro et al. 2002). Available evidence strongly suggests that the current Edisto River shortnose sturgeon population has received a major contribution from Savannah River animals and that the Edisto population has increased over the past 10 to 15 years or more (McCord 2003). Otherwise, the current status of sturgeon stocks in the ACE Basin is poorly understood. If fishery-induced mortality was once the major limiting factor on populations of both species in the ACE Basin, current conditions should promote population growth.

Coosawhatchie and Ashley Rivers: These are small, coastal plain drainages. Atlantic sturgeon were harvested commercially in the Coosawhatchie River in 1982 (Smith et al. 1984). Otherwise, there are no records for this area except reports of juvenile Atlantic sturgeon taken by shrimp trawls in lower Port Royal Sound. Several juvenile Atlantic sturgeon have been taken in the Ashley River during shrimp trawl surveys (J. Jenkins, SCDNR, pers. comm.), but no other records exist. There are no records for shortnose sturgeon in either of these rivers. The status of both the Atlantic and shortnose sturgeon is unknown for these small rivers.

Savannah River: There are spawning populations of both Atlantic and shortnose sturgeon in the Savannah River (Hall et al. 1991; Collins and Smith 1996; Collins et al. 2002; Smith and Collins 1998). However, the status of stocks is poorly understood and survival of juveniles and recruitment to the adult population has been identified as a potential limiting factor in population growth, particularly for shortnose sturgeon (Smith et al. 1992). According to historical distribution records much of the historically available spawning and nursery habitat for sturgeons in the Savannah River remains accessible (USFWS 2001).

Habitat and Natural Community Requirements

Because of the highly migratory nature of sturgeons, particularly the Atlantic sturgeon, these fishes require access to an expansive variety of high quality freshwater and marine habitats. Within state waters, adult Atlantic sturgeon migrate through nearshore Atlantic shelf waters and enter coastal sounds, bays and inlets to access the river basins in which they spawn. Shortnose sturgeon move primarily from tidal estuarine or brackish channels into freshwater reaches to spawn. Both species spawn in freshwater channel habitats from tidal river reaches to at least as far inland as the fall line in large, unobstructed river basins. Eggs of both species are adhesive and successful spawning is dependent upon the availability of relatively clean, hard substrates within river channels for egg adhesion and development. Both spawning and egg survival to

hatching are dependent upon habitats with low to moderate flows and limited sedimentation. Shortnose sturgeon and, presumably, Atlantic sturgeon generally spawn where flow rate is 0.2 to 1.8 meters per second (0.7 to 6.0 feet per second) (Kynard 1997). Nursery and foraging habitats for both sturgeons (including adults within rivers) include all channel and adjacent out-of-channel submerged habitats from a few kilometers seaward to estuarine sounds and bays of river basin deltas. During the fall and winter, sturgeon move seaward into brackish and estuarine channels. The Atlantic sturgeon over winters in deep channels and holes within coastal sounds and bays. It is during such seaward migrations that Atlantic sturgeon may transfer into other river basins by traversing coastal Atlantic continental shelf waters (McCord 2003). Animals tagged in the lower Edisto have been recaptured as far south as Mayport, Florida and as far north as the Pamlico River, North Carolina (McCord 2003).

Challenges

Dams prevent upstream migration of sturgeons and other species (ASMFC 1990; NMFS 1998; USFWS 2001). Atlantic streams from Maine to Florida have undergone a restriction or loss of access for migratory fishes to about 84 percent of stream habitat within historic ranges from dams alone (Busch et al. 1998). Obstructed access to a diversity of habitats may limit basin-specific populations of both Atlantic and shortnose sturgeon. The Waccamaw-Pee Dee, Santee-Cooper and Savannah basins in South Carolina are impacted by dams that restrict migrations of sturgeons into historical habitats (USFWS 2001). Dams can block spawning migrations and severely restrict the availability of spawning and nursery habitat, particularly in large river systems when dams are near the coast (ASMFC 1990), as in the Santee River. Dams and other impediments to migration have eliminated sturgeons from many historical habitats in South Carolina (USFWS 2001); the result being a general reduction in sturgeon populations in even currently accessible river reaches.

The Santee Basin has the second largest drainage area and total discharge (only the Susquehanna is larger) of all river systems on the east coast of the U.S. (Hughes 1994). However, this large watershed has been impacted by damming to a greater extent than most basins on the Atlantic Coast of North America, with nearly 45 dams in the South Carolina portions of the basin alone (USFWS 2001). The original Santee-Cooper diversion project, completed in 1942, shifted approximately 88 percent of the historical Santee River flow into the Cooper River, changing the average Cooper River flow rate from 2 cms (cubic meters per second) or 7 cfs (cubic feet per second) to 442 cms (1560 cfs) (Kjerfve 1976). Prior to rediversion in 1985, water releases at Pinopolis Dam on the Cooper River were generally continuous. A weekly average flow of 122 cms (430 cfs) has been maintained in the Cooper River since rediversion to protect water supplies (Orlando et al. 1994), but generation time has been restricted to as little as 10 hours per day. The original diversion of Santee River historical flows into the Cooper River caused average freshwater flow in the Santee River seaward of Wilson Dam to drop from 525 to 74 cms (1850 to 260 cfs), and allowed saltwater intrusion (Kjerfve and Greer 1978). The Santee-Cooper Rediversion Project returned about 70 percent of the Cooper River flow to the Santee, increasing average flow to approximately 367 cms (1,290 cfs) and reducing salinity in the lower Santee (Orlando et al. 1994). However, there is no minimum flow requirement at St. Stephen Dam on the Rediversion Canal (D. Cooke, SCDNR, per. comm., 2005) and the average daily flow from Wilson Dam is only 18 cms (63 cfs) (Orlando et al. 1994). During periods of low inflow into the Santee-Cooper Lakes, water releases can be discontinued at St. Stephen Dam (D. Cooke, SCDNR, per. comm., 2005). In contrast, the average daily discharge from Wilson Dam can

approximate 500 cms (1,760 cfs) during flood-control releases (Orlando et al. 1994). The net result of flow regimens in both the Cooper and Santee Rivers is flows that are typically in highs and lows with more abrupt changes in flows from peaked power generation and flood releases than are characteristic of more gradual river flow changes that occur in open rivers where waters expand into, and withdraw from, floodplains.

With the construction of the Santee-Cooper lakes (Moultrie and Marion) in the 1940's, the vast majority of the Santee was closed to migratory fishes (USFWS 2001). Both the Pinopolis navigational lock and St. Stephen fish passage facility provide passage for blueback herring and American shad (Timko et al. 2003). However, these facilities do not effectively pass sturgeons, nor do they incorporate efficient outmigration technologies, even for alosines (Cooke et al. 2002; D. Cooke; Timko et al. 2003). Effective passage designs for sturgeons have not yet been determined (NMFS 1998). However, poorly designed fish passage facilities may negatively impact sturgeon populations by increasing mortality. Sturgeons are long-lived species, with adults suffering low natural mortality and individuals contributing to population productivity over several decades (ASMFC 1990; ASMFC 1998; NMFS 1998).

The ecological effects of eliminating large fish such, as sturgeon from rivers and streams is unknown, though possibly substantial (Freeman et al. 2003). For example, some freshwater mussels are dependent upon migratory fishes as hosts for their parasitic larvae and are presently among the most imperiled freshwater fauna (Neves et al. 1997; Vaughn and Taylor 1999), with 29 species of conservation concern in South Carolina. Blockages to migratory fishes are a major, and perhaps the primary, cause of mussel population declines (Williams et al. 1993; Watters 1996), and some species, such as the ebonyshell (*Fusconaia ebena*) in the upper Mississippi River, have been extirpated from portions of their historical range following dam construction that blocked migration of the mussel's larval host, skipjack herring (*Alosa chrysochloris*) in this case (Theler 1987). The alewife floater (*Anodonta implicata*), a rare mussel species in South Carolina, expanded its upstream range by at least 200 km (125 mi) in the Connecticut River after anadromous fish passage was provided at four dams (Smith 1985). Other South Carolina mussel species suspected to use or require anadromous hosts include the tidewater mucket (*Leptodea ochracea*), the Carolina slabshell (*Elliptio congaraea*), the Roanoke slabshell (*Elliptio roanokensis*) and the eastern pondmussel (*Ligumia nasuta*) (Tim Savidge, the Catena Group, Inc., pers. comm.; John Alderman, Alderman Environmental Services, Inc., pers. comm.; Bogan and Alderman 2004; NCWRC).

Dams, and particularly hydropower dams, often produce flow regimens that are not reflective of natural seasonal flows. Dams may reduce minimum flows, thereby potentially dewatering otherwise productive habitats and increasing water temperature (NMFS 1998; USFWS 2001). Pulse flows used for peaking hydropower production can disrupt natural productivity and prey availability for larval and early juvenile fishes (Crecco and Savoy 1987; Limburg 1996), can displace eggs and/or larvae from otherwise highly productive habitats (USFWS 2001), and can disrupt both upstream and downstream migration patterns for adult and juvenile anadromous fishes (ASMFC 1985; ASMFC 1999; Limburg 1996; USFWS 2001).

Atlantic sturgeon prefer moderate water temperatures, 12 to 24°C (54 to 75°F); body weight is negatively impacted at higher temperatures (McCord 2003). Reduced flows caused by dams can reduce dissolved oxygen (DO) to levels unsuitable for sturgeon (Secor and Niklitschek 2001). For example, DO within the Santee River Rediversion Canal can reach less than 3.0 mg/L (milligrams per liter) and more frequently reaches less than 4.0 mg/L during summer

periods with low or no flows from St. Stephen Dam (Cooke and Leach 2004a). At least 20 adult shortnose sturgeon were killed in the Rediversion Canal following a DO crash related to decaying submerged vegetation that had been trapped on trash racks associated with turbines in St. Stephen Dam (Cooke and Leach 2004a). Water releases from deep reservoirs may be poorly oxygenated and/or of below normal seasonal water temperature, thereby causing loss of suitable spawning or nursery habitat in otherwise suitable river reaches. Deepwater releases in late winter through early spring (season of spawning) are often below the required temperatures: 13.3-17.8°C for Atlantic (Borodin 1925), 8.0-15.0°C for shortnose (Dadswell et al. 1984; Buckley and Kynard 1985).

Dredging and bridge construction may negatively impact sturgeons in several ways (ASMFC 1990). Deepened channels can allow saltwater to intrude further inland, and changes in salinity regimens can dramatically impact prey distribution (ASMFC 1990). Prey availability can also be reduced by the removal of benthic invertebrates within sediments (ASMFC 1990). Dredging can also negatively affect fish populations by producing suspended sediments (Reine et al. 1998). Sediment resuspension from dredging can cause increased turbidity and localized depletion of dissolved oxygen, as well as increased bioavailability of any contaminants that may be bound to the sediments (Clarke and Wilber 2000). High concentrations of suspended sediments, as well as relatively low concentrations sustained for several days, have been shown to cause direct mortality, impaired hatching success, reduced larval feeding, and diminished larval growth in several species of estuarine and anadromous fishes (Clarke and Wilber 2000). Suspended sediments have been linked to a variety of lethal and sublethal responses in juvenile and adult fishes that are consistent with oxygen deprivation due to gill clogging (Sherk et al. 1975; Sherk et al. 1974). Behaviorally, chronic turbidity from frequent or prolonged dredging can affect fish migration, spawning, conspecific interactions, and foraging (Coen 1995). Some fishes avoid waters of high sediment load, even during spawning migrations (ASMFC 1985; Reine et al. 1998). Water quality impacts and/or the reduction or elimination of prey may also disturb sturgeon concentration areas near the freshwater-brackish interface. Dredges, primarily hydraulic or hopper dredges may damage or kill sturgeons by entrainment or impingement in drag-arms or impellers (ASMFC 1990; NMFS 1998).

Siltation from dredging and 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, which can reduce survival of eggs, larvae or juveniles (Rogers and Weber 1995, NMFS 1998; USFWS 1998). Bioaccumulation of contaminants, such as dioxin in parts of Winyah Bay, may reduce productivity or increase susceptibility to diseases or stress (Cooper 1989; Sindermann 1994; Varanasi 1992; NMFS 1998).

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 and 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 increased water temperature (Aust and Lea 1991; Perison et al. 1993). Further, siltation results in reduced productivity beginning at lower levels of food-chain relationships

upon which juvenile sturgeons are dependent and disturbance of food-web relationships in adjacent and downstream waterways (Batzer et al. 2005). Forestry BMPs for bottomland forests are recommendations to landowners in order to conserve site productivity, primarily for silviculture, and are voluntary (South Carolina Forestry Commission 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, 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.

Siltation, from erosion due to land use practices or from dredging, physically covers and kills some aquatic life, including submerged aquatic vegetation and thereby increases BOD (biological oxygen demand) (Funderburk et al. 1991; Valdes-Murtha and Price 1998). Submerged aquatic vegetation provides important ecological functions in freshwater habitats. Submerged aquatic vegetation improves water quality (Rybicki and Hammerschlag) and provides habitat for predator avoidance, foraging and nursery development for many macro-invertebrates and resident and migratory fishes (Maldeis 1970; Killgore et al. 1989; Monk 1988). Submerged aquatic vegetation is adversely affected by suspended sediments greater than 15 mg/l (Funderburk et al. 1991) and by deposition of excessive sediments (Valdes-Murtha and Price 1998).

Dewatering of freshwater streams from irrigation and other water removal projects decreases habitat availability and contributes to reduced water quality by concentrating non-point source pollution and increasing water temperature (ASMFC 1985). Density dependent impacts such as predation and competition may also increase. Sturgeons of various sizes can become impinged or entrained by intakes for power plants or by municipal, industrial or agricultural water intakes (NMFS 1998; Hoff and Klauda 1979).

Sturgeon also have been affected by commercial and recreational fishing operations. By-catch from gill nets, trawls or trotlines may cause excessive mortality on adult shortnose sturgeon and on juvenile Atlantic sturgeon (NMFS 1998). By-catch mortality for Atlantic sturgeon occurs in fisheries within the Exclusive Economic Zone (EEZ) (the Atlantic Ocean from 3 to 200 miles offshore). There is currently no management plan for sturgeon in the EEZ. (ASMFC 1998; Kahnle et al. 1998) Evidence of impingement in crab traps has been observed for juvenile Atlantic sturgeon (J.W. McCord, SCDNR, pers. obs.) and abandoned or lost traps may be problematic as potential sources of injury or mortality for both species of sturgeon. Illegal harvest of both species is likely, particularly for animals captured incidentally in American shad and shrimp trawl fisheries, but also from directed effort (NMFS 1998). Allowable take of sturgeons, as permitted under the ESA, may allow excessive mortality, particularly for adults in small populations (NMFS 1998). Further, genetic contamination of unique populations may result from stocking programs (ASMFC 1998; NMFS 1998).

Predation and competition between sturgeon and non-native species, such as flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*), may be additive to 'more natural' sources of mortality. Both of these non-native catfishes are presumed to be problematic to sturgeons as both competitors and predators (NMFS 1998).

Conservation Accomplishments

The shortnose sturgeon was listed as an endangered species in 1967. In addition, both Atlantic and shortnose sturgeon received a high level of protection with the closure of the directed Atlantic sturgeon gill-net fishery in 1985, which made the possession of any sturgeon illegal in South Carolina.

Both sturgeon species were incidentally caught in the ocean shad fishery (J.W. McCord, SCDNR, pers. obs.). The ASMFC's Amendment 1 to the Interstate Fisheries Management Plan (IFMP) for shad and river herring mandated closure by 2005, preceded by an effort phase-out period. Any reduction in shad fishery effort reduces the potential for by-catch and associated mortality. Participation in South Carolina's American shad gill-net fishery has gradually declined over at least the past 25 years (J. McCord, unpublished data).

An IFMP was developed for the Atlantic sturgeon under the auspices of the Atlantic States Marine Fisheries Commission ASMFC (1990 and 1998). In addition to numerous management recommendations, the sturgeon amendment also includes requirements for states to monitor by-catch in all fisheries and to control levels of by-catch if necessary. More importantly, the 1998 amendment required all states to implement a moratorium on sturgeon harvest for 20 to 40 years. Despite the earlier closure of directed Atlantic sturgeon fisheries in South Carolina, the coast wide moratorium is important for management of populations in South Carolina because of the migratory behavior of Atlantic sturgeon.

Additional protection from bycatch mortality was afforded to both Atlantic and shortnose sturgeon with the initiation of bycatch reduction devices (BRDs) and turtle excluder devices (TEDs) in shrimp trawl nets, as required by the NMFS. In 1990, TEDs were required and BRDs were required in 1996. According to commercial shrimp trawler captains interviewed by the author in 1995, sturgeon bycatch has been substantially reduced by these devices.

The Santee-Cooper Rediversion Project completed in 1985 also enhanced year-around flows and average late winter and spring water levels in the Santee River, primarily seaward of the Rediversion Canal. These improved flow regimens have presumably produced increases in the quantity and quality of spawning and nursery habitat for both sturgeons seaward of St. Stephen Dam and the Rediversion Canal. Accordingly, both Atlantic and shortnose sturgeon may have been positively influenced.

Conservation Recommendations

- Conduct statewide surveys of Atlantic and shortnose sturgeon populations, particularly for small rivers where stock status is poor or unknown, to determine abundance (or presence/absence), age structure and recruitment indices of juveniles into spawning populations. Develop standardized sampling protocols for inventorying life stages for both species.
- Expand sturgeon tagging programs to other South Carolina rivers to gather additional information on movements of both species within and between river basins.
- Validate aging techniques for South Carolina sturgeons by analyzing the hundreds of archived hardened fin-rays collected from sturgeons in the lower Edisto River and comparing growth rings with seasonal growth (in length) of recaptured sturgeon.
- Compare the genetic relationship of shortnose sturgeon in the Santee-Cooper Lakes and the Cooper River with those from the Santee and Waccamaw-Pee Dee Rivers and determine the genetic relationships of Atlantic sturgeon for tributary rivers within the Waccamaw-Pee Dee and ACE Basins. Determine genetic relationships for spring and fall spawning Atlantic sturgeon within individual drainage basins.
- Determine the minimum viable populations for both Atlantic and shortnose sturgeon, below which stocking should be considered.

- Develop breeding and stocking protocols for both species of sturgeon that protect the genetic integrity of unique populations.
- Document seasonal distribution of both sturgeons throughout the state in order to identify and map essential habitat.
- Inventory existing sources of mortality for sturgeons and formulate remedies where practical.
- Improve quality and scope of coverage for sturgeon by-catch records received from mandatory catch and effort records collected from shad and herring fisheries and expand the program to include non-gamefish gill-nets. Additionally, create an observer program or survey to collect sturgeon by-catch information from gill-net fisheries and to determine the reliability of mandatory reports. Create an observer program to record sturgeon by-catch information from shrimp trawl fisheries and require sturgeon by-catch reporting for all trawl fisheries.
- Investigate impacts of logging in swamp forests on water quality and habitat, especially as related to sturgeon spawning and nursery habitat.
- Determine impacts of dewatering of freshwater streams from irrigation and other water supply withdrawal projects. Determine the relation of river discharge rates to sturgeon spawning success.
- Investigate potential success for fish passage at various dams by evaluating upstream spawning and nursery habitat.
- Investigate the potential for improving spawning success of both species by deployment of rock to supplement natural spawning substrate or to create new spawning habitat.
- Conduct an interview survey of past sturgeon fishery participants for the purpose of gathering invaluable information on productive fishing techniques and gear, on most productive sites, and on seasonality of sturgeon spawning runs.
- Determine potential impacts of predation and competition from non-native species on sturgeons and, to the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Evaluate state water quality standards and BMPs that may impact wetlands to ensure that these practices adequately protect sturgeon habitat.
- Determine minimum flows below dams that are necessary to maintain appropriate dissolved oxygen levels for sturgeons and the response of sturgeons to low dissolved oxygen, particularly within preferred habitats.
- Determine impacts of pollution, contaminants and siltation on all life history stages of sturgeons.
- Evaluate utilization and effectiveness of existing fish passage structures and protocols for Atlantic and shortnose sturgeon.
- Determine impacts of biotic and abiotic factors on egg, larval and juvenile survival and development and how such factors relate to spawning stock recruitment.
- Assess the impacts of dredging, open water disposal of sediments and blasting on sturgeons and on their habitat and prey base.

- Determine food habits by habitat type and life stage for both species of sturgeon and the relationships of food habits to availability and density of potential prey.
- Determine contaminant loads in sediments of areas frequented by either sturgeon species, determine contaminant loads in sturgeon tissues, and determine the impacts of contaminants on sturgeon health.
- Participate in FERC-relicensing exercises and partner with USFWS, NMFS and NGOs (non-governmental organizations) to ensure that cost-effective and efficient designs for providing both upstream and downstream passage of sturgeons are installed in dams that are currently blocking access to suitable spawning and nursery habitats.
- Partner with NMFS, USFWS, ACOE, NGOs and local governments to improve access to a full diversity of habitats by including fish passage designs wherever appropriate and by removing, breaching or bypassing impediments to migration such as nonfunctional dams, dikes or causeways.
- Build partnerships with NGOs, permitting authorities, and county and local governments to improve and/or implement the use of Best Management Practices (BMPs) in agriculture, silviculture and urban development activities to reduce siltation and contaminant input.
- Partner with the SCDHEC to develop water removal guidelines for agricultural, civil or industrial purposes that include considerations for the needs of migratory fishes.
- Partner with GADNR to study and manage sturgeon populations in the Savannah River.
- Partner with North Carolina natural resource agencies to study and manage Atlantic and shortnose sturgeon populations in the Waccamaw-Pee Dee Basin.
- Partner with GADNR, ACOE, USFWS, NMFS and local governments to provide sturgeon passage at New Savannah Bluff Lock and Dam and at dams inland of this point, should passage be deemed appropriate at other barriers.
- Partner with NGOs state and federal agencies, and industry to discourage deforestation of river floodplains and swamp forests.
- Partner with appropriate permitting authorities, including the ACOE, to design dredging protocols that consider the timing of sturgeon migration and that protect freshwater-brackish interface zones.
- Partner with other coastal states, possibly through the ASMFC, to promote protection of the Atlantic sturgeon in the EEZ.
- Form an alliance with other state and federal agencies as well as NGOs to implement range wide conservation and management of sturgeons as described in the ASMFC IFMP for Atlantic sturgeon and the NMFS FRP for shortnose sturgeon.
- Partner with NGOs and other state and/or federal agencies to promote changes in water release protocols for dams that will restore or approximate natural flow regimens, increase minimum flows and improve water quality below dams.
- Partner with SCDHEC, federal agencies and NGOs to develop or revise river basin plans to identify habitats areas of particular concern (HAPCs), to identify degraded or threatened habitats and to identify preventative or mitigation actions.
- Partner with SCDHEC to designate critical coastal areas, such as freshwater-brackish

interface zones.

- Partner with other state agencies to regionally review and manage projects and planning activities that protect sturgeon habitat.
- Partner with the NMFS, USFWS and other groups to confine allowable take of sturgeons by water intake facilities to levels that do not limit population growth, particularly for small stocks.
- Critical habitats and migration patterns for Atlantic and shortnose sturgeon should be included in Coastal Zone Management Plans, in BMPs for non-point source pollution, and in State Pollution Discharge Elimination Systems permits. Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs regarding critical habitat needs, threats and potential conservation actions for sturgeons.
- Develop education programs to specifically address by-catch of sturgeons in American shad and other gill-net fisheries, trawl fisheries and various trap and trot-line fisheries.

Measures of Success

By improving aquatic ecosystem health and access to and from suitable spawning and nursery habitats, and by monitoring population responses to conservation actions as suggested above, SCDNR will be able to promote and document rebounding populations of both Atlantic and shortnose sturgeons.

CHAPTER 5: FRESHWATER FISH

Highest Conservation Priority – Big River Species

Highfin Carpsucker *Carpiodes velifer*

Robust Redhorse *Moxostoma robustum*

Contributors: Ross L. Self and Jason Bettinger

Description

Taxonomy and Basic Description

The highfin carpsucker is a member of the family Catostomidae, which is represented by eight genera and 25 species in the mid-Atlantic region (Rohde et al. 1994). This family is characterized by soft-rayed fins; a mouth located on the underside of the head, thick fleshy distensible lips, and paired fins attached low on the body (Rohde et al. 1994). The genus *Carpiodes* contains primitive, deep bodied, silver colored carpsuckers with a long dorsal fin (Jenkins and Burkhead 1994). The taxonomic status of the highfin carpsucker on the Atlantic slope is in question (Lee et al. 1980). Current work suggests that the fish is an undescribed species, similar to but distinct from the true highfin carpsucker of the Mississippi drainage. The highfin carpsucker resembles the quillback (*Carpiodes cyprinus*), but the highfin carpsucker has a steeper forehead. Highfin carpsuckers range in length to 50 cm (19.7 inches) (Rohde et al. 1994).

The robust redhorse is a large, heavy-bodied sucker that can reach lengths greater than 70 cm (17.6 inches) and weights up to 8 kg (17.6 pounds). The robust redhorse has large molar-like pharyngeal teeth specialized for crushing hard bodied prey like native mussels. It resembles the river redhorse, *M. carinatum*, but has ten pelvic rays instead of nine (Rohde et al 1994). The fish is bronze on the back and sides and adults are faintly striped on the lower sides. Juveniles have intense red in the caudal fin, which becomes less obvious in adults. Breeding males develop prominent tubercles on the snout, head and anal and caudal fins (GADNR 1999).

After specimens of a large redhorse collected in Georgia and North Carolina in the 1980s and early 1990s were determined to be the fish described by Cope (1870) as *M. robustum*, major revisions of sucker taxonomy were initiated. Jenkins and Burkhead (in a footnote) applied the name *M. robustum* to the large rediscovered redhorse and called it robust redhorse. Smallfin redhorse was moved to the newly elevated genus *Scartomyzon* and given the common name brassy jumprock. Its taxonomic status has still not been completely resolved (NatureServe 2004).

Status

The robust redhorse carries no legal status in South Carolina or North Carolina, but is listed as endangered in Georgia. It is considered critically imperiled (S1) in North Carolina and Georgia, which are the only other states where it occurs (NatureServe 2004). In a recent assessment of southeastern fishes, the robust redhorse was considered in danger of extinction throughout all or part of its range (Warren et al. 2000).

The highfin carpsucker is not listed in South Carolina; however it's limited distribution and questionable taxonomic status likely warrants listing in South Carolina.

Population Distribution and Size

Distribution

The highfin carpsucker, in the broad sense, is distributed throughout the Lake Michigan drainage and Mississippi River basin from Pennsylvania south to Louisiana (NatureServe 2004). It also occurs on the Atlantic slope from the Cape Fear River to Savannah River drainages and Gulf slope drainages from Choctawhatchee River, Alabama and Florida to the Pearl River, Louisiana and Mississippi (Page and Burr 1991). The Atlantic slope and gulf slope populations likely differ at the species level from those of the Mississippi and Lake Michigan drainages. In South Carolina, the highfin carpsucker occurs in the Broad and Congaree Rivers in the upper Santee River basin and the Savannah River. Historically the highfin carpsucker also occurred in the Pee Dee River; however, that population may have been extirpated (H. Bart, pers. comm.).



Robust redhorse are now known to exist in the Ocmulgee and Oconee rivers (Georgia), the Savannah River (Georgia/South Carolina) and the Pee Dee River (North Carolina/South Carolina). In addition to wild populations, small stocked populations have been established by introducing fish in the Ocmulgee, Ogeechee and Broad Rivers in Georgia (RRCC 2004).

Population Size and Trend

Highfin carpsucker population size and trend is not well known. There appear to be healthy populations with recruitment in the Broad River,

Congaree River and Savannah River. If the highfin carpsucker does still exist in the Pee Dee River, it would have to be considered a remnant population. Preservation of populations in the Santee River are extremely important to the global preservation of the species given declining populations in the Cape Fear River and Pee Dee River (W. Starnes, pers. comm.).

Robust redhorse population size in the Oconee River was originally estimated as approximately 1,000 to 3,000 adults in an 80 km (50 mile) section of river. Annual sampling currently suggests that the Oconee population may not be reproducing at levels sufficient to sustain the population. Further, this population is vulnerable to catastrophic events (NatureServe 2004). The latest population estimate for the Oconee River is fewer than 200 adults (J. Evans, GA DNR pers. comm., August, 2004).

The Savannah River appears to be supporting a substantial population of robust redhorse (RRCC 2004). However, no estimates of the size of the Savannah population have been made to date. Although, populations estimates for the Savannah River are currently ongoing (W. Starnes, pers. comm.).

Status surveys for robust redhorse in the Yadkin /Pee Dee drainage have identified what appears to be a remnant population. Over a five-year period, seven specimens have been collected; however, several of these specimens were considered to be juveniles when captured.

Wirgin et al. (2001) examined mitochondrial DNA (mtDNA) variation in *M. robustum* and concluded that the Oconee/Ocmulgee River and Savannah River populations should be treated as evolutionarily significant units. Based on a very limited sample size, mtDNA variation supports the idea that the Yadkin/Pee Dee populations may represent a third evolutionarily significant unit.

Habitat and Natural Community Requirements

The highfin carpsucker inhabits rivers in areas with moderate or swift current over sand or gravel substrate. Robust redhorse is known only from habitats in mainstream rivers where it has been collected in riffles, runs and pools. Adults are usually found in association with tree snags, often in deep water near shore. Spawning occurs in coarse gravel habitats (GADNR, 1999). Additionally, juvenile robust redhorse have been collected from various locations in Clarks Hill Reservoir (J. Strom Thurmond Reservoir). Fish stocked in the Broad River of Georgia have moved downstream into the reservoir and have survived quite well. These reservoir collections tend to indicate a tolerance of, or a preference for, lake habitat during a portion of the life cycle (RRCC 2000), though these habitats are not part of its natural riverine habitat.

Challenges

Habitat loss and disruption of spawning migrations resulting from dams and impoundments; predation and competition by introduced nonnative species like buffalo, flathead catfish and blue catfish; and significant deterioration of water quality due to sedimentation and pollution are believed to have contributed to the decline of the robust redhorse. Additionally, the limited range of known populations and low rates of recruitment to the adult population represent challenges to the species' future (RRCC 2004). Although it has a wider distribution, the highfin carpsucker shares the same challenges as the robust redhorse.

Conservation Accomplishments

The Robust Redhorse Conservation Committee (RRCC) was established in 1995 under a Memorandum of Understanding (MOU) between state and federal resource agencies, private industry and the conservation community to work proactively to recover the population across its historic range. The RRCC was formed in lieu of listing the species under the Endangered Species Act. Partners include thirteen signatory members to the MOU, two cooperating members under the MOU, and a variety of university research and resource management facilities as affiliate members.

A plan, entitled *Conservation Strategy for the Robust Redhorse* that provides overall conservation guidance to assure the continued survival of the species was adopted by the RRCC in 1998 and updated in 2003. It establishes short- and long-term conservation goals, describes the status and distribution of the species, discusses problems facing the species and presents conservation actions that should be implemented to accomplish short- and long-term goals (RRCC 2004). The recovery goal established by the RRCC is six self-sustaining populations of robust redhorse across its former range (Nichols 2003).

A total of 18,920 robust redhorse fingerlings (5 to 6 inches) were stocked into the Broad River by the SCDNR during fall 2004. Those fish were stocked below Neal Shoals and Parr Shoals

Reservoirs. Stocking of robust redhorse into the Broad River will continue each year until a self-sustaining population is achieved (F. Sessions, SCDNR, pers. comm.).

Conservation Recommendations

- Conduct surveys of South Carolina's major drainages to determine the presence of both the robust redhorse and the highfin carpsucker.
- Determine habitat preference and utilization for various life stages for the robust redhorse and the highfin carpsucker.
- Characterize genetic relationships of existing wild populations for both the robust redhorse and the highfin carpsucker.
- Develop a greater understanding of life history for both the robust redhorse and the highfin carpsucker.
- Renew the MOU that formed the RRCC and continue working with partners to achieve the goals set forth in the conservation strategy developed by the RRCC for the robust redhorse.
- Identify, protect and enhance critical robust redhorse habitats.
- Reintroduce the robust redhorse to appropriate water bodies (Broad and Congaree Rivers) in South Carolina in order to establish self-sustaining populations.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. Establishment of a breeding population of robust redhorse in the Broad River would provide a measure of success to the stocking program for this species.

Highest Conservation Priority – Coastal Plain Species

Bridle Shiner *Notropis bifrenatus*

“Thinlip” Chub *Cyprinella* spp. [c.f. *zanema*]

Sandhills Chub *Semotilus lumbee*

“Broadtail” Madtom *Noturus* spp. [c.f. *insignis*]

Carolina Pygmy Sunfish *Elassoma boehlkei*

Bluebarred Pygmy Sunfish *Elassoma okatie*

Savannah Darter *Etheostoma fricksium*

Contributor: Jason Bettinger

Description

Taxonomy and Basic Description

The bridle shiner is a member of the cyprinid family (minnows) and currently resides in the genus *Notropis*. With 71 species, *Notropis* is the second largest genus of freshwater fishes in

North America (Rohde et al 1994). Bridle shiners are relatively small, reaching a maximum total length of about 60 mm (2.3 inches). A prominent back lateral stripe extends from the tip of the snout to the tail fin. The back is straw colored and the sides of the fish are silver with blue-green iridescence. Breeding males develop light yellow to bright yellow-gold color on the lower sides of their bodies and faint yellow fins (Jenkins and Burkhead 1994).

The “thinlip” chub is a new and currently undescribed species that is similar to the Santee chub, *Cyprinella zanema*. When described, the “thinlip” chub will probably remain in the genus *Cyprinella*. Containing 29 species, *Cyprinella* is the second largest genus of American cyprinids, after *Notropis* (Jenkins and Burkhead 1993). Members of the genus *Cyprinella* are distinguished from other cyprinids by their large vertical diamond-shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). The “thinlip” chub is a slender fish with a long snout and a barbel in the corner of its inferior mouth. A light yellow-green stripe is present above the dark lateral stripe. “Thinlip” chubs attain sizes similar to Santee chubs (*C. zanema*), about 75 mm (3 inches).

The sandhills chub, another member of the cyprinid family, belongs to the genus *Semotilus*. There are four species of *Semotilus*, two of which occur in South Carolina (creek chub and sandhills chub). Fish in the genus *Semotilus* are large minnows characterized by a robust body, large head and a dark blotch or smudge in their dorsal fin. They also have a very small barbel in a groove above the upper lip near the corner of their mouth except in the Lumbee River where the barbel is absent. The sandhills chub has relatively fine scales, a diffuse black lateral stripe, and a pinkish wash to the body in breeding season. Sandhills chubs can attain lengths of 240 mm (9.4 inches) (Rohde et al. 1994).

The “broadtail” madtom is a new and currently undescribed member of the family Ictaluridae (bullhead catfishes) and a member of the genus *Noturus* (Rohde et al. 1994). Fishes in this genus are known as madtoms and, with 27 species, comprise the most diverse genus of ictalurids. Madtoms are small and can be distinguished from other catfish by their long adipose fin, which is continuous with the caudal fin. The “broadtail” madtom is a slender bodied fish with fine black speckling on an otherwise pale body. Although there is not much known about this fish, it probably reaches lengths similar to the speckled madtom (*N. leptacanthus*), which has a maximum total length of 94 mm (3.7 inches) (Rohde et al. 1994).

The Carolina pygmy sunfish is a member of the family Elasmobranchidae; this family of small secretive fishes contains six known species, all of which are placed in the genus *Elassoma*. The elasmobranchs are found only in the southeastern United States (Rohde et al. 1994). Carolina pygmy sunfish range in length from 20 to 32 mm (0.8 to 1.3 inches). As with other members of the genus *Elassoma*, the Carolina pygmy sunfish lacks a lateral line, has a relatively large eye, an upturned mouth and a rounded caudal fin. Males of the species display alternating blue and black bars along their sides. The bars on the females alternate between dark brown and light brown (Rohde et al. 1994).

The bluebarred pygmy sunfish is also a member of the small secretive family of Elasmobranchidae. Bluebarred pygmy sunfish range in length from 24 to 35 mm (0.9 to 1.4 inches). As with other members of the genus *Elassoma*, the bluebarred pygmy sunfish lacks a lateral line, has a relatively large eye, an upturned mouth and a rounded caudal fin. This colorful little fish is very similar to the Carolina pygmy sunfish, with alternating bright blue and black bars, but the black bars of the bluebarred pygmy sunfish are about three times wider than the blue bars (Rohde et al. 1994).

The Savannah darter is a member of the family Percidae (perch) and placed in the genus *Etheostoma*. Percidae is a large family containing approximately 176 species, 162 of which occur in North America (Jenkins and Burkhead 1993). *Etheostoma*, comprising approximately 115 species, is the largest genus of freshwater fishes in North America (Etnier and Starnes 1993). Percids include some of the most beautifully and brightly colored North American fishes. Darters are benthic species that spend most of their lives in close contact with the substrate. Although most darter species have very specific habitat requirements, as a group they occupy a myriad of habitats. Darters can be found in torrential mountain streams, lowland swamps and just about every habitat in between. Darters are characterized by having two dorsal fins, relatively large pectoral fins and an elongate body. The Savannah darter is characterized by a broad dark stripe on its side and a red marginal or submarginal band on its first dorsal fin. This colorful darter also displays alternating green and orange bars on its lower side as well as orange on its belly. Savannah darters reach a length of 74 mm (2.9 inches) (Rohde et al. 1994).

Status

The bridle shiner is listed in both South Carolina and North Carolina as a species of special concern. In North Carolina, the bridle shiner is considered critically imperiled (NatureServe 2004). It carries no federal status, but is listed as imperiled or possibly extinct in six of the 15 states that comprise its historic range (NatureServe 2004). In a recent assessment of southeastern fishes, the bridle shiner was identified as a species vulnerable to imperilment (Warren et al. 2000).

Because the “thinlip” chub is an undescribed species, it has not been listed in South Carolina. It is, however, considered a species of special concern in North Carolina.

The sandhills chub is a state species of special concern in North Carolina and South Carolina, the only states where it occurs. In North Carolina, the sandhills chub is considered vulnerable; in South Carolina it is considered imperiled (S2) (NatureServe 2004). In a recent assessment of southeastern fishes, the sandhills chub was considered vulnerable to imperilment (Warren et al. 2000).

The “broadtail” madtom is a federal species of concern that is listed as threatened in South Carolina. In North Carolina, the only other state where it occurs, it is considered a species of concern. This species is critically imperiled in South Carolina (NatureServe 2004) and is considered vulnerable to imperilment throughout its range (Warren et al. 2000).

The Carolina pygmy sunfish is a federal species of concern, and listed as threatened in South Carolina and North Carolina, the only two states where it occurs (S1). It was identified as a species vulnerable to imperilment in a recent assessment of southeastern freshwater fishes (Warren et al. 2000).

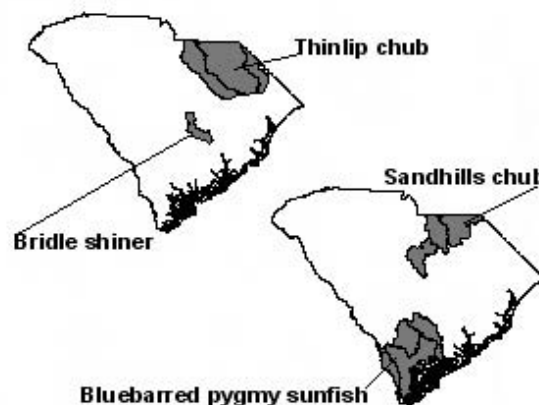
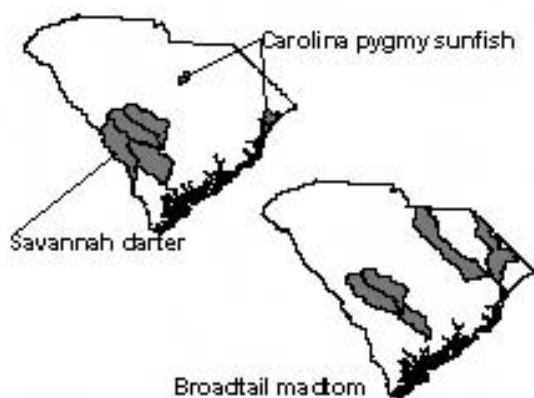
The bluebarred pygmy sunfish is a federal species of concern and is listed as a species of special concern in both South Carolina and Georgia, the only two states where it occurs. While this small sunfish is considered vulnerable to imperilment throughout its range (Warren et al. 2000), it is considered critically imperiled in Georgia (NatureServe 2004).

The Savannah darter carries no legal status in South Carolina or Georgia, the only states where it occurs. However, it is considered imperiled (S2) in the state of Georgia (NatureServe 2004).

Population Distribution and Size

The bridle shiner has a widespread but spotty distribution. Globally it occurs in the Atlantic drainages of eastern North America from western Lake Ontario east to Maine and south to South Carolina. Within South Carolina, the only known population occurs in Lake Marion (F. Rohde, pers. comm.).

The “thinlip” chub occurs only in the Carolinas and is believed to exist only in the upper coastal plain portions of the Lynches, Pee Dee and Little Pee Dee Rivers as well as portions of the Cape Fear River in North Carolina.



The sandhills chub occurs in the headwaters of coastal plain streams in the sandhills region of south-central North Carolina and north-central South Carolina (NatureServe 2004). In South Carolina, it is almost wholly restricted to the Carolina Sandhills Ecoregion in headwater streams of the upper Lynches River, Pee Dee River and Wateree River drainages.

The “broadtail” madtom is restricted to coastal plain streams in the Carolinas. Within South Carolina, one or two populations have been identified in the Edisto, Lynches, and Little Pee Dee Rivers.

Only a few populations of Carolina pygmy sunfish have been identified in South Carolina. One population exists in Big Pine Tree Creek in the Santee River Basin near Camden, South Carolina. A few populations are known from the Waccamaw River with one or two populations in the upper Waccamaw River in Horry, County, South Carolina, and another population in the ditches of abandoned rice near Georgetown, South Carolina. The only other known occurrences for this species are in North Carolina where two population centers have been identified in the upper Waccamaw River drainage. The range for Carolina pygmy sunfish in North Carolina is restricted to approximately 38.85 square km (15 square miles) of the Waccamaw River drainage (NatureServe 2001).

Bluebarred pygmy sunfish are restricted to the lower Savannah River drainage in Georgia and South Carolina and the lower Combahee and Edisto Rivers in South Carolina. The populations within South Carolina are restricted to the coastal plain, occurring most frequently in the Carolina Flatwoods Ecoregions. Bahama Swamp, in Jasper County, South Carolina represents some of the best available habitat left for bluebarred pygmy sunfish in the state.

The Savannah darter is only found in the Savannah River drainage of Georgia and South Carolina and the upper Edisto and Combahee River drainages in South Carolina. Furthermore, this species appears to be restricted to the coastal plain; however, there is one record for Savannah darter from above the fall line in Rocky Creek, McCormick County, South Carolina. It is not clear if

this record is a misidentification, possibly the very similar Christmas darter, or if the Savannah darter occurs above the fall line. Most of the occurrences for the Savannah darter are in the sandhills and the southern loam plains of the upper coastal plain.

Population Size and Trend

The bridle shiner populations are severely fragmented, with gaps in excess of 200 km (124.3 miles) between known localities. Furthermore, these populations are declining throughout the species' range (NatureServe 2004). Once common in Pennsylvania (Cooper 1983), its distribution has been reduced to a single extant population (PennDot 1998). The bridle shiner is rare or declining in Massachusetts (Chandler et al. 1998), Connecticut, Delaware, Maine, New York, North Carolina, Rhode Island, South Carolina and Vermont (Shervinskies 1998). In Virginia, the bridle shiner is somewhat successful in the James River drainage but is likely extirpated from four other drainages (Jenkins and Burkhead 1994).

“Thinlip” chub population size and trend is not well known. Its population is restricted to a very small geographic area. The “thinlip” chub is not commonly encountered within its known range (F. Rohde, pers. comm.).

Sandhills chub populations are currently stable in a small range of streams in the Carolinas. However, this species is extremely vulnerable due to its limited range.

“Broadtail” madtom population size and trends are not known. This undescribed species is difficult to collect; as a result, little is known about its status (F. Rohde, pers. comm.).

When found, the Carolina pygmy sunfish is often abundant and the status of the population is currently believed to be stable. Increased survey efforts in the Waccamaw and Santee drainages will likely lead to the discovery of additional populations (F. Rohde, pers. comm.).

Bluebarred pygmy sunfish populations are localized, often abundant and uncommon in South Carolina (Page and Burr 1991). In spite of this, these populations are currently considered stable.

Savannah darter population size and trend is not well known.

Habitat and Natural Community Requirements

The bridle shiner inhabits the quiet areas of warmwater streams, swamps and lakes with clear or slightly stained, but not turbid water. This species is most often associated with abundant aquatic vegetation as these areas are used for feeding and breeding. It is generally found over sand, mud or gravel substrates. Bridle shiners can be found in tidal and slightly brackish water in the southern portion of its range (Burkhead and Jenkins 1991). In South Carolina, it is only found in the shallow lacustrine areas of Lake Marion (F. Rohde, pers. comm.).

The “thinlip” chub habitat requirements are not well known but are likely similar to those of the Santee chub. The Santee chub inhabits small to medium sized streams with sand and rocky runs or current-swept pools (Rohde et al. 1994).

The sandhills chub occurs in both small headwater streams and moderate sized streams in the sandhills of the Carolinas. It is generally associated with clean gravel and/or sand substrates (Rohde and Arndt 1991; Rohde et al. 1994).

The “broadtail” madtom generally occupies the middle of narrow and deep coastal plain rivers with sand and gravel substrates (Page and Burr 1991). The habitats of this fish are poorly known but broadtail madtoms are often associated with woody debris (F. Rohde, pers. comm.).

The Carolina pygmy sunfish inhabits slow-moving acidic waters of ponds, ditches and streams in the coastal plain. This species is generally associated with abundant aquatic vegetation and shallow water (Rohde et al. 1994).

The bluebarred pygmy sunfish inhabits drainage ditches, stagnant ditches and the backwaters of creeks and rivers. It is found in shallow water with abundant submerged and/or emergent vegetation that is rooted in soft detritus-rich substrate (Rohde and Arndt 1987). This species often inhabits disturbed areas such as roadside ditches and backwaters near boat ramps (Rohde and Arndt 1987).

The Savannah darter inhabits clear or tannin-stained creeks and small rivers, where it occupies areas with strong current and sand or gravel substrates. It is generally found in or near aquatic vegetation or woody debris (Layman 1993; Rohde et al. 1994).

Challenges

The bridle shiner, along with many other fishes, is adversely affected by habitat alterations. Increased water turbidity may hamper its ability to feed by sight. Additionally, increased turbidity may inhibit the growth of submerged aquatic vegetation that is essential for bridle shiner feeding, reproduction and cover (Jenkins and Burkhead 1993). Agricultural runoff may also negatively impact its habitat (Burkhead and Jenkins 1991). In South Carolina, limited distribution of this species makes it extremely vulnerable to imperilment.

The “thinlip” chub and the sandhills chub are threatened by the same anthropogenic disturbances that challenge all aquatic fauna. However, due to their limited distribution, they are especially vulnerable to development as the sandhills region of South Carolina is under constant development pressure. Habitat modifications in this region that impact the “thinlip” chub, the sandhills chub and other species include agriculture, residential development and tourism. Damming headwater streams to create ponds for golf courses eliminates important lotic habitats; the new lentic environments favor competing and often predatory species such as bluegill and largemouth bass. Poor agricultural, silvicultural and road construction practices often lead to stream siltation and nonpoint source water pollution (Walters 1995). Unregulated use of motor vehicles in the stream bottoms also results in stream siltation and destruction of fish habitat. Sandhills chubs inhabit small headwater streams that are easily disrupted, but also easily protected.

The “broadtail” madtom, like other small ictalurids, is adversely affected by the nonnative flathead catfish (*Pylodictis olivaris*). 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).

Although the Carolina pygmy sunfish is often locally abundant and believed to be currently stable, its limited distribution is cause for concern. The isolation of this species makes it extremely vulnerable to development, pollution and habitat alterations. Conservation efforts within South Carolina are critical to the global conservation of the species.

Bluebarred pygmy sunfish are fairly tolerant of human disturbances; in fact, most populations occur in heavily disturbed areas. However, this species is vulnerable to habitat alterations and pollution as well as drought because it is mostly found in roadside ditches (Rohde and Arndt 1987).

Although the Savannah darter is currently considered stable (Warren et al. 2000), its limited distribution is cause for concern. Seventy-five percent of the Savannah darter’s global distribution occurs in South Carolina. Loss of habitat in South Carolina from development, nonpoint and point source pollution and poor land management practices would threaten the species global existence.

Conservation Accomplishments

Riverbanks Zoo currently has a propagation and maintenance program of representative populations of Carolina pygmy sunfish and bluebarred pygmy sunfish.

Bridle shiner populations are currently protected as part of the Santee Wildlife Refuge.

Conservation Recommendations

- Determine statewide distribution and population status for brindle shiner, “thinlip” chub, sandhills chub, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter with statewide stream surveys.
- Describe life history and habitat requirements for brindle shiner, “thinlip” chub, sandhills chub, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter.
- Identify critical habitats and areas with healthy populations for brindle shiner, “thinlip” chub, sandhills chub, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter.
- Survey Lake Marion and its tributary streams to identify the presence of additional brindle shiner populations and verify its existence in Lake Marion.
- Conduct genetic assessments to determine appropriate taxonomy for bridle shiners, “thinlip” chubs, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter.
- Explore reasons for decline of bridle shiners in South Carolina.
- Formally determine specific or subspecific status of the “thinlip” chub.
- Resample known locations to determine the population status of the sandhills chub and expand monitoring efforts within the Sandhills National Wildlife Refuge (NWR) in order to quantify the population within the refuge.
- Formally describe the “broadtail madtom” and examine morphological and genetic differences among the populations in the Edisto, Pee Dee, Lynches, and Lumber Rivers.
- Protect critical habitats for brindle shiner, “thinlip” chub, sandhills chub, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat for brindle shiner, “thinlip” chub, sandhills chub, “broadtail” madtom, Carolina pygmy sunfish, bluebarred pygmy sunfish and Savannah darter.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina’s aquatic habitats.

- Educate off-road motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

Highest Conservation Priority – Other Species

Christmas Darter *Etheostoma hopkinsi*

Saluda Darter *Etheostoma saludae* (form of *E. collis*)

Redeye Bass *Micropterus coosae*

Contributors: Dan Rankin and Jason Bettinger

Description

Taxonomy and Basic Description

The Christmas darter (Rohde et al. 1994) is a member of the family Percidae; this diverse family contains approximately 150 species of darters, all of which are found in rivers, lakes, swamps and springs of eastern North America. The Christmas darter belongs to the genus *Etheostoma*, the largest genus of North American fishes (Jenkins and Burkhead 1994). The Christmas darter is the only South Carolina representative of the subgenus *Oligocephalus*, one of the largest subgenera of *Etheostoma*. Two subspecies have been identified: *E. binotatum* from the Savannah River drainage in both Georgia and South Carolina and *E. hopkinsi* from the Altamaha and Ogeechee river drainages in Georgia. Kuehne and Barbour (1983) have hypothesized possible species level differentiation of *E. binotatum* and *E. hopkinsi* due to marked differences in appearance of breeding males. The colorful Christmas darter ranges in length from 41 to 71 mm (1.6 to 2.8 inches). As is typical of other members of the subgenus *Oligocephalus*, the Christmas darter has a small conical head, broad frenum and two anal spines. Breeding males have a blue marginal and a red sub-marginal band on the spiny dorsal fin (Kuehne and Barbour 1983). This darter has 10 to 12 dark green bars on its side, separated by a red bar in a mature male and a yellow bar in the female. Its greenish back has eight dark saddles and its belly is light green.

Hubbs and Cannon (1935) first described the Saluda darter (*Etheostoma saludae*) from the Saluda River system of the Santee drainage. They described the fish as a separate species from Carolina darter (*Etheostoma collis*). Collette (1962) was uncertain if *E. saludae* was specifically or subspecifically different from *E. collis collis*, the Carolina darter of the Pee Dee and Catawba (Santee drainage) drainages and *E. collis lepidinion* of the Roanoke, Neuse and Cape Fear drainages. Collette (1962) and Page (1983) noted *E. saludae* differed from the two Carolina darter subspecies principally in having interorbital pores (2 versus 0) and in number of anal spines (2 versus 1). Kuehne and Barbour (1983) listed the Saluda darter as a separate species but stipulated, "...the two forms (*saludae* and *collis*) may not actually be specifically distinct." Jenkins and Burkhead (1994) stated they found no "sufficiently distinctive" character for taxonomic recognition of *E. saludae* or subspecific recognition within the *E. collis* group. Robins et al. (1991), Rohde et al. (1994) and Nelson et al. (2004) followed that the Saluda darter was

conspecific with the Carolina darter; all adopted the scientific name *E. collis* for the broadened species with no subspecific distinctions. However, Rohde (pers. comm.) now feels *E. saludae* may be specifically or subspecifically different. Currently, it is still not clear if *E. saludae* is a separate species from *E. collis*; however, there is sufficient genetic and morphologic difference between the two that they should be managed separately as evolutionary significant units (J. Quattro, pers. comm.). The Saluda darter is plain in color with brown on the back and sides and a yellow to white belly. The sides have a dozen or so brown blotches and are speckled with brown dots. This small darter only reaches about 60 mm (2.4 inches).

The redeye bass is a member of the family Centrarchidae. Redeye bass represent one of only two native black basses in South Carolina; both smallmouth and spotted bass (*Micropterus dolomieu* and *M. punctulatus*, respectively) are introduced in this state. The closest relative of the redeye bass is the shoal bass (*M. cataractae*), which is endemic to the Apalachicola River system (Lee et al. 1980). Redeye bass are similar in structural features and more closely related to spotted bass than to smallmouth bass. However, redeye bass are known to hybridize with both species (Turner and Bulow 1989; Pierce and Van Den Avyle 1997; Philipp et al. 2002). In native stream habitat, redeye bass range in length from 144 to 381 mm (5.6 to 15 inches) (Rohde et al. 1994); however, in the Savannah River impoundments, redeye bass often exceed this size range. Redeye bass are typically olivaceous to bronze dorsally with black blotching or mottling. The jaw extends even with the back of the eye. Laterally, redeye bass have black vertical bars or blotches, which are not connected unlike the lateral stripe of spotted bass. Redeye bass typically have ten or fewer lateral bars or blotches, whereas spotted bass generally have more than ten. Redeye bass have ventro-lateral streaks that are typically darker and more irregular than those in spotted bass. A white margin on the upper and lower tips of the caudal fin and often along the margin of the anal fin is a key character. This margin may be less obvious in older specimens. The anal fin typically has dark pigmentation. About sixty percent of redeye bass from the upper Savannah River basin possess a tooth patch on the tongue (SCDNR unpublished data).

Status

The Christmas darter is currently considered stable within its range (Warren et al. 2000). NatureServe (2004) listed the status as apparently secure both globally (G4) and locally in South Carolina and Georgia (S4). The South Carolina Department of Natural Resources Heritage Program lists the Christmas darter as a species of special concern.

Warren et al. (2000) listed the global status of the broader Carolina darter as vulnerable within its range and it is considered a species of special concern in both North Carolina and South Carolina. NatureServe (2004) considered the global status as undetermined due to inadequate surveys. NatureServe (2004) also listed the local status as undetermined for South Carolina (S?). The local status for North Carolina and Virginia was vulnerable (S3) and imperiled (S2), respectively (NatureServe 2004). Currently, Saluda darter is recognized as a synonym of the Carolina darter; however, our taxa team considered it an evolutionarily significant unit (ESU) of Carolina darter and suggested that it be managed separately. Saluda darter is an imperiled, narrow-range endemic of South Carolina.

The redeye bass is currently stable (Warren et al. 2000) and secure (G5) (NatureServe 2004). NatureServe (2004) did not list a state rank for the redeye bass in South Carolina and stream populations appear to be fairly secure. Reservoir populations, on the other hand, are likely imperiled due to potential displacement by spotted bass and hybridization with nonnative black

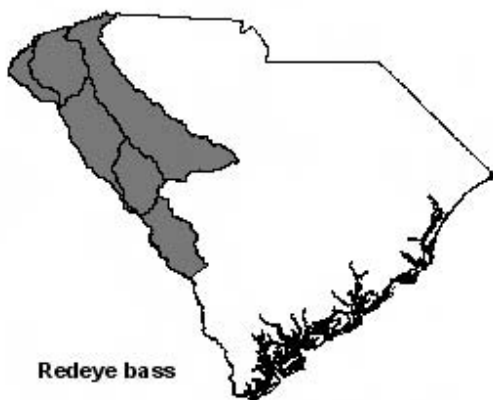
bass species (smallmouth bass and spotted bass). In Tennessee, redeye bass are considered vulnerable (S3) and in North Carolina they are considered imperiled (S1), largely due to their limited range (NatureServe 2004).

Population Distribution and Size

Distribution

The Christmas darter is found in the upper Savannah River drainage, primarily above the fall line. Populations identified below the fall line may be Savannah darters. Outside of South Carolina, Christmas darters are found in the Altamaha and Ogeechee drainages in Georgia, both above and below the fall line (NatureServe 2004).

The Saluda darter only occurs in South Carolina, where it is restricted to the Saluda, Broad and Congaree River basins (Kuehne and Barbour 1983).



The native range of the redeye bass includes the Mobile Basin above the fall line and the upper Chattahoochee, Altamaha and Savannah Drainages (Etnier 1993; Rohde 1994; Lee 1980). Ramsey (1973) considered all populations outside this range to be a result of stocking. Redeye bass have also been introduced in Tennessee, Kentucky, California and Puerto Rico (Etnier 1993; Lee 1980). The redeye bass occurs in the Saluda River (Santee drainage), South Carolina, primarily in the river's mainstem and tributaries below the Saluda Dam. One report of redeye from a tributary

stream upstream of Saluda Dam is documented in the Clemson University museum collection. However, redeye bass are conspicuously absent in cool headwater rivers of the North, Middle and South Saluda Rivers and their tributaries, in what appears prime redeye habitat. This would tend to support taxonomists opinion that redeye bass are not native to the Saluda River system. The Chattooga River, once being a tributary to the Chattahoochee system (Ross 1970), likely explains the presence of redeye bass in the Savannah drainage. In South Carolina, redeye bass are also found below the fall line in the mainstem of the Savannah River (SCDNR unpublished data).

Population Size and Trend

The Christmas darter was considered by Kuehne and Barbour (1983) to be currently stable. They note that *E. binotatum* is common in creeks along the fall line containing gravel and rubble substrate and in headwater creeks in the Savannah River drainage. Page and Burr (1991) also refer to the Christmas darter as fairly common. However, areas of abundance are often disjunct. Major land disturbances within critical habitat could cause severe loss within their range. Our taxa team was of the impression that Christmas darter may be in decline within South Carolina.

The Saluda darter is thought to be doing well within its narrow range, with the exception of populations in close proximity to Columbia, South Carolina. There, populations may be in decline due to habitat loss and contamination (F. Rohde, pers. comm.).

Redeye bass appear abundant in upper Savannah River tributaries (SCDNR unpublished data) and in Lakes Jocassee and Hartwell (Duke Power unpublished data; SCDNR unpublished data). Redeye bass appear somewhat resilient to habitat alterations. Coneross Creek, a tributary to the Seneca River arm of Lake Hartwell, harbors good numbers of redeye bass despite being severely impacted both by increased sediment loading from agriculture and development and by greatly increased nutrient loads from a large municipal sewage discharge. Abundance of redeye bass has decreased in Lake Keowee as a result of non-native spotted bass introductions (Duke Power, unpublished data). The same trend is expected in Lakes Jocassee and Hartwell as spotted bass abundance increases. Redeye bass appear to be fairly common in streams of the upper Savannah. Although redeye bass reportedly perform poorly in impoundments within their native range, this species has thrived in the large oligotrophic and mesotrophic reservoirs of the upper Savannah River system, such as Jocassee, Keowee and Hartwell (Barwick and Moore 1983; SCDNR unpublished data). Redeye bass also occur in lakes Russell and Thurmond, although apparently in lower abundance (SCDNR unpublished data). Recent introduction of spotted bass into Lake Keowee has resulted in hybridization with redeye bass and a major decline in redeye bass abundance (Duke Power unpublished data). It is not known what effects spotted bass will have on redeye bass in tributary streams. Many of the tributaries to the lakes have barriers to upstream fish movement, which may protect stream populations of redeye bass from invasion of spotted bass.

Habitat and Natural Community Requirements

The Christmas darter inhabits gravel or rubble riffles in cool water springs, creeks and small to medium-sized rivers where stronger currents exist. It sometimes occurs in slower moving waters with submerged vegetation (Rohde et al. 1994).

The Saluda darter inhabits sluggish to calm areas in clear to slightly turbid small streams with a substrate of mud, sand, gravel and/or bedrock (Collette 1962; Rohde et al. 1994). However, in Wateree Creek, a large South Carolina stream, the Saluda darter was found in moderate gradient among cobble and leaf packs (pers. obs.).

Redeye bass occur in a variety of habitats in South Carolina from fast flowing, high gradient streams of the Blue Ridge and upper piedmont ecoregions to low gradient streams and the Savannah River below the fall line. It is found in small streams to large rivers and reservoirs.

Challenges

The Christmas darter is currently stable throughout its range; however, the wide separations between critical habitats and healthy populations are a concern. Because of the limited distribution of the Christmas darter within South Carolina, this fish is vulnerable to development, deforestation, loss of riparian cover, siltation and the effects of impoundments within areas of abundance.

The Saluda darter is challenged due to its limited distribution solely within South Carolina. It is especially vulnerable to development because many Saluda darter populations occur in streams within the greater Columbia metropolitan area and are, therefore, increasingly subject to chemical contamination and siltation from urban runoff. Other threats include agricultural runoff and habitat destruction resulting from inundation by dams.

The redeye bass is primarily threatened by the introduction of the non-native spotted bass. Other threats may include deforestation and associated stream warming and siltation, impoundment, acid deposition, and displacement by non-native fishes (D. Rankin, SCDNR, pers. comm.).

Conservation Accomplishments

Redeye bass habitat is primarily protected by land ownership patterns in some key habitats streams such as Chattooga River, Chauga River, Eastatoee River and Stevens Creek. However, the amount of unprotected habitat for this species far exceeds protected habitat.

Conservation Recommendations

- Determine statewide distribution and population status of Christmas darters, Saluda darter and redeye bass with statewide stream surveys.
- Describe life history and habitat requirements of Christmas darters, Saluda darter and redeye bass.
- Determine the status of known populations of both Christmas and Saluda darters. Saluda darter surveys in the Broad River Drainage are critical to understanding the genetic relationship of *E. saludae* and *E. collis*. Resurvey historically identified locations of Christmas darters below the fall line to determine its current status.
- Conduct a genetic survey to determine the relationship between Christmas and Savannah darters.
- Inventory and monitor water quality and habitat in redeye bass streams to identify water quality threats as well as habitat needs and deficiencies
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.
- Monitor the success of redeye bass habitat protection and advocate for additional protection through the environmental permit review process.
- Promote redeye bass as a sport fishery in larger streams.
- Conduct an education and outreach campaign to raise awareness of the impacts of illegal introductions of non-native species.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality

are also likely to protect most of these species. Genetic resolution of the status of the Saluda darter will allow for more specific management protocols for that species.

High Conservation Priority – Big River Species

Quillback *Carpiodes cyprinus*

“Carolina” Redhorse *Moxostoma* sp.

Contributors: Scott D. Lamprecht and Jason Bettinger

Description

Taxonomy and Basic Description

Both the quillback and the “Carolina” redhorse are members of the family Catostomidae, which is represented by eight genera and 25 species in the mid-Atlantic region (Rohde et al. 1994). This family is characterized by soft-rayed fins, a mouth located on the underside of the head, thick fleshy distensible lips and paired fins attached low on the body (Rohde et al. 1994).

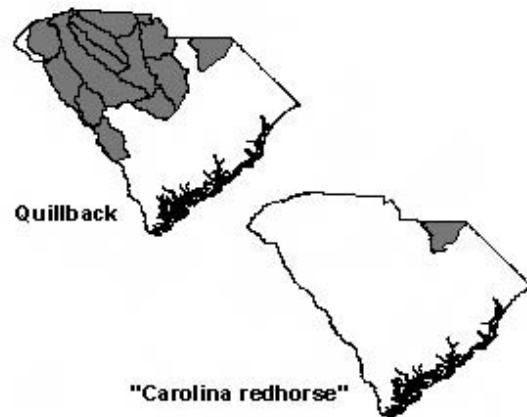
Current taxonomic and genetic work indicates that Atlantic slope quillback-type fish that is found in South Carolina may represent an undescribed species. Quillback are high bodied, laterally compressed fish that range in length from 300 to 660 mm (11.8 to 25.9 inches). They have a long, falcate dorsal fin with 23 to 30 rays, a small conical head, a silver to golden body, large conspicuous scales about twice as high as wide and a lateral line that runs the length of the body. Quillback lack mouth barbels and dorsal and anal fin spines. The quillback’s first long dorsal ray does not usually reach the full length of the dorsal fin base, while the first dorsal ray of the similar highfin carpsucker typically is as long as the fin (Rohde et al. 1994; Jenkins and Burkhead 1993). Quillback feed on insect larvae and other benthic organisms. They are spring spawners that can attain an age of at least 11 years (Jenkins and Burkhead 1993).

The “Carolina” redhorse is an undescribed member of the catostomid family. When officially described, the “Carolina” redhorse will be in the genus *Moxostoma*. Currently, there are approximately ten species in this genus known as the “typical redhorses” (Jenkins and Burkhead 1993); one or two of these have not been described. “Carolina” redhorse is most similar to the golden redhorse (*M. erythrurum*).

Status

Quillback populations are considered to be stable by Warren et al. (2000) and common, widespread and abundant by NatureServe (2004). The status of quillback in South Carolina is under review and will likely change if the quillback-type fish on the southern Atlantic slope are described as a new species.

The “Carolina” redhorse was identified as endangered in a recent assessment of southeastern freshwater fishes (Warren et al. 2000). It is not listed in South Carolina or North Carolina, but is considered critically imperiled in North Carolina (NatureServe 2004), the only other state where it occurs.



Population Distribution and Size

Distribution

In the broad sense, the quillback is distributed from the Great Lakes region in the St. Lawrence River, Hudson Bay and Mississippi River basins from Quebec to Alberta, Canada; south to Louisiana and west to Wyoming in the United States. It also occurs on the Atlantic slope from the Delaware River, New York, to the Altamaha River, Georgia. In gulf slope drainages, it occurs from the Apalachicola River in Florida and Georgia to the Pearl River in Louisiana (Page and Burr 1991). The southern Atlantic slope populations in South Carolina are reported in the upper portions of the three major South Carolina drainages: the Pee Dee, Santee, and Savannah. Fish from these populations are likely distinct from those of the interior basin and gulf slope drainages (Nature Serve 2004).

The “Carolina” redhorse is restricted to the Pee Dee and Cape Fear River drainages in North Carolina and South Carolina. In South Carolina, this form is only found in the Pee Dee River within 15 to 20 miles of the North Carolina state line (W. Starnes, pers. comm.).

Population Size and Trend

The quillback is commonly encountered during non-directed sampling efforts. Populations with abundant numbers are observed in the upper Santee and Savannah River drainages while quillback are rare in the Pee Dee (SCDNR unpublished data). Population declines in the Pee Dee River may be related to introduced non-native species, like buffalo.

The “Carolina” redhorse is in severe decline in both North Carolina and South Carolina. In South Carolina, this fish is very rarely collected despite tremendous amounts of sampling effort directed at their habitats. Because it is found so rarely, the South Carolina population of “Carolina” redhorse is in danger of extirpation (W. Starnes, pers. comm.).

Habitat and Natural Community Requirements

The quillback is found in warm, low- to moderate-gradient reaches of most major rivers, including upper portions of associated reservoirs (Rohde et al. 1994; Jenkins and Burkhead 1993). Quillback occur over varied substrates in rivers, but seldom over mud. They tend to occupy calm water; however, quillback may shift to swifter and deeper depths during low water. Quillback reportedly spawn in riffles, calm stream reaches and in floodplain bayous, laying eggs on gravel, sand, mud and organic matter (Scott and Crossman 1973; Jenkins and Burkhead 1994). Specific habitat requirements for “Carolina” redhorse are not well known. This fish occupies medium sized rivers with moderate gradient (NatureServe 2004) and prefers the deep pool areas along shore that contain woody debris (W. Starnes, pers. comm.).

Challenges

Quillback populations are likely stable throughout their range. However, habitat degradation from deforestation and urbanization remains as much a challenge to this native species as it does most other riverine animal species. The population of “Carolina” redhorse is limited to one short section of the Pee Dee River in South Carolina. Even small alterations to that river reach or to the upstream reaches in North Carolina could lead to the extirpation of the species from South Carolina.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Identify the full range of quillback in South Carolina through incorporation of existing and future observations.
- Resolve taxonomic relationships of Atlantic slope, interior basin and gulf slope quillback populations.
- Continue to survey for “Carolina” redhorse in the upper reaches of the Pee Dee River. Protect any populations discovered.
- Continue to advocate for responsible development and the adoption of best management practices in timber and agricultural land use, especially in the upper Pee Dee system.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

High Conservation Priority – Blue Ridge and Piedmont Species

Carolina Fantail Darter *Etheostoma flabellare brevispina*

Smoky Sculpin *Cottus bairdii* complex

Contributors: Mark Scott and Jason Bettinger

Description

Taxonomy and Basic Description

The Carolina fantail darter is a member of the family Percidae. This diverse family contains approximately 150 species of darters, all of which are found in rivers, lakes, swamps and springs of North America (Kuehne and Barbour 1983). The Carolina fantail darter belongs to the genus *Etheostoma*, the largest genus of North American fishes. The Carolina fantail darter is the only South Carolina representative of the subgenus *Catonotus*. The subspecies *E. f. brevispina*, identified from Virginia, North Carolina and South Carolina has been named “Carolina” fantail darter (Warren et al. 2000). Blanton (2001) hypothesized possible species level differentiation of *E. f. brevispina* due to marked differences in morphology and pigmentation. The adult fantail darter ranges from 45 to 95 mm (1.8 to 3.7 inches) in total length (Jenkins and Burkhead 1993). As is typical of other members of the subgenus *Catonotus*, the Carolina fantail darter has a deep caudal peduncle, frenum, closely set pelvic fins and broadly joined gill membranes. Additionally, this fish is characterized by a spiny dorsal fin comprised of seven spines with enlarged tips. The Carolina fantail darter usually has seven dark bars on the side against light body coloration (Page and Burr 1991; Rohde et al. 1994).

The smoky sculpin is a member of the family Cottidae, which is a large family of mostly northern-hemisphere marine fishes found around the world. The genus *Cottus* is strictly confined to freshwaters of North America and Eurasia (Robins 1961, Page and Burr 1991). The taxonomy of the genus is uncertain at present. The name “smoky” sculpin has been used to reference the *C. bairdii*-like form occurring in South Carolina, which may be a subspecies or potential new

species; however, the formal description has not yet been published (Jenkins and Burkhead 1993, Warren et al. 2000). The *C. bairdii* complex is widespread, occurring in the eastern half of North America from arctic Canada southward where cool streams and rocky substrates are present, as well as in western North America on both sides of the continental divide. The adult smoky sculpin ranges in total length from 58 to 114 mm (2.3 to 4.5 inches). As is typical of other members of the genus *Cottus*, the smoky sculpin has a large head and mouth, two dorsal fins (the first is spiny and the second is soft-rayed) and three reduced preopercular spines. This sculpin has a complete lateral line, or nearly so, and well-developed palatine teeth. Red marginal and black basal bands in the spinous dorsal fin are found on males. Pigmentation is highly variable, with body background color ranging from coppery brown to slate gray, approaching black in nuptial males, with dark brown to black mottling on sides and back (Robins 1961; Page and Burr 1991; Jenkins and Burkhead 1993).

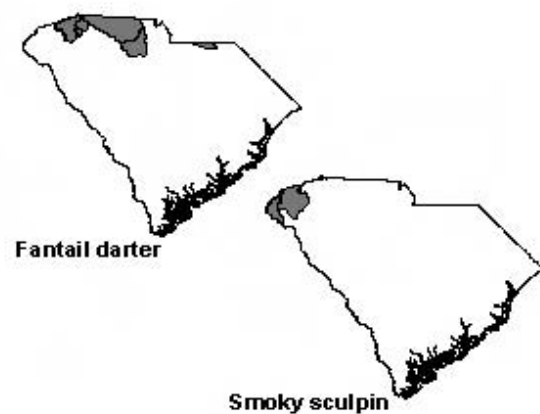
Status

The Carolina fantail darter is considered globally secure but critically imperiled (S1) in South Carolina (NatureServe 2004). Warren et al. (2000) listed the global status of Carolina fantail darter as currently stable within its range. The South Carolina Department of Natural Resources (SCDNR) lists the Carolina fantail darter as a species of special concern. The smoky sculpin is not listed in South Carolina. Warren et al. (2000) listed the global status of smoky sculpin as currently stable within its range.

Population Distribution and Size

Distribution

The fantail darter is widely distributed as a complex of closely related forms that are in need of taxonomic resolution, with some variants perhaps warranting species status (Blanton 2001). It is found from the Carolinas northward to Great Lakes tributaries from New York to Minnesota and south in the Mississippi basin to the Ozarks and northern Alabama. The Carolina fantail darter form is endemic to the piedmont and Blue Ridge sections of the upper Pee Dee and Santee River drainages in South Carolina (Warren et al. 2000).



The smoky sculpin is endemic to the southern portion of the Blue Ridge physiographic region (Warren et al. 2000). In South Carolina, it is found in the extreme upper Savannah River drainage, primarily in the Blue Ridge ecoregion; however, peripheral populations extend down onto the inner Piedmont in a few locations. The Savannah populations are thought to have colonized the basin due to stream capture of Tennessee drainages (Jenkins et al. 1971). Outside of South Carolina, the species occurs in the Blue Ridge portions of north Georgia, east Tennessee, and western North Carolina (Jenkins and Burkhead 1993).

Population Size and Trend

The fantail darter complex is widespread and common in eastern North America, and the *brevispina* form is considered secure in North Carolina. Little is known of population size or

trends in South Carolina, although the species can be commonly collected in the upper Broad River basin (SCDNR unpublished data). Kings Creek in York County, South Carolina and its tributaries contain healthy Carolina fantail darter populations (SCDNR unpublished data).

The smoky sculpin in South Carolina is only found in the extreme upper Savannah River drainage, primarily the Chattooga River and tributaries. Populations in the Chattooga are locally abundant and appear to be currently stable based on yearly fish population sampling (SCDNR unpublished data), and future population viability is likely, particularly in light of the protected status afforded the Chattooga as a Wild & Scenic River.

Habitat and Natural Community Requirements

The Carolina fantail darter inhabits gravel or rubble riffles in creeks and small- to medium-sized rivers where stronger currents exist. Rocky substrates are important to its benthic feeding habits and spawning behavior.

The smoky sculpin inhabits clear, cold to cool headwaters, creeks, springs and small montane rivers of high to moderate gradient. Substrates are rubble and gravel, which are important to its benthic feeding habits and crevice spawning behavior.

Challenges

The Carolina fantail darter and the smoky sculpin are currently stable throughout their range. The limited distribution of these species within South Carolina makes them vulnerable to impacts from land development, deforestation, loss of riparian cover, siltation and hydrologic alterations (channelization and impoundment construction). Because of their limited distribution within South Carolina, such habitat alteration could extirpate them from the state, although this appears a more likely threat to the fantail darter than to the sculpin. This is because the area of core sculpin abundance is a protected area, the Wild & Scenic Chattooga River.

Conservation Accomplishments

The core area of smoky sculpin abundance is protected by the Wild and Scenic Chattooga River.

Conservation Recommendations

- Identify additional populations of Carolina fantail darters and smoky sculpins and determine the status of known populations through targeted surveys. Conduct landscape level surveys to identify critical habitats and areas with healthy populations.
- Describe life history and habitat requirements for both Carolina fantail darters and smoky sculpins.
- Conduct genetic studies of the Carolina fantail darter to resolve taxonomic questions regarding differentiation of Santee and Pee Dee populations and to resolve taxonomic question regarding differentiation of Savannah populations of the smoky sculpin.
- Identify and protect areas with healthy populations and intact critical habitat for both the Carolina fantail darter and the smoky sculpin.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Consider species needs when participating in the environmental permit review process.
- Encourage responsible landuse planning.

- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. Genetic resolution of the status of the both species will allow for more specific management protocols.

High Conservation Priority – Coastal Plain Species

Bannerfin Shiner *Cyprinella leedsi*

Blackbanded Sunfish *Enneacanthus chaetodon*

Pinewoods Darter *Etheostoma mariae*

Contributors: David Allen, Chris Thomason and Jason Bettinger

Description

Taxonomy and Basic Description

The bannerfin shiner is a member of the family Cyprinidae. This is the world's largest family of fishes, containing about 194 genera and almost 2,440 species. Eighty-six species occur in the mid-Atlantic region. With 29 species, *Cyprinella* is the second largest genus of American cyprinids after *Notropis* (Jenkins and Burkhead 1993). Members of the genus *Cyprinella* are distinguished from other cyprinids by their large vertical diamond-shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). Bannerfin shiner can be distinguished from other *Cyprinella* by the position of the black blotch; which occurs on the anterior portion of the dorsal fin. Bannerfin shiners are deep bodied, slender fish with a flattened underside and long rounded snout. The back is olive tan with a black middorsal stripe; the belly is white and the flanks are silvery gray. Bannerfin shiners reach lengths of 100 mm (3.9 inches) (Rohde 1994 et al.).

The blackbanded sunfish is a member of the family Centrarchidae. The 30 species of this family include the sunfishes, crappies and black basses. Blackbanded sunfish are a deep bodied, extremely compressed fish with a small mouth and six black bars on a silvery body. They generally reach an adult length of 50 to 82 mm (2 to 3.2 inches). The caudal fin is rounded. The pelvic fins are pink to red, anteriorly (Rohde 1994).

The pinewoods darter is a member of the family Percidae and placed in the genus *Etheostoma*. This family includes four genera of darters. One of these, *Etheostoma*, is the largest genus of freshwater fishes in North America; it contains approximately 115 species (Etnier and Starnes 1993). These fish are characterized by having two dorsal fins, relatively large pectoral fins and an elongate body. The pinewoods darter is a member of the subgenus *Belophlox*, which can be separated from most other darters by the presence of a broad dark stripe on its side and contrasting light lateral line (Rohde et al. 1994). The pinewoods darter has roughly ten elongate dark blotches on its side and a red marginal or submarginal band in its first dorsal fin. Pinewoods darters reach a maximum length of about 74 mm (2.9 inches) (Page and Burr 1991).

Status

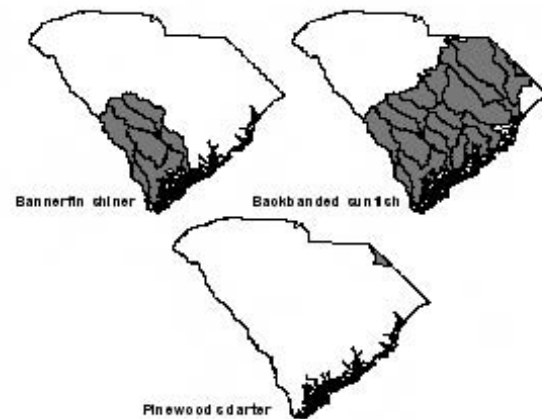
The bannerfin shiner is not listed in South Carolina, but is considered vulnerable to imperilment in Georgia and Florida (NatureServe 2004).

The blackbanded sunfish is not listed in South Carolina, but is considered as at least vulnerable in seven of nine states where it historically occurred (NatureServe 2004). It is presumed extirpated from Pennsylvania and is considered critically imperiled in Virginia, Maryland and Georgia (NatureServe 2004).

The pinewoods darter is a federal species of concern listed as endangered in South Carolina and of special concern in North Carolina, the only other state where it occurs. It was identified as a species vulnerable to imperilment in a recent assessment of southeastern freshwater fishes (Warren et al. 2000) and considered imperiled in North Carolina and critically imperiled in South Carolina (NatureServe 2004).

Population Distribution and Size*Distribution*

The bannerfin shiner occurs in Atlantic slope drainages from the Edisto River, South Carolina to the Altamaha River, Georgia (NatureServe 2004). It also occurs in the gulf slope drainages of the Ochlockonee and Suwanee Rivers in Georgia and Florida (Marcy et al. 2005). In South Carolina, the species is restricted to the coastal plain ecoregion in the Edisto and Savannah River drainages (SCDNR unpublished data).



The blackbanded sunfish is widely distributed in the coastal plain from New Jersey to Florida, as well as in streams of gulf slope drainages of Georgia and Florida (NatureServe 2004). The range is fragmented; this species is often missing from areas where appropriate habitat is seemingly present (Rohde et al. 1993). In South Carolina, the blackbanded sunfish is found predominantly in the upper coastal plain from the Little Pee Dee River south to the Savannah River.

The pinewoods darter is restricted to the Little Pee Dee River system in North and South Carolina. The species is found only in the sandhills, just below the fall line. In South Carolina, the pinewoods darter has only been found in Panther and Beaverdam Creeks near McColl, South Carolina. There have been no recent collections of the pinewoods darter; it has likely been extirpated from the state (F. Rohde, pers. comm.).

Population Size and Trend

Bannerfin shiner populations appear to be stable (Warren et al. 2000; NatureServe 2004), although it is uncommon and sometimes rare (Page and Burr 1991; NatureServe 2004). Collections have been made at numerous sites throughout its limited range. The blackbanded sunfish is currently considered secure. Although this species is sometimes locally common, it is more often uncommon in field collections (Rohde et al. 1993). Its fragmented range and noticeable absence in appropriate habitats give the impression that it is a species in decline. The pinewoods darter, though common in a very localized area of the sandhills region in North

Carolina, is believed to be extirpated from South Carolina. Development pressures in the sandhills give this fish an uncertain future.

Habitat and Natural Community Requirements

The bannerfin shiner inhabits channels of medium to large sized, sand-bottomed coastal plain rivers. Schools often gather in eddies behind woody debris or in-stream structures. They rarely enter tributary streams further upstream than the modern floodplain (Marcy et al. 2005). As with other *Cyprinella* species, the bannerfin shiner is a crevice spawner, depositing eggs in crevices of logs and rocks and thus requires coarse substrates and instream structures such as logs to deposit its eggs (Rohde et al 1994).

The blackbanded sunfish is found in quiet, shallow, densely vegetated margins of lakes, ponds, swamps, roadside ditches and streams with sand or mud bottoms (Shute et al. 1981; Jenkins and Burkhead 1994). They are largely restricted to stained, but not turbid, acidic water with a pH of 4.0 to 5.0. In the lotic systems of the Middle Savannah River Basin, adults seasonally migrate into beaver ponds to spawn (Marcy et al. 2005).

Pinewoods darter adults occupy shallow streams with clear or tannin stained water. They often position in moderate current with gravel or rubble substrates. Young inhabit pools with vegetation, sand or silt substrates that have little flow (NatureServe 2004).

Challenges

The bannerfin shiner appears to be stable and widely distributed throughout its range. The major challenge to this species is from pollution (NatureServe 2004). However, habitat alterations could present isolated problems (NatureServe 2004).

The blackbanded sunfish is adversely affected by the practice of draining of ponds and swamps as well as by pesticide contamination (Burkhead and Jenkins, 1991). Additionally, the potential for this species to be collected for the aquaria trade could result in adverse impacts to populations (Burkhead and Jenkins 1991).

Challenges to the pinewoods darter include sedimentation of stream bottoms and loss of habitat. Residential development, timber harvest and road construction/maintenance have likely led to increased sedimentation of pinewoods darter habitat. Further, both dam construction on streams to create ponds for golf courses and golf course irrigation has led to a direct loss of habitat and favor competitive and often highly predacious species like the redbreast sunfish, bluegill and largemouth bass (NatureServe 2004).

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution, population status, life history and habitat requirements for the bannerfin shiner, the blackbanded sunfish and the pinewoods darter with statewide stream surveys.
- Identify streams and rivers with healthy bannerfin shiner populations and intact critical habitat in the Savannah River drainage below the Fall Line, the Edisto River System and the ACE basin. Protect these areas, once identified.
- Identify lotic and lentic habitats with healthy blackbanded sunfish populations and intact

critical habitat in the coastal plain of South Carolina. Protect these areas, once identified.

- Survey streams in the sandhills ecoregion of the Little Pee Dee River system to determine the existence or extirpation of Pinewoods darter. Previous positive locations in Panther Creek and Beaver Dam Creek should be surveyed. Protect any identified areas.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.
- Educate aquarists as to the adverse impacts of removing fish from the wild.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

High Conservation Priority – Other Species

Turquoise Darter *Etheostoma inscriptum*

Seagreen Darter *Etheostoma thalassinum*

Piedmont Darter *Percina crassa*

Contributors: Gene Hayes and Jason Bettinger

Description

Taxonomy and Basic Description

The turquoise darter, the seagreen darter and the Piedmont darter are all members of the family Percidae. Both turquoise and seagreen darters are in the subgenus *Etheostoma*; this subgenus contains 14 species, 11 of which occur in South Carolina (Rohde et al. in press). The Piedmont darter and blackbanded darter are the only representatives in the genus *Percina* found in South Carolina.

The turquoise darter is a moderate-sized darter ranging in adult length from 66 to 78 mm (2.6 to 3.1 inches) (Rohde et al. 1994). Adults of both sexes have five to six dark dorsal saddles and six blotches on the side (Kuehne and Barbour 1983). The male turquoise darter is brown with several horizontal rows of small red spots, while the sides of the female are yellow-brown with brown saddles and blotches. The colorful breeding males take on a pinkish body color with dark green

bars on the side. The lower portion of the head becomes blue, as do the pelvic fins, anal fins and outer extremes of the caudal fin. The dorsal fins of males become blue-green with red edges during the spawning period (Rohde et al. 1994).

The seagreen darter is a moderate-sized darter ranging in adult length from 66 to 78 mm (2.6 to 3.1 inches) (Rohde et al. 1994). This species has seven squarish, dark brown saddles and a similar number of small dark brown blotches on the sides. The first dorsal fin has a red edge with a dusky black base. The second dorsal fin is reddish-orange. Pelvic and anal fins are blue (Rohde et al. 1994). Breeding males are brilliantly colored and develop tubercles on the mid ventral scales just anterior to the anus and also on the caudal peduncle (Kuehne and Barbour 1983).

The absence of tubercles in breeding Piedmont darter males places this darter in subgenus *Alvordius*. The specific name *crassa* means “thick” and refers to the rather stocky appearance of this species (Kuehne and Barbour 1983). The Piedmont darter is a moderate-sized darter ranging in adult length from 68 to 90 mm (2.7 to 3.5 inches) (Rohde et al. 1994). The fish has a general brown color with seven to nine vertically elongated oval blotches joined by a mid-lateral band. A caudal spot is usually diffuse and vertically elongated (Kuehne and Barbour 1983). The Piedmont darter has a black chin bar, black breast spot and a large black teardrop below the eye. The first dorsal fin has a black edge, a tan band below, a yellow interior and vertical black markings below the lower portion of each spine (Rohde et al. 1994). Chin, throat and breast are lightly stippled in females and more heavily so in males.

Status

The turquoise darter is not listed in South Carolina or Georgia, but is a fish of special concern in North Carolina, where it is considered critically imperiled (NatureServe 2004), likely due to its very restricted range in that state. In a recent assessment of southeastern fishes, the turquoise darter was considered currently stable (Warren et al. 2000).

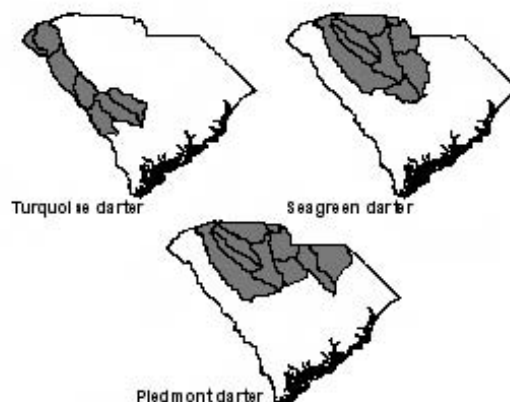
Seagreen darter is not listed in North Carolina or South Carolina, but Guillory et al. (1978) considered the seagreen darter as a species of special concern in North Carolina. Currently, it is considered vulnerable in North Carolina (NatureServe 2004) and stable throughout its range (Warren et al. 2000).

Warren et al. (2000) classified the Piedmont darter as currently stable. Due to its limited habitat in Virginia, it is considered a special concern species (Guillory et al. 1978), classified as critically imperiled (NatureServe 2004). The Piedmont darter is not listed in North Carolina or South Carolina where it is abundant and considered apparently secure (NatureServe 2004).

Population Distribution and Size

Distribution

The turquoise darter is found in the Savannah River drainage in North Carolina, Georgia and South Carolina. In Georgia, it is also found in upper Ogeechee and Altamaha River drainages (Page and Burr 1991). In South Carolina, it is most often found above the fall line, but also occurs in the upper Edisto River in the coastal plain.



The seagreen darter is restricted to the Santee River drainage of the Carolinas. This species inhabits lower elevation tributaries in the mountain regions and is also found over a broad area of the upper piedmont in the Carolinas (Rohde et al. 1994). It is less frequently found below the fall line in tributaries of the Congaree River.

The Piedmont darter is found primarily from northwestern to southeastern North Carolina and in north central South Carolina. The northern extreme of its range extends into a small portion of southwestern Virginia (Rohde et al. 1994).

Population Size and Trend

The turquoise darter is frequently documented in stream surveys; however, the true abundance of the species is unknown. Detailed survey and inventory for range and abundance of the turquoise darter are needed (Kuehne and Barbour 1983). The seagreen darter appears not to be threatened at this time because it is locally common in many of the streams of the upper Santee drainage. Detailed survey and inventory for range and abundance of the seagreen darter are needed (Kuehne and Barbour 1983). The Piedmont darter is frequently documented in stream surveys; however, the true abundance of the species is unknown.

Habitat and Natural Community Requirements

The turquoise darter is a riffle dweller within large streams and small rivers. In much of its range, riffle habitat conditions occur sporadically, accounting for the darter's spotty distribution. It normally lives in moderately swift areas of a stream at depths of 10 to 30 cm (4 to 12 inches) (Kuehne and Barbour 1983). The seagreen darter favors a habitat of rock, rubble or gravel riffles in large creeks and rivers with moderate to swift currents (Kuehne and Barbour 1983). It has adapted to wide variations in temperature and water clarity. The Piedmont darter is found in clean, moderate to large streams with a sand to cobble substrate. Though a riffle dweller, this darter does not seem to favor extremely strong currents (Kuehne and Barbour 1983; Rohde et al. 1994).

Challenges

Although all three of these species are currently considered stable, conservation efforts within South Carolina are critical to their global conservation. Approximately one-third of the global distributions of turquoise darter and Piedmont darter and more than half the global distribution of seagreen darter occur in South Carolina. Within the state, destruction of stream riffle habitat caused by land development, deforestation, loss of riparian cover, siltation and hydrologic alterations like channelization and impoundments could jeopardize these species. The seagreen darter is especially vulnerable, given its limited distribution in the upper Santee River basin. Coastal plain populations of the turquoise darter are of concern due to increased development pressures in that region. Further, in extreme headwaters of their range, turquoise and seagreen darters may be adversely affected by brown and rainbow trout introductions.

Conservation Accomplishments

Populations of turquoise darters and Piedmont darters occurring in Matthews Creek, Big Falls Creek and Howard Creek are protected through land purchase and/or conservation easements.

Conservation Recommendations

- Determine statewide distribution and population status of turquoise, seagreen and Piedmont darters with statewide stream surveys.

- Describe life history and habitat requirements of turquoise, seagreen and Piedmont darters.
- Identify streams with healthy populations and intact critical habitat in the Savannah River drainage and upper Edisto River basin for turquoise darter and in the Saluda River, Broad River, Congaree River and Catawba River Basins for seagreen darter. Protect these areas, once identified.
- Study the potential predator/prey relationship between darters (turquoise and seagreen darters) and introduced trout (brown and rainbow trout) and the impact of this relationship on the native darters.
- Identify streams with healthy Piedmont darter populations and intact critical habitat in the upper Santee and Pee Dee drainages. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

High Conservation Priority – Piedmont Species

Greenhead Shiner *Notropis chlorocephalus*

Santee Chub *Cyprinella zanema*

Carolina Darter *Etheostoma collis*

Contributors: Gene Hayes and Jason Bettinger

Description

Taxonomy and Basic Description

The greenhead shiner is a member of the family Cyprinidae; this large family of carps and minnows is distributed nationwide (Rohde et al. 1994). The genus *Notropis* (true shiners) contains approximately 93 species; it is the largest genus of American cyprinids (Jenkins and Burkhead 1993), and the second largest genus of freshwater fishes in North America (Rohde et al. 1994). In South Carolina, there are 16 species of *Notropis*. The greenhead shiner is probably

most closely related to the yellowfin shiner, *N. lutipinnis*, which is found in other portions of the Santee River drainage as well as the Savannah River drainage (Page and Burr 1991). The greenhead shiner will reach a length of 64 mm (2.5 inches) (Eddy and Underhill 1979). It is olivaceous, dusted with black specks and has a dusky lateral band. The mouth is relatively large and oblique (Blair et al. 1957). It is very similar to the yellowfin shiner; however, greenhead shiner breeding males are red with bright white fins (Page and Burr 1991).

The Santee chub is also a member of the family Cyprinidae. Containing 29 species, *Cyprinella* is the second largest genus of American cyprinids (Jenkins and Burkhead 1993). Members of the genus *Cyprinella* are distinguished from other cyprinids by their large, vertical diamond shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). In South Carolina, there are eight species of *Cyprinella*. The Santee chub is probably most closely related to the “thinlip” chub; these two species share similar habitat types (Rohde et al. 1994). The Santee chub can reach a length of 75 mm (3 inches) (Page and Burr 1991). This chub has a slender, fusiform body, a long snout, and exhibits dark cross-hatching on the back and sides. Breeding males are silvery with yellow fins and black streaks on dorsal and caudal fins (Rohde et al. 1994).

The Carolina darter is a member of the perch family, Percidae. It is classified in the subgenus *Hololepis*, which contains three species in South Carolina (Rohde et al. 1994). It is a resident of the Yadkin, Pee Dee and Catawba drainages in North and South Carolina (Cloutman 1979). Carolina darters reach a length of 60 mm (2.4 inches) (Rohde et al. 1994). The fish has a small head and mouth with a highly arched, incomplete lateral line (Kuehne and Barbour 1983). The brown-spotted sides are marked with a median dark stripe that breaks into blotches on the peduncle (Eddy and Underhill 1979). A primary basicaudal spot has two spots of lesser intensity above and below (Rohde et al. 1994). Breeding males do not develop bright colors but may have breeding tubercles on the pelvic fin spine and rays as well as on all anal fin rays (Kuehne and Barbour 1983).

Status

The greenhead shiner is listed as a fish of special concern in South Carolina and currently considered stable within its range (Warren et al. 2000), and apparently secure in North Carolina (NatureServe 2004).

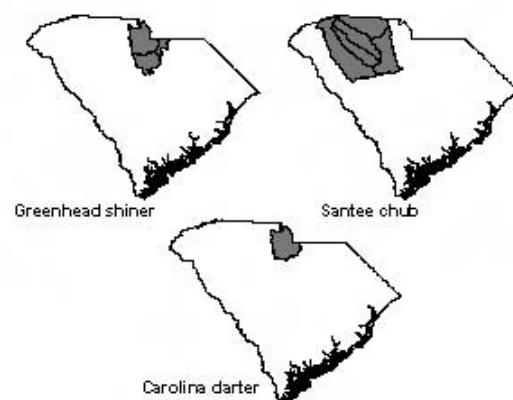
The Santee Chub is currently stable throughout its range (Warren et al. 2000) and considered vulnerable in North Carolina (NatureServe 2004).

The Carolina darter is a federal species of concern, listed as a species of special concern in South Carolina and North Carolina, and was identified as a species vulnerable to imperilment in a recent assessment of southeastern freshwater fishes (Warren et al. 2000). The species is considered vulnerable (S3) in North Carolina and imperiled (S2) in Virginia (NatureServe 2004; Rohde et al. 1994).

Population Distribution and Size

Distribution

The greenhead shiner is endemic to the Catawba



River basin of the Santee drainage, occurring in both North Carolina and South Carolina (Rohde et al. 1994). There is also a population in the upper Lynches River, which may represent a distinct form of the greenhead shiner (F. Rohde, pers. comm.).

The Santee chub is restricted to the Santee River drainage within South Carolina, primarily in the piedmont and Blue Ridge foothills (Rohde et al. 1994). A few populations of Santee chub found in the coastal plain represent an undescribed species known as the “thinlip” chub. Outside of South Carolina, “thinlip” chub is also found in the Cape Fear River drainage of North Carolina (F. Rohde, pers. comm.).

The Carolina darter exists only in the piedmont region from south-central Virginia through North Carolina into north-central South Carolina. The range in South Carolina is restricted to the Catawba River basin (F. Rohde, pers. comm.).

Population Size and Trend

Population size and trend information for greenhead shiner is not known within South Carolina. However, Warren et al. (2000) classified this species as stable within its range. Population size and status information for the Santee chub is also unknown.

Population size and trend information for the Carolina darter is not known. Detailed survey and inventory for range and abundance of the Carolina darter are needed, since it may be a species that is disappearing (Kuehne and Barbour 1983). This species is known from a few dozen localities in Virginia, North Carolina and South Carolina, but has not been collected from several of those locations in recent surveys (NatureServe 2004). However, this species may be more widespread than presently documented (F. Rohde, pers. comm.). A great deal of additional survey effort is needed. Jenkins and Burkhead (1993) reported six to eight locations for this species in Virginia, but some of these are believed to be extirpated.

Habitat and Natural Community Requirements

The greenhead shiner inhabits rocky, flowing pools within clear headwater streams, creeks and small rivers in the Piedmont ecoregion of South Carolina (Page and Burr 1991). The Santee chub inhabits small to medium sized streams with sand and rocky runs or current-swept pools (Rohde et al. 1994). This species seems to be able to tolerate more turbid and warm waters than its close relative, the big-eye chub, *Hybopsis amblops* (Page and Burr 1991). The Carolina darter inhabits small to moderate sized streams in areas of low current velocity. Habitat substrates preferred by this species are usually characterized by mud, sand and sometimes bedrock. This darter seems to be tolerant of fine sediments covering the substrate it inhabits (Kuehne and Barbour 1983; Rohde et al. 1994).

Challenges

The greenhead shiner is rare in South Carolina. Because its distribution is limited to the upper Catawba River system and the upper Lynches River within South Carolina, this species is vulnerable to development within the Catawba River and Lynches River systems. Conservation efforts within South Carolina are important to the global preservation of this species.

The Santee chub is often locally abundant in piedmont South Carolina and believed to be currently stable, but its limited distribution is cause for concern. The major threats to this species are deforestation, loss of riparian cover, siltation and impoundments. Conservation efforts within South Carolina are important to the global conservation of this species.

Geographic isolation of the Carolina darter makes it extremely vulnerable to development, pollution and habitat alterations. Due to the precarious status throughout its range, any environmental threat should be a concern to the species' well being. Conservation efforts within South Carolina are critical to the global conservation of the species.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution, population status, life history and habitat requirements for the greenhead shiner, the Santee chub and the Carolina darter with statewide stream surveys.
- Identify streams with healthy greenhead shiner populations and intact critical habitat in the Catawba River and Lynches River and their tributaries. Protect these areas, once identified.
- Conduct a genetic study of the greenhead shiner and its close relative, the yellowfin shiner, to resolve taxonomic questions, including a comparison of the Catawba River and Lynches River greenhead shiner forms.
- Identify streams with healthy Santee chub populations and intact critical habitat in the Broad River and its tributaries. Protect these areas, once identified.
- Conduct a genetic study of the Santee chub and its close relatives, the thicklip and "thinlip" chubs, to resolve taxonomic questions.
- Identify streams with healthy Carolina darter populations and intact critical habitat in the Catawba River basin tributaries. Protect these areas, once identified.
- Conduct traditional taxonomic studies and genetic studies to identify differences between the *Etheostoma collis collis* and *Etheostoma saluda* forms.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. Genetic resolution for all three species will allow for more specific management protocols.

Moderate Conservation Priority – Big River Species

Notchlip Redhorse *Moxostoma collapsum*

V-lip Redhorse *Moxostoma pappillosum*

White Catfish *Ameiurus catus*

Striped Bass *Morone saxatilis*

Contributors: Forest Sessions, Scott Lamprecht and Jason Bettinger

Description

Taxonomy and Basic Description

The notchlip redhorse is a member of the family Catostomidae and belongs to the genus *Moxostoma*. *M. collapsum* was formerly downgraded to a race of *M. anisurum*, the silver redhorse (Jenkins 1970). Jenkins and Burkhead (1993) reported that the Atlantic slope populations of *M. anisurum* appear to have a more elongate body form, smaller head parts and, perhaps, a tendency to occupy smaller streams than the Mississippi basin silver redhorse. Further, Warren et al. (2000) noted a forthcoming taxonomic rearrangement and recognized *M. collapsum* as a species distinct from *M. anisurum* (Nelson et al. 2004). Adult notchlip redhorse range in length from 350 to 450 mm (14 to 18 inches) and have a moderate to high-back form. These fish have a V-shaped lower lip with lip surfaces that are semipapillose. The dorsal fin has a slightly concave or straight margin and usually 14 or 15 dorsal rays. The upper tip of the caudal fin is often pointed with the lower tip usually rounded. The back is tan, brown or olive. The sides can be shiny silver, yellow, gold, copper or mixtures of these. Scale bases are a pale iridescent green. Pale red can be present in the dorsal and caudal fins with orange-red present in the lower fins (Jenkins and Burkhead 1993).

The V-lip redhorse is also a member of the family Catostomidae and belongs to the genus *Moxostoma*. Buth (1978) regarded the V-lip redhorse to be the most primitive species in the subgenus *Moxostoma*. The V-lip redhorse has been recently considered a sister species of the silver redhorse, *M. anisurum* (Jenkins and Burkhead 1993). Adult V-lip redhorse range in length from 230 to 325 mm (9 to 13 inches) and have an elongate body with slender form. These fish have a V-shaped lower lip with a finely papillose lip surface. The dorsal fin is moderately concave and usually has 12 or 13 dorsal rays. The color of the back is tan-olive and often has a silver sheen. The sides are silver, gold or brassy, with dark scale bases. Faint red may be present at the edges of the caudal and anal fins. Paired fins are orange or pale red (Jenkins and Burkhead 1993).

The white catfish is a member of the family Ictaluridae and the genus *Ameiurus*, which contains medium-sized catfish. Five of the seven species of *Ameiurus* occur in South Carolina. This genus is characterized by a lack of scales, eight barbels, one stout spine supporting dorsal and pectoral fins, an upper jaw protruding over the lower, cardiform teeth on jaws and an adipose fin (Jenkins and Burkhead 1993). The white catfish is bluish-gray to olive above and white on the belly with unmarked sides. The tail is slightly forked with rounded tips. Maximum length is 590 mm (23 inches), but white catfish are typically less than 500 mm (20 inches) long. The anal fin is convex with a ray count ranging between 19 and 23. White catfish feed on plants, insects and fish. Spawning occurs in late spring and early summer. These catfish are relatively long-lived, reaching a maximum of 14 years (Rohde et al. 1994; Jenkins and Burkhead 1993).

The striped bass is a member of the family Moronidae, which contains four North American species (Jenkins and Burkhead 1994) that are known as the temperate basses. The striped bass,

commonly called “rockfish” or “lineside,” has a compressed moderately deep body covered with ctenoid scales. Striped bass have an olive green back, a silvery flank with several thin dark lines and silvery white belly. Striped bass are a large robust fish attaining adult sizes of up to 2000 mm (78 inches), but most striped bass in freshwater systems are much smaller, measuring less than 1000 mm (39 inches).

Status

The notchlip redhorse is currently considered secure throughout its native range (Warren et al. 2000; NatureServe 2004); however, the secure designation was applied when notchlip redhorse was still considered a race of silver redhorse. With the elevation of notchlip redhorse to specific status, its limited range on the Atlantic Slope from Virginia to Georgia and population declines in several rivers such as the Neuse and Cape Fear Rivers, its status may be revised. Throughout its range, the notchlip redhorse is considered common to abundant (NatureServe 2004).

The V-lip redhorse is currently considered apparently secure (NatureServe 2004). Though it may be uncommon in certain areas like South Carolina, it is not considered rare. However, there is some concern about the long-term outlook for the species due to declines and other factors (NatureServe 2004).

The white catfish is considered to be currently stable by Warren et al. (2000) and common, widespread and abundant by Nature Serve (2004). It is considered stable throughout most of its native range although it is considered vulnerable in Alabama (NatureServe 2004). However, populations have greatly declined in the Neuse River, Cape Fear River, Pee Dee River (W. Starnes, pers. comm.) and Edisto River (W. McCord, pers. comm.) since the introductions of flathead catfish and blue catfish.

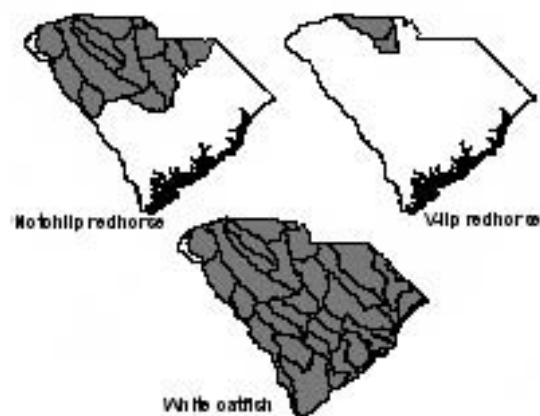
The striped bass is not listed in South Carolina and is currently considered stable (Warren et al. 2000) and secure or apparently secure (NatureServe 2000) throughout the majority of its native range. Although the species is currently appears stable, there are populations of concern in South Carolina. South Carolina is home to small reproductively isolated populations of striped bass that exhibit minimal anadromy and are generally restricted to their natal coastal rivers (Bulak et al. 2004). It is those small unique populations that warrant conservation concern in South Carolina.

Population Distribution and Size

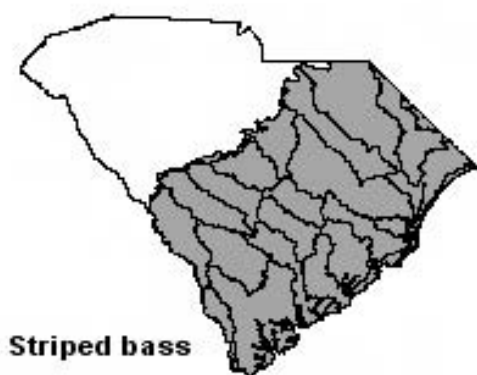
Distribution

The notchlip redhorse occurs on the Atlantic slope from Roanoke–Chowan drainage in Virginia to Altamaha River drainage, Georgia (NatureServe 2004). In South Carolina, the notchlip redhorse is found in the mainstem and larger tributaries of the Pee Dee, Santee and Savannah Rivers. It is generally restricted to the piedmont and upper coastal plain (SCDNR unpublished data).

The V-lip redhorse occurs on the Atlantic slope from Roanoke–Chowan drainage in Virginia to the Santee River drainage in South Carolina. In South Carolina, the species is restricted to the upper Broad River drainage, where it is rarely found (SCDNR unpublished data).



The white catfish is native to the major Atlantic slope drainages from Delaware to Florida. It is also found on the eastern Gulf slope in Alabama, Florida and Georgia. The white catfish has been introduced widely outside its native range. This species has been reported across the entire state of South Carolina (Nature Serve 2004), with few exceptions. White catfish are unlikely inhabitants of cold-water habitats of the northwestern portion of the state and are likely inhabitants of undocumented portions of the coastal plain and midlands of South Carolina (SCDNR unpublished data).



The striped bass's native range includes coastal rivers on the Atlantic Slope from the St. Lawrence River, Canada, to the St. Johns River, Florida, and in Gulf Slope drainages from western Florida to Lake Pontchartrain, Louisiana (NatureServe 2004). The striped bass has been introduced into rivers and reservoirs throughout the United States as it provides a valuable recreational fishery. The populations of conservation concern within South Carolina inhabit coastal rivers in the lower coastal plain including the Savannah River, New River, Combahee River, Ashepoo River, Edisto River,

Santee-Cooper Rivers, Black River, Lynches River, Pee Dee River, Little Pee Dee River and Waccamaw River.

Population Size and Trend

The notchlip redhorse is secure in North Carolina, although declining in the lower Neuse River, lower Cape Fear River, and lower Pee Dee River (W. Starnes, pers. comm.) and apparently secure in Virginia and Georgia. Population size and trend is under review in South Carolina (NatureServe 2004).

The V-lip redhorse is apparently secure in Virginia and North Carolina. In South Carolina, the abundance and trend of V-lip redhorse is under review. It is rarely found in South Carolina (SCDNR unpublished data).

White catfish populations in North Carolina and South Carolina coastal rivers have declined since the introduction of nonnative blue catfish and flathead catfish, (*Ictalurus furcatus* and *Pylodictis olivaris*, respectively) (W. Starnes, pers. comm.; SCDNR unpublished data).

Striped bass population trends within the coastal rivers are not well known. However, based on anecdotal evidence it appears that the coastal striped bass populations have declined. Coastal striped bass populations appear to be relatively small. A recent study of the Combahee River estimated the population of striped bass greater than 300 mm (12 inches) to be only 406 individuals (Bulak et al. 2004).

Habitat and Natural Community Requirements

The notchlip redhorse inhabits medium to large rivers of moderate gradient (NatureServe 2004). Within a stream, the notchlip redhorse is a pool-dweller. It can also be found in natural and artificial lakes (Jenkins and Burkhead 1994).

The V-lip redhorse inhabits rocky runs and silty to firm-bottomed pools within warm, medium-

sized streams to large rivers of moderate or gentle gradient (Jenkins and Burkhead 1994). The V-lip redhorse is a benthic feeder and has been observed feeding in slow current, gravel-bottomed areas (NatureServe 2004).

White catfish inhabit warm ponds, reservoirs and medium to large rivers in freshwater and brackish water habitats (Jenkins and Burkhead 1994).

Striped bass inhabit medium to large rivers; they are also found in impoundments, where they have been introduced, but are often unable to complete their life cycle. They prefer to occupy areas with clean sandy bottoms, fine gravel and rock (NatureServe 2004). Adult striped bass have a thermal tolerance of 6 to 27° C (Merriman 1941), but seek temperatures between 18 to 25°C when available (Coutant and Carroll 1980; Crance 1984). During spawning, striped bass occupy shallow rocky and gravelly areas with strong turbulent water flow. Striped bass eggs are semibouyant; they drift and sink slowly requiring moderate current to keep the eggs from settling to the bottom and dying before they are hatched in one to three days (Scruggs 1955, Etnier and Starnes 1993). Optimum water temperatures for successful striped bass egg hatching and survival is 17 to 18°C (Hassler et al. 1981).

Challenges

Although the notchlip redhorse is currently stable throughout the majority of its range, habitat degradation such as deforestation and siltation represent a potential challenge to this species. The V-lip redhorse has a very limited distribution in South Carolina; any habitat loss or catastrophic pollution event in the upper Broad River drainage could lead to the extirpation of the species from South Carolina. Both species may experience impacts from exotic catfish species like blue and flathead catfish that likely prey on juvenile and adult redhorse (Guire et al. 1984; Bart et al. 1994); buffalo also adversely affect these species through competition (W. Starnes, pers. comm.).

Predation by and competition with introduced flathead catfish and blue catfish may negatively affect abundance of the white catfish and limit its distributions in portions of its range.

The major challenges to South Carolina's coastal striped bass populations include siltation, increased river water temperatures, hydrologic modification and over-exploitation. Clearing forests and riparian areas of coastal rivers and their tributaries have lead to increased siltation and potentially warmer water temperatures. Warmer water temperatures may decrease the amount of summertime refuge habitat for striped bass and negatively impact reproduction. In the Combahee River, striped bass used areas with greater riparian overstory and associated cooler water temperatures as summer-time thermal refuges (Bjorogo et al. 2000). Current creel restrictions for coastal river striped bass (10 fish per day) may not be sufficient to protect these small striped bass populations, especially considering increased population growth in the area and the potential for greater harvest. Dams also negatively impact striped bass populations by disrupting migrations and altering thermal and hydrologic regimes. The presence of impoundments along the Savannah and Pee Dee Rivers may partially account for limited reproduction in those systems. Additionally, stocking nonendemic striped bass into coastal rivers may compromise the genetic integrity of these small isolated populations (Bulak et al. 2004).

Conservation Accomplishments

In order to protect the genetic integrity of small isolated striped bass populations, current South Carolina Department of Natural Resources (SCDNR) stocking policy allows only endemic stocks to be used to augment coastal river striped bass populations. Further, a ten-year moratorium on

striped bass fishing in the lower Savannah River has allowed adult stocks to recover in that river; however, recruitment is still poor.

Conservation Recommendations

- Determine statewide distribution and population status of the V-lip redhorse, the notch-lip redhorse, the white catfish and the striped bass with statewide stream surveys.
- Describe life history and habitat requirements of the V-lip redhorse, the notch-lip redhorse, the white catfish and the striped bass.
- Identify critical habitats and areas with healthy populations of the V-lip redhorse, the notch-lip redhorse, the white catfish and the striped bass. Protect these areas, once identified.
- Investigate the existence of the V-lip redhorse in the Pee Dee River.
- Identify and monitor key striped bass habitats like thermal refuges and spawning sites.
- Assess striped bass reproductive potential in the coastal rivers.
- Determine reasons for lack of striped bass recruitment in the Savannah and Pee Dee River Systems.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.
- Avoid further spread of exotic catfish species like blue and flathead catfish by educating landowners, fishermen and the general public to the discontents of stocking non-native species.
- Augment coastal striped bass populations with endemic strains, as needed.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. An increase in coastal striped bass populations within the state would also indicate that restoration and habitat protections were successful.

Moderate Conservation Priority – Carolina Endemics

Greenfin Shiner *Cyprinella chloristia*

Fieryblack Shiner *Cyprinella pyrrhomelas*

Thicklip Chub *Cyprinella labrosa*

Lowland Shiner *Pteronotropis stonei*

Highback Chub *Hybopsis hypinotus*

Rosyface Chub *Hybopsis rubrifrons*

Contributor: Jason Bettinger

Description

Taxonomy and Basic Description

The greenfin shiner is a member of the cyprinid family (minnows) and belongs to the genus *Cyprinella*. This genus, with 29 species, is the second largest of American cyprinids, after *Notropis* (Jenkins and Burkhead 1993). Members of the *Cyprinella* genus are distinguished from other cyprinids by their large vertical diamond-shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). As with the other *Cyprinella*, the greenfin shiner is a crevice spawner (Jenkins and Burkhead 1993). The greenfin shiner is a relatively deep-bodied *Cyprinella* with a midlateral stripe that is more pronounced posterior to the dorsal fin. The breeding male often displays lime-colored dorsal and caudal fins. Adult greenfin shiners range in length from 44 to 72 mm (1.7 to 2.8 inches) (Rohde et al. 1994).

The fieryblack shiner is also a member of the *Cyprinella* genus in the family Cyprinidae (minnows). Adult fieryblack shiners range in length from 47 to 110 mm (1.8 to 4.4 inches). This attractive species has a red snout, a black bar behind the opercle and a black margin on the caudal fin (Rohde et al. 1994). Breeding males display bright red and white bands on the caudal fin (Rohde et al. 1994).

The thicklip chub is a member of a group of three fishes known as the barbled *Cyprinella*. The thicklip chub can be distinguished from nonbarbeled *Cyprinella* by its chub-like appearance and the presence of barbels in the corner of its mouth. The thicklip chub is a slender fish with a horizontal and inferior mouth. The back of the fish is marked with prominent cross-hatching and ranges in color from dark olive (juveniles and females) to steel blue (breeding males). All fins have cream-colored edges; males develop straw to red colored fins during the breeding season. Adults range in length from 46 to 75 mm (1.8 to 3 inches) (Rohde et al. 1994).

The lowland shiner, another cyprinid, is a member of the genus *Pteronotropis*. There are currently seven recognized species in the genus *Pteronotropis*, all of which are restricted to the lower coastal plain from Mississippi to South Carolina (Etnier and Starnes 1993). The lowland shiner has a small head and deeply compressed body; the dorsal and anal fins are enlarged and triangular in shape. This species has a broad bluish-black stripe that extends from the snout to the base of the tail. Above the broad lateral stripe is a thinner gold to orange stripe. The lowland shiner can attain a length of 65 mm (2.5 inches) (Rohde et al. 1994).

The highback chub is a member of the genus *Hybopsis* in the family Cyprinidae. This fish looks similar to numerous shiners, but often has a small barbel in the corner of its inferior mouth, a long snout and upward-looking eyes (Rohde et al. 1994). The highback chub has a strongly arched dark olive body with a black lateral stripe that extends onto the snout. During the breeding season, males display red fins.

The rosyface chub is also a member of the genus *Hybopsis* in the cyprinid family. The rosyface chub has the typical chub body, somewhat elongate with a long snout, upward-looking eyes and a small barbel in the corner of its inferior mouth. Breeding males can be distinguished from other members of *Hybopsis* by the strong rosy-red coloration that develops on the anterior third of the body. Rosyface chubs can attain a length of 84 mm (3.25 inches) (Rohde et al. 1994).

Status

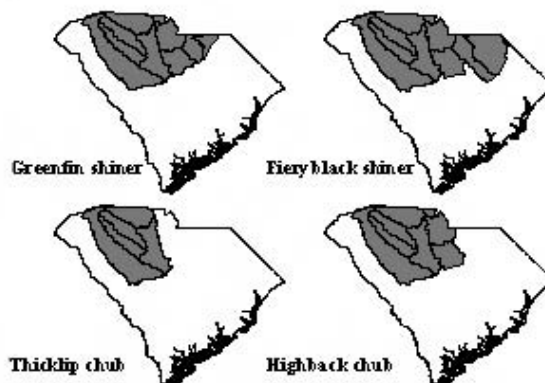
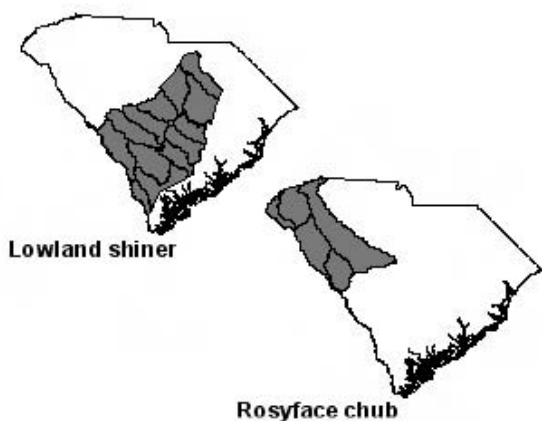
None of these fish is listed federally or within the state of South Carolina as a fish of special concern. All are apparently secure; however, there is some concern for their long-term status based on their limited distributions. Both the greenfin shiner and the fieryblack shiner are considered apparently secure (S4) in North Carolina (NatureServe 2004). In North Carolina, the thicklip chub is considered vulnerable (S3) (NatureServe 2004). The highback chub is considered apparently secure (S4) in North Carolina and imperiled (S2) in Virginia (NatureServe 2004). The rosyface chub is considered critically imperiled (S1) in North Carolina, largely due to its limited distribution within the state; Georgia has listed the rosyface chub as vulnerable (S3) (NatureServe 2004). The lowland shiner is a newly recognized species (Suttkus et al. 2003) that was previously synonymized with sailfin shiner (*Pteronotropis hypselopterus*) and, therefore, does not currently have a concern status, although it may warrant one based on its limited distribution.

Population Distribution and Size

Distribution

The greenfin shiner and the fieryblack shiner are completely restricted to the Carolinas. The greenfin shiner and the fieryblack shiner are restricted to the Santee and Pee Dee River systems above the fall line in North Carolina and South Carolina.

The thicklip chub and the highback chub are largely restricted to the Carolinas; however, there have been a few occurrences of highback chubs and one record for the thicklip chub in the Pee Dee drainage of Virginia (Jenkins and



Burkhead 1993). The thicklip chub, at least in South Carolina, appears to be restricted to the Broad and Saluda drainages of the Santee River system above the fall line. In North Carolina, the thicklip chub is found both in the upper Pee Dee and upper Santee drainages. The highback chub is found in the Blue Ridge foothills and piedmont sections of the Santee and Pee Dee River drainage.

The lowland shiner is restricted to Georgia and South Carolina from the Pee Dee River drainage to the Satilla River drainage (Suttkus et al.

2003). Within South Carolina, the lowland shiner is largely restricted to the southeastern coastal plain from the Pee Dee River to the Savannah River and is most commonly found in the Edisto and Combahee River systems.

The rosyface chub is restricted to the Saluda, Savannah and Altamaha River drainages of Georgia and South Carolina, predominantly above the fall line (SCDNR unpublished data).

Population Size and Trend

Information on population size and status is limited. However, all six species appear to currently be stable in South Carolina (SCDNR unpublished data).

Habitat and Natural Community Requirements

Both the greenfin shiner and the fieryblack shiner require cool, clear water in creeks and small to moderately sized rivers. The greenfin shiner prefers the slower areas and margins of pools and runs with clean sand and rocky substrates. The fieryblack shiner is generally associated with rocky runs and pools below riffles (Page and Burr 1991; Rohde et al 1994). As with other *Cyprinella* species, the greenfin shiner and fieryblack shiner are crevice spawners, depositing eggs in crevices of logs and rocks and thus require coarse substrates and instream structures such as logs to deposit their eggs (Rohde et al 1994).

The thicklip chub and the highback chub are found in cool to warmwater creeks and small rivers with clear to turbid water. They are generally found in riffles and runs with sandy, gravely and rocky bottoms (Page and Burr 1991; Jenkins and Burkhead 1994). The rosyface chub inhabits the pools and margins of riffles in small streams and the banks and eddies of larger streams. It is generally found over sand or gravel and requires clean gravel in fast riffles for reproduction (NatureServe 2004).

The lowland shiner occurs in small to medium clear and blackwater streams. It prefers areas with moderate flow like slow riffles, runs and flowing pools. The lowland shiner is generally associated with clean sand substrate and aquatic vegetation (Suttkus et al. 2003).

Challenges

All of these species are currently stable with relatively large distributions throughout the state. They are of conservation concern because they only occur in the Carolinas and Georgia and only within a few major drainages. Two-thirds of the global range of the greenfin shiner occurs within the state of South Carolina. Approximately one-half of the global distributions of the fieryblack shiner, the lowland shiner, the thicklip chub, the highback chub and the rosyface chub occur in South Carolina. Conservation efforts within South Carolina are critical to the global preservation of these species. Challenges to these species are similar to those faced by other aquatic fauna and include point and nonpoint source pollution, deforestation and loss of riparian corridors, impoundment development, siltation from poor land use practices and unplanned or poorly planned urban and suburban development. Development of the Interstate 85 corridor between Charlotte, North Carolina and Greenville, South Carolina could also result in adverse impacts to several of these species.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution and population status of the greenfin shiner, the lowland shiner, the fireblack shiner, the thicklip chub, the rosyface chub and the highback chub with statewide stream surveys.
- Describe life history and habitat requirements of the greenfin shiner, the lowland shiner, the fireblack shiner, the thicklip chub, the rosyface chub and the highback chub.
- Identify critical habitats and areas with healthy populations of the greenfin shiner, the lowland shiner, the fireblack shiner, the thicklip chub, the rosyface chub and the highback chub.
- Determine the status of the lowland shiner given its recent taxonomic revision.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

Moderate Conservation Priority – Coastal Plain Species

Bluefin Killifish *Lucania goodei*

Banded Killifish *Fundulus diaphanus*

Pugnose Minnow *Opsopoeodus emiliae*

Mud Sunfish *Acantharchus pomotis*

Contributors: Miller White and Jason Bettinger

Description

Taxonomy and Basic Description

The bluefin killifish is a member of the family *Fundulidae* (topminnows). The fundulids occupy a variety of freshwater and brackish water habitats. As the name topminnow suggests, the members of this family are adapted to life near the surface with excellent vision and eyes that are oriented upward. The bluefin killifish reaches a length of 49 mm (1.9 inches). This species looks similar

to members of *Fundulus* but with a more laterally compressed body. There is a black stripe on the side from the snout to the base of the tail. The body is grayish white. The dorsal and anal fins of males contain a significant amount of blue and are edged with black; fins of females are clear (Rohde et al. 1994).

The banded killifish is a member of the large genus *Fundulus*, in the family Fundulidae (topminnows). Two subspecies are recognized, *F. d. diaphanus* and *F. d. menona*. The banded killifish reaches a length of 130 mm (5.1 inches). The fundulids are commonly used as bait (Jenkins and Burkhead 1993) and are important for mosquito control (Rosen 1973). Hobbyists also keep many members of the family in aquaria. The banded killifish is distinguished from others in the genus by a more elongate body, longer and more flattened snout, small scales and numerous narrow bars. Bars are darker than the background color in females and silvery in males (Rohde 1994 et al.).

Two subspecies of pugnose minnow are recognized, *O. e. peninsularis* and *O. e. emiliae*. This is a delicate-looking minnow with a maximum length of about 5 cm (2 inches). It has a distinctive small mouth that is nearly vertical and a blunt snout. Head on, the mouth resembles an inverted U. The scales of the back and sides are edged in black, creating a crosshatched pattern. Overall coloration is dusky yellow, silvery on the belly and with a black stripe on the side from head to base of the tail (Rohde 1994 et al.).

The mud sunfish is a small secretive member of the family Centrarchidae and the only member of the *Acantharchus* genus. The 30 species of this family include the sunfishes, crappies and black basses and represent the second largest fish family indigenous to North America (Jenkins and Burkhead 1993). The mud sunfish is a chunky centrarchid with large eyes and mouth and a rounded caudal fin. It is olive green in color with 3 to 6 dark brown stripes on its side (Rohde et al. 1994). It is the only sunfish with cycloid scales (Rohde et al. 1994). Adult mud sunfish reach total lengths of about 218 mm (8.5 inches).

Status

The bluefin killifish is listed as a species of special concern in North Carolina and South Carolina and listed as unusual in Georgia. The bluefin killifish is considered critically imperiled (S1) in South Carolina, Georgia, Alabama and North Carolina (NatureServe 2004). In Florida, the only other state where it occurs, its status is under review, but is reported as common to abundant (NatureServe 2004).

The banded killifish is listed as a fish of special concern in South Carolina, but considered secure or apparently secure throughout most of its range (NatureServe 2004). It is classified as critically imperiled (S1) in locations on the fringes of its range, including South Carolina, Illinois, South Dakota, Manitoba and Newfoundland (NatureServe 2004).

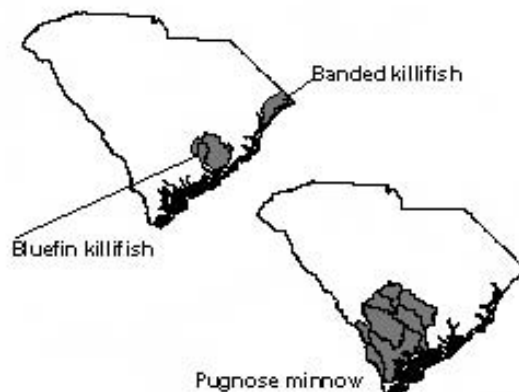
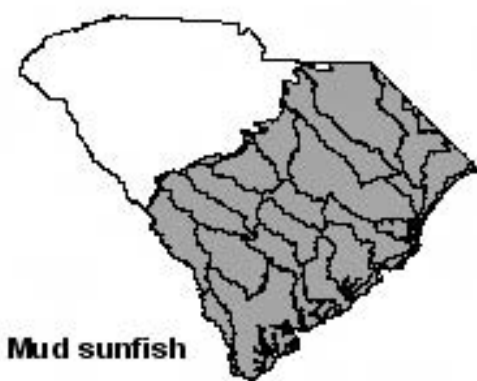
The pugnose minnow has a large range in the lowlands extending from the southeastern U.S. to the southern Great Lakes region. It is common, although sometimes spotty throughout most of its range, but is becoming less common in some areas (NatureServe 2004).

The mud sunfish is currently considered stable throughout its range (Warren et al. 2000). However, it is considered at least vulnerable to imperilment in five (Delaware, Florida, Georgia, Maryland and Virginia) of the ten states where it occurs. It is presumably extirpated from New York and possibly extirpated from Pennsylvania (NatureServe 2004). It is unranked in South Carolina and apparently secure in North Carolina and New Jersey (NatureServe 2004).

Population Distribution and Size

Distribution

The bluefin killifish is mostly confined to peninsular Florida but is also found in western Florida to the lower Choctawhatchee River drainage and north in coastal Georgia to the Ogeechee River drainage. It is found in the Chipola River drainage in southeastern Alabama, in the Wilmington area of North Carolina and in Cooper River and Four Hole Swamp, South Carolina. Rohde et al. (1994) suggested it might have been introduced into North and South Carolina, as its range in those states is small and isolated.



The banded killifish is widely distributed in Atlantic slope drainages from the Pee Dee River, South Carolina, north to Maritime Provinces and Newfoundland; St. Lawrence– Great Lakes and Mississippi River basins from Quebec to Manitoba; south to southern Pennsylvania, northern Illinois, and northeastern Nebraska (Page and Burr 1991). The subspecies, *F. d. diaphanus* dominates in Atlantic slope drainages and *F. d. menona* in the remainder of its range, with the exception of the St. Lawrence and Lake Erie drainages, where the two subspecies integrate. In South Carolina,

the banded killifish occurs only in the Waccamaw and Sampit Rivers (SCDNR unpublished data).

The pugnose minnow occurs from the Nueces River drainage in southern Texas to the Edisto River drainage in South Carolina and north in the Mississippi River and Great Lakes basins to southeastern Kansas, southeastern Minnesota, Wisconsin, Michigan, southern Ontario, Ohio and West Virginia. The subspecies *O. e. peninsularis* occurs in the Florida peninsula and *O. e. emiliae* in the remainder of its range, except areas of intergradation in southern Georgia and northeastern Florida west to Ochlockonee river (Page and Burr 1991; Lee et al. 1980). In South Carolina, the pugnose minnow occurs only in a small area, from the Edisto River southward (Rohde et al. 1994).

The mud sunfish is widely distributed but uncommon within the coastal plain from New York to northern Florida. It also occurs in the Gulf Coastal Plain in northern Florida and southern Georgia from the Suwannee River to Saint Marks River (NatureServe 2004). In South Carolina, it is primarily restricted to the coastal plain below the fall line in the Savannah, ACE, Santee and Pee Dee River drainages.

Population Size and Trend

The bluefin killifish is common in Florida but apparently only occurs in small numbers outside of Florida (NatureServe 2004). The banded killifish is common to abundant throughout much of its range. In South Carolina, it is classified as critically imperiled because of its limited distribution.

The pugnose minnow is common to rare, depending on location; it has been greatly reduced in numbers and even extirpated in some parts of its range (Rohde et al. 1994). Mud sunfish population size and trend is not well known in South Carolina, in part due its secretive nature and nocturnal behavior. Based on anecdotal reports from biologists, it appears that this fish is not a common as it once was.

Habitat and Natural Community Requirements

The bluefin killifish inhabits heavily vegetated ponds, lakes, sloughs, ditches and areas of little or no current in streams, such as pools or backwaters. It is frequently associated with spring habitats and may occur in waters with moderate salinity (up to 10.3 ppt) (NatureServe 2004). In the Cooper River, South Carolina it is found in abandoned rice fields that have breached dikes and are contiguous with the river.

The banded killifish thrives in a wide range of salinities, from fresh water to estuaries with salinity as high as 20 ppt. It inhabits quiet waters of lakes, ponds and sluggish streams, usually over a sand, gravel or detritus-covered bottom where there are patches of submerged aquatic plants. Banded killifish also frequently occur in estuarine waters. Schools of these fish tend to stay in shallows in summer (NatureServe 2004).

The pugnose minnow is usually found in lowlands in clear to turbid, sluggish, often weedy waters of lakes, reservoirs, sloughs, swamps and streams of all sizes. It prefers areas with a soft mud bottom (NatureServe 2004).

The mud sunfish inhabits darkly stained, often acidic, and heavily vegetated coastal plain streams, ponds, lakes and swamps (Jenkins and Burkhead 1993, Rohde et al. 1994). In streams, it prefers sluggish pools and backwaters and occupies areas with silt, mud and detritus substrates.

Challenges

None of these fish are threatened globally, but the limited distribution of banded killifish, bluefin killifish and pugnose minnow in South Carolina is cause for concern. The perceived decrease in mud sunfish abundance also warrants concern. Challenges to these species are similar to those for other aquatic fauna and include alterations in channel morphology and flow, point and nonpoint source pollution and sedimentation.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution, population status, life history and habitat requirements of the bluefin killifish, the banded killifish, the pugnose minnow and the mud sunfish with statewide stream surveys.
- Identify lotic and lentic habitats with healthy populations and intact critical habitat in the Cooper River and Four Hole Swamp Watershed for bluefin killifish and the Waccamaw and Sampit River systems for banded killifish. Protect these areas, once identified.
- Conduct genetic evaluation of bluefin killifish to determine whether South Carolina populations are distinct from populations in Florida.
- Determine the causes for the decline or potential extirpation of pugnose minnow in South Carolina.

- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

Moderate Conservation Priority – Mountains and Upper Piedmont

Blacknose Dace *Rhinichthys atratulus*

Central Stoneroller *Campostoma anomalum*

Eastern Brook Trout *Salvelinus fontinalis*

Contributors: Dan Rankin and Jason Bettinger

Description

Taxonomy and Basic Description

The blacknose dace is a widely distributed cyprinid of the genus *Rhinichthys*, first described in 1804. *Rhinichthys* exhibit considerable morphological and genetic variation (Etnier 1993). Two members of this genus occur in South Carolina (Rohde 1994), with an additional three species in the western United States (Etnier 1993). Two subspecies of blacknose dace are recognized: an Atlantic slope form, *R. a. atratulus*, found in and north of the New River, Virginia; and a western form, *R. a. meleagris*, in north-central North America (Jenkins and Burkhead 1993). Recently, a third subspecies (*R. a. obtusus*), an upland form found in the southern Ohio River to Mobile Basin, was elevated to species status and named the western blacknose dace (*R. obtusus*) (Nelson et al. 2004). It would stand to reason, based on the zoogeographical evidence (Ross 1971) of a historic connection between the upper Savannah and upper Tennessee River system, that blacknose dace in South Carolina would most likely be more closely related to the western blacknose dace. However, the species in South Carolina is currently recognized as *R. atratulus* (blacknose dace) (Nelson et al. 2004).

Adult blacknose dace range in length from 44 to 100 mm (1.7 to 3.9 inches) (Rohde 1994). The species has small scales, a frenum, a subterminal mouth with a small barbel in each corner, a moderate sized head, small eye, moderate-sized mouth and fleshy lips. The breast and belly are

fully scaled. There is a black lateral stripe extending from the snout through the eye to the caudal area, separating a brownish back from a whitish belly (Jenkins and Burkhead 1993).

The central stoneroller was first described in 1820 from Kentucky (Jenkins and Burkhead 1993). The genus *Campostoma* is systematically complex and dynamic. Five species are currently recognized: *C. anomalum*, widespread in central and eastern North America; *C. ornatum* in Mexico, southern Arizona and Texas (Etnier and Starnes 1993); *C. oligolepis* in the middle and lower Tennessee drainage; *C. pauciradii* in the southeastern United States (Jenkins and Burkhead 1993); and *C. pullum* in the Great Lakes drainage, the Wabash River portion of the Ohio River drainage, the Susquehanna River drainage and direct tributaries to Mississippi River (Etnier and Starnes 1993). There are two subspecies of *Campostoma anomalum*: *C. a. anomalum*, and *C. a. michauxi* (Lee et al. 1980). The geographic limits of these subspecies have not been defined, but upper Tennessee and Santee drainage fish are considered to be *C. a. michauxi* (Jenkins and Burkhead 1993). Page and Burr (1991) tentatively assigned *C. a. anomalum* to the Ohio River and upper Atlantic drainages, and *C. a. michauxi* to the Santee and Savannah River drainages. Based on zoogeographical evidence (Ross 1971) of a historic connection between the upper Savannah and upper Tennessee River system, central stonerollers in South Carolina would most likely be *C. a. michauxi*. Further investigation is indicated to make this determination.

Adult central stonerollers range in length from 122 to 239 mm (4.8 to 9.4 inches) (Rohde 1994). The species is a round-bodied, chub-like minnow with a ventral mouth, hard ridge along the lower jaw, moderate head and eye, and a rounded snout. The back is brown to olive with a brassy sheen. The belly and fins are typically light colored (Jenkins and Burkhead 1994).

The eastern brook trout is a member of the family Salmonidae. Although its common name identifies this fish as a trout, it is actually a char from the genus *Salvelinus*, which contains seven to ten species (Behnke 1980; Cavendar 1980; Kendall and Behnke 1984). However, it has been suggested that this genus may contain as many as 16 species (Behnke 1990). The eastern brook trout is the lone living member of the subgenus *Baione*, as its only other member, the silver char (*Salvelinus agassizi*), has become extinct (Jenkins and Burkhead 1993). Native southern Appalachian populations south of the New River in Virginia are genetically distinct from northern populations at subspecific levels (Stoneking et al. 1981; McCracken et al. 1993; Danzmann et al. 1998; Guffey et al. 1999). In South Carolina, only three populations of the genetically pure southern Appalachian genotype are known to occur out of more than a dozen documented stream populations (Guffey 1995). Two additional populations possess low levels of introgression of northern alleles.

The brilliantly marked char range in adult length from 130 to 508 mm (5.1 to 10.0 inches) (Rohde et al. 1994); however, in the southern Appalachians, eastern brook trout rarely exceed 250 mm (9.8 inches) (Jenkins and Burkhead 1993). This char is identified by a white leading margin on a black sub-margin or streak on the ventral fins; yellow and olive pale spots and red spots with a pale blue halo on an olive background along the side; and a vermiculate (wormlike) back. The belly is brilliant orange-red bordered by black at the ventrolateral margin, especially in breeding males. Larger breeding males develop a distinct kype (hook) on the lower jaw.

Status

The blacknose dace is listed as a species of special concern in South Carolina, but is currently stable within its range (Warren et al. 2000, NatureServe 2004). The blacknose dace is considered critically imperiled (S1) in South Carolina and vulnerable (S3) in Georgia (NatureServe 2004).

This listing for South Carolina may be overly pessimistic in that much of blacknose dace habitat has been protected in the Mountain Bridge Wilderness Area at Jones Gap State Park in Marietta, South Carolina.

The central stoneroller is currently stable within its native range (Warren et al. 2000). NatureServe (2004) listed the status as secure globally (G5). There currently is no state ranking assigned in South Carolina.

Eastern brook trout are considered currently stable and secure (G5) by Warren et al. (2000) and NatureServe (2004), respectively. NatureServe (2004) listed eastern brook trout in South Carolina as imperiled (S2). South Carolina is the only state in the species' range where it is considered imperiled.

Population Distribution and Size

Distribution

The blacknose dace is found in Atlantic, Great Lakes, Hudson Bay, Mississippi, and upper Mobile Bay basins from Nova Scotia to Manitoba and south to Nebraska, northern Alabama, northern Georgia and the coastal plain in Virginia (Page and Burr 1991; NatureServe 2004). In South Carolina, blacknose dace are found in the upper Savannah River drainage and Saluda River system in the Blue Ridge and inner piedmont ecoregions (SCDNR unpublished data).



The central stoneroller is found throughout much of the eastern and central U.S. in the Atlantic, Great Lakes, Mississippi River and Hudson Bay (Red River) basins from New York and southern Ontario west to North Dakota and Wyoming, and south to South Carolina and Texas; Thames River system, Ontario; gulf slope drainages from Galveston Bay, Texas to Rio Grande, Mexico; and isolated populations in southwestern Mississippi and eastern Louisiana (Page and Burr 1991). In South Carolina, the central stoneroller is found in the mountain and upper piedmont ecoregions of the upper Savannah River drainage, Saluda and Broad River systems (SCDNR unpublished data).

The native range for eastern brook trout extends from Canada south and east to Hudson Bay and southward through the northern states from eastern Minnesota and northeastern Iowa eastward to Pennsylvania. The native range also includes the Appalachian uplands, particularly the Blue Ridge, south to Georgia. Drainage changes in the region, stream captures and piracies (Ross 1970) likely explain the occurrence of eastern brook trout in Atlantic slope drainages of the southern Appalachians, south of the New River, Virginia. These drainage changes in headwaters of the Savannah River drainage and Saluda River system in South Carolina, coupled with the occurrence of pure southern Appalachian genotypes in both systems (Guffey 1995), are indicative of native heritage for South Carolina brook trout. The eastern brook trout has been widely introduced outside its native range in North America and is established on all continents except Australia and Antarctica (Jenkins and Burkhead 1993).

Population Size and Trend

Blacknose dace are common throughout their range (Page and Burr 1991, Rohde et al. 1994, Etnier and Starnes 1993). NatureServe (2004) has a local ranking of imperiled and vulnerable for South Carolina and Georgia, respectively; this indicates limited abundance along the species southernmost range. Healthy populations are known to occur in Howard Creek (Savannah drainage), Matthews Creek and Big Falls Creek (Santee drainage). Blacknose dace also occur in lower abundance in the Chattooga, Whitewater, Eastatoee, Middle Saluda and South Saluda Rivers (SCDNR unpublished data).

In the broad sense, the central stoneroller is common to ubiquitous throughout its native range (Etnier and Starnes 1993) and common in most Blue Ridge drainages westward. Page and Burr (1991) describe the species as common to abundant throughout much of its range, generally absent on the piedmont and in the coastal plain and uncommon in the Great Plains. The central stoneroller is very abundant in the Chattooga River (SCDNR unpublished data).

The eastern brook trout is widespread and seemingly stable across its range; however, a troubling decline in miles of stream occupied in the southern Appalachians has occurred over the last century (Etnier and Starnes 1993). The range for eastern brook trout in Great Smoky Mountains National Park (Moore 1981) was estimated to have declined approximately 70 percent since monitoring efforts began. Factors resulting in this decline are deforestation (King 1937; Jenkins and Burkhead 1993) causing excessive siltation and warming, acidification, competition from non-native introductions and global warming (Etnier and Starnes 1993; Larson and Moore 1985; Moore et al. 1986). A similar level of decline appears to have taken place in South Carolina and likely other regions of the southern Appalachians. Wild brook trout inhabit over 3,000 km (1,864 miles) of streams across the southern Appalachian region (Habera and Moore 2005). Southern Appalachian brook trout populations are distributed from the New River drainage in Virginia southward into Tennessee, North Carolina, South Carolina and Georgia. The southern Appalachian genotype (subspecies) comprises only about 17 percent of these streams. Most populations are located in the upper Tennessee River (Mississippi River) system; however, a few also occur in three Atlantic coast and two gulf coast drainages. About fifty percent of brook trout streams in the Tennessee River system are the pure southern genotype, while only about five to ten percent of stream populations in the Atlantic slope are pure. Seventy percent or more of the known brook trout resource in the southern Appalachians within each state and 88 percent overall occurs on public lands (Habera and Moore 2005).

Habitat and Natural Community Requirements

The blacknose dace occurs in small to medium size coolwater creeks with slow to rapid current and a diverse substrate of sand, gravel and rock (Rohde et al. 1994). In South Carolina, blacknose dace are known to occur sympatrically with eastern brook trout (SCDNR unpublished data).

The central stoneroller is found in small to medium rivers with cool clear water, moderate or sometimes rapid current and gravel or rubble substrates. It commonly occurs in pools with current and riffles of small rocky streams. Occasionally central stonerollers are found in slow-moving turbid water (NatureServe 2004).

The eastern brook trout inhabits rocky, often high-gradient, well-shaded, pristine coldwater mountain creeks (Rohde et al. 1994), generally above 600 m (1,969 feet) in elevation, but occasionally down to 490 m (1,608 feet) in streams with north-facing aspects (Etnier and Starnes

1993). Brook trout require high dissolved oxygen levels and cannot tolerate temperatures regularly above 20 degrees Celsius (68 degrees Fahrenheit). This trout also occurs in high elevation beaver ponds and lakes. Brook trout are the most tolerant of the salmonids with regard to acidity, tolerating pHs from 4.5 to 9.5 (Jenkins and Burkhead 1993).

Challenges

In South Carolina, the blacknose dace is vulnerable because of its limited distribution. The central stoneroller may be somewhat vulnerable in South Carolina due to its limited distribution that is apparently associated with drainage changes (Ross 1971). Additionally, development, deforestation, loss of riparian cover, siltation and impoundments in coolwater streams adversely affects these species.

The eastern brook trout is challenged by deforestation; specifically the associated water temperature rises and siltation from timber harvesting practices (King 1937; Jenkins and Burkhead 1993). Additionally, impoundments, acid deposition and displacement by non-native salmonids adversely affect this species (Etnier and Starnes 1993; Larson and Moore 1985; Moore et al. 1986).

Conservation Accomplishments

Populations of blacknose dace found in Matthews Creek, Big Falls Creek and Howard Creek have been protected through fee simple land purchase and/or conservation easements in those areas.

Many conservation practices have been accomplished for the eastern brook trout. Range and population levels have been monitored across the species' range and taxonomic characterization of the eastern brook trout is well advanced. Further, water quality designations designed to protect the species have been implemented. The American Fisheries Society–Trout Committee's position paper (management plan) is a valuable tool for management of the southern Appalachian population of eastern brook trout.

Additionally, the recent development of a state, federal and non-governmental organizations (NGOs) "joint venture" will focus on protection and restoration of eastern brook trout across its range in the U.S. To assist in this restoration, successful biological restoration techniques have been developed for this species. The South Carolina Department of Natural Resources, the National Park Service, U.S. Forest Service, and Trout Unlimited are partnering to restore eastern brook trout populations in South Carolina; however, funding is currently inadequate to fully implement restoration. Education and outreach efforts regarding conservation of this species have been successful; however, these efforts need to be intensified.

Conservation Recommendations

- Determine statewide distribution and population status with statewide stream surveys for the blacknose dace, central stoneroller and eastern brook trout.
- Describe life history and habitat requirements for the blacknose dace, central stoneroller and eastern brook trout.
- Identify streams with healthy populations and intact critical habitat in the upper Savannah River drainage, and Saluda River System for blacknose dace and the upper Savannah River drainage, Saluda River System and Broad River system for central stoneroller. Protect these areas, once identified.

- Determine the status of known eastern brook trout populations; establish long-term monitoring programs for those populations.
- Refine distribution information for eastern brook trout, primarily on privately owned lands.
- Assess water quality and habitat in brook trout streams to identify threats and deficiencies; establish long-term water quality and habitat monitoring programs in those streams.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.
- Aggressively seek protection of brook trout habitat through land acquisition, conservation easements, agreements and other methods.
- Seek protection of brook trout populations from over-harvest through a creel limit reduction and minimum size limit to protect spawning stocks.
- Where feasible and appropriate, implement brook trout restoration in headwater streams.
- Conduct water quality monitoring and habitat enhancement in brook trout streams where habitat is determined to be impaired.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. An increase in native brook trout populations within the state would also indicate that restoration and habitat protections were successful.

Moderate Conservation Priority – Other Species

Snail Bullhead *Ameiurus brunneus*

Flat Bullhead *Ameiurus platycephalus*

Contributor: Jason Bettinger

Description

Taxonomy and Basic Description

The snail bullhead is a member of the family Ictaluridae. The ictalurids, with approximately 46 species, represent the largest family of fishes indigenous to only North America (Jenkins

and Burkhead 1993). The genus *Ameiurus* contains the moderately sized (reaching only a few pounds) catfish collectively known as the “bullheads.” Snail bullheads have a large flat head, a decurved snout profile, uniformly colored maxillary barbel, short rounded anal fin, emarginate tail and a large dusky blotch at the base of the dorsal fin. Snail bullheads vary greatly in color and pattern, but in general they have a brown or yellow-green back, mottled sides of the same colors and white belly. In their natural habitats (rivers and streams) snail bullheads typically reach maximum adult sizes of 294 mm (11.4 inches) (Rohde et al. 1994); however, in disturbed habitat such as impounded river reaches and reservoirs, they reach substantially greater sizes (443 mm, 17.6 inches) (SCDNR unpublished data).

The flat bullhead, also a member of the family Ictaluridae and the genus *Ameiurus*, is very similar to the snail bullhead in appearance. Flat bullheads differ from snail bullheads by having a bicolor maxillary barbel that has white leading edge, a relatively straight snout profile, gold yellow to dark brown colored back, dark mottling along the sides, and a cream colored belly.

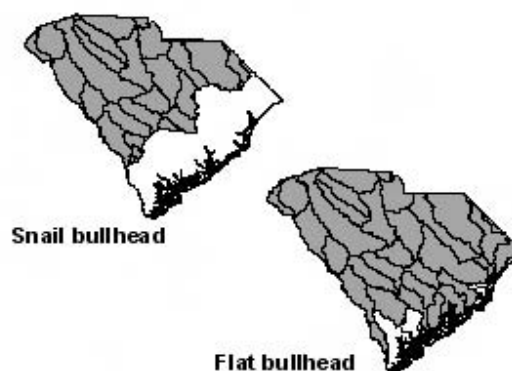
Status

Neither the snail bullhead nor flat bullhead is listed in South Carolina. However, in a recent assessment of southeastern fishes, each of these species was considered vulnerable to imperilment (Warren et al. 2000). The snail bullhead is considered at least vulnerable to imperilment in four of the six states where it occurs. It is considered imperiled (S2) in Virginia, vulnerable (S3) to imperilment in North Carolina, Alabama and Florida, and apparently secure (S4) in Georgia (NatureServe 2004). The flat bullhead was considered vulnerable (S3) to imperilment in Virginia and apparently secure (S4) to secure in Georgia and North Carolina (NatureServe 2004).

Population Distribution and Size

Distribution

Snail bullheads occur along the Atlantic Slope from the Dan River system in Virginia and North Carolina south to the Altamaha River system in Georgia and the Saint Johns River drainage in Florida (NatureServe 2004). They also occur in Gulf slope drainages of the Apalachicola River system in Georgia, Alabama and Florida and the upper Coosa River system in northern Georgia (Page and Burr 1991). Flat bullheads occur in the piedmont and coastal plain of the Atlantic Slope, from the Roanoke River drainage, Virginia south to the Altamaha River drainage, Georgia. In South Carolina, both species occur from the mountains to the piedmont in nearly every major drainage, but are most common above the fall line.



Population Size and Trend

Both species appear to be relatively stable in South Carolina streams; however, their fate in the larger rivers is uncertain due to the presence of the nonnative flathead catfish. They are common to abundant in the upper Santee drainage, but decreasing trends have been noted in many coastal rivers like the Edisto River, following the introduction of flathead catfish (C. Thomason, SCDNR,

pers. comm.). The largest populations of snail bullhead and flat bullhead are probably located in the Broad River system, a system where the flathead catfish has yet to be introduced.

Habitat and Natural Community Requirements

The snail bullhead is found in rocky riffles, shoals, runs and pools in streams and rivers. The flat bullhead is typically found in streams, rivers and impoundments occupying areas with mud, sand or rock bottoms, with slow flowing water. Both species can be found in the same stream or river, with the snail bullhead typically inhabiting the shoals and riffles, while the flat bullhead can be found along the banks and in pool areas (Jenkins and Burkhead 1993; Rohde et al. 1994; NatureServe 2004).

Challenges

Both these bullheads are adversely affected by the same myriad of challenges for all aquatic species, such as sedimentation, hydrologic modification, impoundments, nonpoint source pollution, and development. Additionally, these species are also threatened by the introduction of nonnative ictarlurids like the flathead catfish and the blue catfish; both of these non-native species displace and prey on the smaller bullheads. Flathead catfish have been shown to prey on bullhead species and greatly reduce their numbers (Guire et al. 1984; Ashley and Buff 1986; Quinn 1988; Bart et al. 1994).

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution, population status, life history and habitat requirements of the snail bullhead and flat bullhead with statewide stream surveys.
- Identify critical habitats and areas with healthy populations of the snail bullhead and flat bullhead. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.
- Prevent the spread of flathead catfish and other nonindigenous aquatic species.
- Educate the public as to the discontents of stocking nonnative species.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure

and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

Moderate Conservation Priority – Pee Dee Fringe Species

Satinfin Shiner *Cyprinella analostana*

Whitemouth Shiner *Notropis alborus*

Redlip Shiner *Notropis chiliticus*

Comely Shiner *Notropis amoenus*

Contributors: Ross L. Self and Jason Bettinger

Description

Taxonomy and Basic Description

The satinfin shiner, the whitemouth shiner, the redlip shiner and the comely shiner are all members of the family Cyprinidae. Cyprinidae is the family of true minnows and, with about 2,000 species, is the largest family of fishes in the world (Jenkins and Burkhead 1993).

The satinfin shiner is in the genus *Cyprinella*, the second largest cyprinid genus in the Americas (Jenkins and Burkhead 1993). Fishes of the genus *Cyprinella* are characterized by large vertical diamond shaped scales and a dark blotch on the dorsal fin. The dorsal fin of the satinfin shiner exhibits black speckles on all membranes with a distinct black blotch on its rear half (Rohde et al. 1994). The anal fin of the species typically has nine rays. Breeding males appear gray-blue with yellow fins (Rohde et al. 1994). Adults range in size from 47 to 110 mm (1.9 to 4.3 inches) (Rohde et al 1994).

The whitemouth shiner, the redlip shiner and the comely shiner are all members of the genus *Notropis*. Containing about 71 species, *Notropis* is considered the genus of true shiners (Rohde et al 1994). The true shiners are generally small and nearly all lack a barbel. Silver color is dominant; breeding males of many species have bright colors (chiefly red) and some are boldly black-patterned. A great deal of variation occurs across the genus in morphology, color, and biology.

The whitemouth shiner exhibits a body profile that is moderate to somewhat elongate (Jenkins and Burkhead 1993). The species has a jagged-edged midlateral stripe that continues around the snout or upper lip (Rohde et al. 1994). The mid-lateral stripe is confluent with the caudal spot (Jenkins and Burkhead 1993). These fish have eight dorsal rays and seven anal rays (Jenkins and Burkhead 1993). Adults range in size from 40 to 50 mm (1.6 to 1.9 inches) in length (Jenkins and Burkhead 1993).

The redlip shiner is characterized by bright red lips with red coloration in the dorsal, anal and caudal fins and with black blotches on the sides (Rohde et al. 1994) and the lateral line is complete (Jenkins and Burkhead 1993). These fish have eight or nine anal rays (Jenkins and Burkhead 1993). Breeding males exhibit scarlet-red coloration in body and eye with yellow fins (Rohde et al 1994). Adults range in length from 40 to 55 mm (1.6 to 2.2 inches) (Jenkins and Burkhead 1993).

The comely shiner is a slender fish with a somewhat pointed snout. The dorsal fin is quite

posteriorly placed. The anal fin margin is strongly concave. These fish have eight dorsal rays and ten to twelve anal rays. Breeding males have small tubercles on head. Adults range in length from 55 to 75 mm (2.2 to 2.9 inches) (Jenkins and Burkhead 1993).

Status

The satinfin shiner is under review in South Carolina for classification of its status. Across much of its range, it is considered to be secure (NatureServe 2004). The whitemouth shiner is considered to be apparently secure nationally (NatureServe 2004). Its status, however, does vary from apparently secure to critically imperiled as one moves across its range. In South Carolina, the status of the whitemouth shiner is uncertain. The redlip shiner is listed as a species of special concern in South Carolina and considered to be critically imperiled (S1) (NatureServe 2004). Its status across much of its range is apparently secure (NatureServe 2004). Status of the comely shiner in South Carolina is uncertain and needs further review. It is generally considered stable across the southern portion of its range (NatureServe 2004).

Population Distribution and Size

Distribution

The satinfin shiner is found on the Atlantic slope from the Pee Dee River drainage in North and South Carolina, north to lower Hudson River drainage and southern Lake Ontario drainage in New York (Page and Burr 1991). In South Carolina, the satinfin shiner is restricted to tributary streams of the upper Pee Dee River drainage in the slate belt and sandhills ecoregions (SCDNR, unpublished data).

The whitemouth shiner is known from the Roanoke, Cape Fear, Pee Dee and Santee River drainages in North Carolina and South Carolina, and the Chowan and Roanoke River drainages in Virginia. However, it has apparently extirpated from the Chowan drainage. It is found largely on the outer half of the Piedmont Province, where it is fairly common. The whitemouth shiner is apparently absent from intervening Tar and Neuse drainages (NatureServe 2004). In South Carolina, its distribution is apparently restricted to the slate belt in the upper Lynches and Pee Dee River systems.

The redlip shiner is native to the Pee Dee drainage and the Dan River system of the Roanoke River drainage in North Carolina and Virginia. This species has recently been introduced and is apparently established in New River drainage and Cape Fear drainage in North Carolina and Virginia. It is abundant in mountain streams and common in the piedmont (Page and Burr 1991). In South Carolina, the redlip shiner is restricted to the sandhills and slate belt ecoregions in the upper Pee Dee River drainage.

The most viable populations of satinfin shiner, redlip shiner and whitemouth shiner likely occur in Thompson Creek, Chesterfield County, South Carolina.

The comely shiner occurs in Atlantic slope drainages (upper coastal plain and piedmont) from the Hudson and Susquehanna drainages in New York south through the Cape Fear drainage in North Carolina. There is a recent record from Rocky Creek, part of the Yadkin River system



in Montgomery County, North Carolina. Globally, the comely shiner is considered common (NatureServe 2004). Records from the Pee Dee drainage may be result of an introduction (Jenkins and Burkhead 1993). In South Carolina, there have been only two records of the comely shiner; both were from the upper Pee Dee River.

Population Size and Trend

The satinfish shiner is common across its range, with a limited distribution in South Carolina. The whitemouth shiner is considered fairly common across its range, with a limited distribution in South Carolina. The redlip shiner is considered abundant in mountain streams within its range, less abundant in the Piedmont, with a very limited distribution in South Carolina. The comely shiner is considered common to uncommon in the southern portion of its range, with a very limited distribution in South Carolina.

South Carolina the southern-most extreme portion of the range for all four species and may not be part of the natural range of the comely shiner or redlip shiner. Conservation actions in South Carolina may have little impact on the overall status of these fishes. However, due to the limited habitat available for these species in South Carolina, if they are to be maintained as part of South Carolina's fauna then it is essential that the habitat requirements for these fishes be better understood and actions taken to protect and preserve appropriate sites for the survival of these species.

Habitat and Natural Community Requirements

The satinfish shiner occupies pools and runs of creeks and small to medium weed-free rivers with substrate ranging from sand to gravel and rubble. Occasionally, this species is found in headwaters and tidal portions of some large rivers. Eggs are attached to branches, stumps and logs and may be deposited in cracks in rocks, in crevices under loose submerged bark, between exposed tree roots and/or under flat rocks (NatureServe 2004).

The whitemouth shiner occurs in small to medium-sized warm water streams like headwaters, creeks and small rivers. These streams typically have colorless to slightly stained, clear to turbid water, no vascular plants, a sand-rubble-bedrock substrate and a swift current with alternating pools and riffles (NatureServe 2004).

The redlip shiner occupies flowing pools of clear headwaters, creeks and small rivers of the piedmont and mountains; it prefers areas with sand-gravel to rubble bottom. The redlip shiner spawns on nests of bluehead chub (*Nocomis leptocephalus*) (Johnson 1991; NatureServe. 2004).

The comely shiner uses a variety of habitats; it is usually found in runs and flowing pools of creeks and medium to large rivers, especially in channels, over sand, gravel or rubble (NatureServe 2004).

Challenges

All four of these species are vulnerable in South Carolina due to their very limited distribution, but are currently stable throughout much of their range. Challenges to these species are similar to those of other aquatic fauna and include point and nonpoint source pollution, deforestation and loss of riparian corridors, impoundment development, channelization and siltation from poor land use practices and unplanned or poorly planned urban and suburban development. Because of their limited distribution, they are also vulnerable to habitat losses due to anthropogenic influences such as water withdrawals or environmental disturbances such as drought.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution and population status of the whitemouth shiner, the satinfin shiner, the redlip shiner and the comely shiner with statewide stream surveys.
- Describe life history and habitat requirements of the whitemouth shiner, the satinfin shiner, the redlip shiner and the comely shiner.
- Survey Thomson Creek in Chesterfield County to determine the status of the whitemouth shiner, the satinfin shiner, and the redlip shiner as this stream likely houses the strongest populations of these species and may have been severely impacted by the drought of 2002. Protect these areas, once identified.
- Determine the existence and viability of the comely shiner in the Pee Dee drainage.
- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

Moderate Conservation Priority – Savannah Drainage Fringe Species

Whitetail Shiner *Cyprinella galactura*

Warpaint Shiner *Luxilus coccogenis*

Tennessee Shiner *Notropis leuciodus*

Mirror Shiner *Notropis spectrunculus*

River Chub *Nocomis micropogon*

Longnose Dace *Rhinichthys cataractae*

Banded Darter *Etheostoma zonale*

Florida Gar *Lepisosteus platyrhinchus*

Contributor: Jason Bettinger

Description

The upper Savannah River contains several fish species that are typically found in the Tennessee drainage, and not on the Atlantic slope. The presence of the whitetail shiner, the Tennessee shiner, the warpaint shiner, the mirror shiner, the longnose dace and the banded darter in the Savannah River of the southern Atlantic slope is likely due to a stream capture from the Tennessee River (Ross 1970). In South Carolina, these species occur only in the Chattooga and Seneca River systems of the upper Savannah River drainage.

Taxonomy and Basic Description

The whitetail shiner is a member of the cyprinid family (minnows) and belongs to the genus *Cyprinella*. Containing 29 species, *Cyprinella* is the second largest genus of American cyprinids after *Notropis* (Jenkins and Burkhead 1993). Members of the genus *Cyprinella* are distinguished from other cyprinids by their large vertical diamond shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). As with the other *Cyprinella*, the whitetail shiner is a crevice spawner (Jenkins and Burkhead 1993). Whitetail shiners have moderately deep and compressed bodies. Two large creamy white spots at the base of the caudal fin separate the whitetail shiner from other *Cyprinella* (Rohde et al. 1994). During the breeding season males often display a red tint to the dorsal fin. Adults range in size from 44 to 150 mm (1.7 to 5.9 inches) (Rohde et al. 1994).

The warpaint shiner is also a member of the cyprinid family (minnows). Fishes within the genus *Luxilus* are characterized by deep strongly compressed bodies and large lateral scales which are much higher than wide (Jenkins and Burkhead 1993; Rohde et al. 1994). Warpaint shiners range in length from 76 to 151 mm (3.0 to 5.9 inches). This attractive species displays a dark submarginal band in the dorsal and caudal fins and a prominent red slash on the opercle behind the eye. Breeding males display red on the upper lip and snout (Rohde et al. 1994).

The Tennessee shiner is also a member of the cyprinid family (minnows) and belongs to the genus *Notropis*. With 71 species, *Notropis* is the second largest genus of freshwater fishes in North America (Rohde et al 1994). The Tennessee shiner is a slender with a prominent midlateral stripe and a lateral line set off by dashes terminating in a small rectangular spot at the base of the caudal fin. During the breeding season, the bodies and fins of males take on a red hue and they display a lime green stripe on their upper side. Adult Tennessee shiners range in length from 43 to 82 mm (1.7 to 3.2 inches) (Rohde et al. 1994).

The mirror shiner is also in the cyprinid family and a member of the genus *Notropis*. The mirror shiner is identified by its slender body, broad head, small subterminal mouth and upward-directed

eyes (Rohde et al. 1994). During breeding season, the males of this otherwise bland fish display red-orange fins with white margins. Adults range in length from 43 to 75 mm (1.7 to 3 inches) (Rohde et al. 1994).

The river chub is a member of the genus *Nocomis*, which contains seven species, only two of these occur in South Carolina. River chubs range in size from 92 to 320 mm (3.6 to 12.6 inches). When breeding, the male displays a pink-blue head and lower body with red-orange fins (Rohde et al. 1994). Mature males develop a humped head and have breeding tubercles on the front of the snout. *Nocomis* species, including the river chub, are considered “keystone species” because other fishes are dependent on the behavior of *Nocomis* species for their own reproduction. During the breeding season, male river chubs build gravel nests by digging a depression in the substrate and then refilling the pit with a mound of suitable-sized gravel. Other fishes, including many shiner species, spawn on the nests constructed by *Nocomis* species (Etnier and Starnes 1993; Jenkins and Burkhead 1993; Rohde et al. 1994).

The longnose dace is a member of the large and diverse cyprinid family and resides in the genus *Rhinichthys*. There are nine species of *Rhinichthys*, two of which occur in South Carolina. The dace are slender minnows with elongate bodies, pointed snouts, fine scales and a small barbel in each corner of the mouth. *Rhinichthys* means “snout fish,” alluding to their prominent snouts (Jenkins and Burkhead 1993). The longnose dace has a long fleshy snout that extends well beyond the mouth. Their body color is dark olive and the dorsal and caudal fins are often reddish in color. The longnose dace gets rather large for a minnow, reaching lengths of 160 mm (6.3 inches) (Rohde et al. 1994).

The banded darter is a member of the perch (*Percidae*) family and placed in the genus *Etheostoma*, which, containing approximately 115 species, is the largest genus of freshwater fishes in North America (Etnier and Starnes 1993). Darters are characterized by having two dorsal fins, relatively large pectoral fins and elongate bodies. Adult banded darters range in length from 54 to 78 mm (2.1 to 3.1 inches). The male banded darter has nine or more dark green bars that extend down onto the belly (Rohde et al. 1993). The first dorsal fin has a green edge over a red band. The pelvic and anal fins are also often colored with green highlights. Females and juveniles are typically drab with yellowish-tan bars.

The Florida gar is a member of the ancient family *Lepisosteidae*, a lineage of fishes that arose some 200 million years ago (Wiley 1976). *Lepisosteidae* is a small family with only seven members, all of which are New World species (Rohde et al. 1994). Five of those species occur in North America. The gars are truly unmistakable with a heavy armor of diamond-shaped scales and long beak-like mouth equipped with needle-sharp conical teeth. The Florida gar can be distinguished from the longnose gar (*Lepisosteus osseus*), the only other gar occurring in South Carolina, by its broader and shorter snout. The Florida gar can attain lengths of 1320 mm (52 inches) (Page and Burr 1991).

Status

The whitetail shiner, the warpaint shiner, the Tennessee shiner, the mirror shiner, the river chub, the longnose dace and the banded darter are all listed as species of special concern in South Carolina. Globally, all of these fish are considered to be stable and secure (Warren et al. 2000; NatureServe 2004). The mirror shiner is apparently secure, although uncommon, throughout some of its range (NatureServe 2004). The Florida gar is not listed in South Carolina and is considered to be secure globally (NatureServe 2004).

Population Distribution and Size

Distribution

Within South Carolina, all species in this group except the Florida gar are restricted to the Chattooga and Seneca River system in the upper Savannah River drainage. The only known South Carolina population of Florida gar is located near Steel Creek in the lower Savannah River drainage (Doug Martin, personal communication). The Florida gar occurs throughout most of peninsular Florida and the Savannah and Ocklockonee River drainages in Georgia (Page and Burr 1991).



The whitetail shiner occurs east and west of the former Mississippi Embayment. It occurs in the Cumberland and Tennessee drainages of Virginia, Kentucky, North Carolina, Tennessee, Georgia, Alabama and Mississippi. It also occurs in the upper Savannah drainage in South Carolina and the upper Savannah and Santee drainages in North Carolina. West of the Mississippi River, the whitetail shiner occurs in the St. Frances and White River drainages of Missouri and Arkansas (Page and Burr 1991).

Outside of South Carolina, the warpaint shiner and the mirror shiner occur in the upper Tennessee River drainage of western Virginia, western North Carolina, eastern and southern Tennessee and northern Georgia. The warpaint shiner also occurs in northern Alabama. The Tennessee shiner occurs throughout most of the Tennessee drainage in Alabama, Georgia, Tennessee, North Carolina, Tennessee and Kentucky.

The river chub occurs in Atlantic drainages from the Susquehanna River in New York to the James River in Virginia; in the Great Lakes basin from New York to Michigan; in the Ohio River basin from New York to eastern Illinois and south to northern Georgia and Alabama. The river chub is also present in the upper Santee River in North Carolina and the upper Savannah River in South Carolina and Georgia (Page and Burr 1991).

The longnose dace occurs throughout most of the continental United States and Canada. The banded darter also has a wide distribution; it occurs in the Lake Michigan and Mississippi River basins from Minnesota to New York and south to northern Alabama and Georgia.

Population Size and Trend

Information on population size and status is limited for these species. From what is known about the upper Savannah River drainage, it appears that the whitetail shiner, the warpaint shiner, the mirror shiner, the Tennessee shiner, and the longnose dace can all be found in the Chattooga River. There have been no recent records of the banded darter or the river chub from either the Chattooga or Seneca River drainages. The banded darter may have been extirpated from the state, the last known collection occurred in 1986 (F. Rohde, pers. comm.). Outside of South Carolina, all of these species, including the Florida gar, are considered to be stable and often common (NatureServe 2004).

Habitat and Natural Community Requirements

All four of these shiner species inhabit clear coolwater streams and rivers with moderate to high gradients (Jenkins and Burkhead 1993) and gravel and rubble substrates. The warpaint shiner and the mirror shiner are generally found in the slower moving areas associated with pools, slow runs and riffle margins. The whitetail shiner is common in deep pools near riffles and is often associated with large boulders and rocky banks (Mayden 1989). As with other *Cyprinella* species, the whitefin shiner is a crevice spawner, depositing eggs in crevices of logs and rocks and thus requires coarse substrates and instream structures such as logs to deposit its eggs (Rohde et al 1994). The Tennessee shiner inhabits the midwater areas of riffles, runs and pools adjacent to moderate and swift current (Jenkins and Burkhead 1993). The warpaint shiner and, to a lesser extent, the Tennessee shiner are dependent on chub nests (*Nocomis* spp.) for reproduction. The Tennessee shiner has also been observed spawning in shallow gravel runs without nests (Jenkins and Burkhead 1993).

The river chub is generally found in small to medium sized warmwater rivers with moderate to high gradient. This species occupies swift current and runs with gravel and boulder substrates. The longnose dace is found in high gradient streams and small rivers with substrates of sand, gravel or rock. This species has been found in very swift currents of two feet per second (0.6 meters per second) (Rohde et al. 1994).

Florida gar inhabits large rivers with low gradient, often occupying the sluggish pools and backwater areas with mud and sand substrates. Flooded bottomlands are important for reproduction of this species (NatureServe 2004).

Challenges

Although all of these species are currently stable throughout the majority of their ranges, their limited distribution in South Carolina makes them vulnerable to imperilment within the state. Because of their limited distribution within South Carolina, they are especially vulnerable to development within the Chattooga River system. The major challenges to these species are deforestation, loss of riparian cover, siltation and impoundments.

Conservation Accomplishments

There are currently no conservation accomplishments known at this time for these species.

Conservation Recommendations

- Determine statewide distribution and population status of the whitetail shiner, the warpaint shiner, the Tennessee shiner, the mirror shiner, the river chub, the longnose dace, the banded darter and the Florida gar with statewide stream surveys.
- Describe life history and habitat requirements of the whitetail shiner, the warpaint shiner, the Tennessee shiner, the mirror shiner, the river chub, the longnose dace, the banded darter and the Florida gar.
- Identify critical habitats and areas with healthy populations of the whitetail shiner, the warpaint shiner, the Tennessee shiner, the mirror shiner, the river chub, the longnose dace, the banded darter and the Florida gar. Protect these areas, once identified.
- Conduct targeted surveys of the Seneca River Basin to confirm the existence or extirpation of the whitetail shiner, the longnose dace and the banded darter. Surveys should be

concentrated on the Toxoway River and the tributaries of Lake Jocassee. Protect these areas, once identified.

- Protect critical habitats from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible landuse planning.
- Consider species needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative affects of crossing streams at multiple locations and using stream bottoms as trails.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect most of these species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures.

CHAPTER 9: FRESHWATER SNAILS

Buffalo Pebblesnail

Gillia altilis

Contributor: Jennifer Price

Description

Taxonomy and Basic Description

The Buffalo pebblesnail has a simple, smooth shell with a very low spire. It is tan or brown in color and reaches a size of 6 to 8 mm (0.24 to 0.32 inches) in length (R. Dillon, College of Charleston, pers. comm., March 6, 2005).

Status

The status of the Buffalo pebblesnail is currently under review for state listing by the South Carolina Natural Heritage Program; this state appears to represent the southern end of this snail's range. It is considered stable (S5) in both Virginia and North Carolina and critically imperiled (S1) in New York (NatureServe 2005). However, lack of recent records for the Buffalo pebblesnail in Virginia and North Carolina leave some doubt about the accuracy of the S5 rankings in those states. In South Carolina, the Buffalo pebblesnail has only been found at one site in recent years.

Population Distribution and Size

The historic range of the Buffalo pebblesnail is along the Atlantic coast from South Carolina to New Jersey. It has been introduced to the Great Lakes area and possibly to Vermont (Benson 2005). In South Carolina, it was originally reported in the Santee Canal, which ran from the Port of Charleston to the Santee River (Lea 1841). In the late 1980s, the Buffalo pebblesnail was found in many localities in Virginia (Steve Roble, Virginia Department of Conservation and Recreation, personal communication, February 8, 2005) and was common in Lake Champlain in Massachusetts (Doug Smith, Assistant Dean, University of Massachusetts, personal communication, January 27, 2005). However, very few populations have been found in recent years. It is not clear whether reduced sightings of the Buffalo pebblesnail is due to a decline in its global abundance or to the fact that few people are conducting extensive surveys for snails.

Habitat and Natural Community Requirements

Little is known about the habitat requirements for the Buffalo pebblesnail. Its presence in the great lakes indicates that it can be found in cold, clear lakes; however, it can also be found in streams and rivers (Benson 2005).

Challenges

Currently, the relative abundance of the Buffalo pebblesnail is unknown. More information about this species' habitat requirements and population trends is needed to determine specific challenges.

Conservation Accomplishments

There are currently no known conservation accomplishments for the Buffalo pebblesnail.

Conservation Recommendations

- Conduct surveys to determine the range, status and habitat requirements of the Buffalo pebblesnail to better understand this species.
- Explore the need to determine special concern status for the Buffalo pebblesnail, based on survey results.

Measures of Success

Additional knowledge about the Buffalo pebblesnail will allow for proper management of this species.

Pebblesnail

Somatogyrus spp.

Contributor: Jennifer Price

Description

Taxonomy and Basic Description

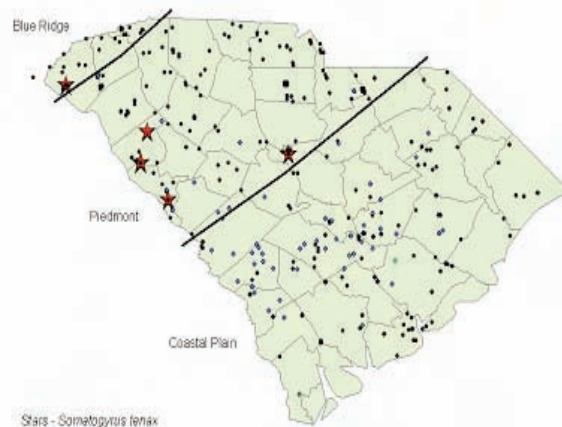
This pebblesnail has a small, brown spiral-shaped shell approximately 3.6 mm (0.14 inches) in length; it was recently found in South Carolina and its identity is somewhat questionable. Two possible identifications for this species are the Savannah pebblesnail (*Somatogyrus tenax*) and the panhandle pebblesnail (*Somatogyrus virginicus*). However, neither of these species has previously been documented in South Carolina. The Savannah pebblesnail is thought to be endemic to Georgia. The panhandle pebblesnail is found in Virginia and North Carolina. Dillon (2004b) now believes that the Savannah pebblesnail is synonymous with the panhandle pebblesnail; however, the malacological community has not yet evaluated this claim.

Status

Because this pebblesnail has not been definitively identified, its current status is not known. However, because all *Somatogyrus* species in the southeast are rare, we expect the status to be endangered, threatened or special concern. This snail is likely one of two species; therefore, their status is provided. The Savannah pebblesnail has a ranking of S2 and G2/G3 in Georgia (NatureServe 2004). The panhandle pebblesnail is ranked as G1/G2 and S1 in both Virginia and North Carolina (NatureServe 2004).

Population Distribution and Size

In South Carolina, the unknown pebblesnail has been found at five sites in Oconee, Abbeville, McCormick and Richland Counties. The following map shows stars at the locations where this species was found during Dillon's survey (2004a); these represent the only known locations for this species in South Carolina. Dots indicate other sites that were surveyed. This range map may not be an exhaustive description of the range of this species in the state.



Habitat and Natural Community Requirements

Somatogyrus spp. is found in the piedmont and lower parts of the Blue Ridge Mountains. It is restricted to streams and rivers with very clear flowing water and a rocky substrate (R. Dillon, College of Charleston, pers. comm., July 28, 2004).

Challenges

Siltation of streams and rivers through agricultural runoff and erosion of unstable stream banks appears to be the main challenge to *Somatogyrus* spp.. 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). 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.

Conservation Accomplishments

There are currently no known conservation accomplishments for *Somatogyrus* spp..

Conservation Recommendations

- To promote awareness, encourage protective riparian buffers through landowner education programs in areas where *Somatogyrus* spp. is found. Specifically focus on Cedar Creek in northwestern Richland County where land use is rapidly being transformed from rural to suburban land uses.
- Encourage establishment of conservation easements in areas where *Somatogyrus* spp. is found. Specifically focus on Cedar Creek in northwestern Richland County.
- Work with partners to establish appropriate recommendations for riparian buffer widths and minimization of impervious surfaces in South Carolina that will help protect stream health.
- Develop a landowner education program to promote sound land stewardship practices that result in the reduction of non-point source pollution in water bodies. Specifically focus education efforts in the vicinity of known occurrences for *Somatogyrus* spp.
- Determine the taxonomy of the *Somatogyrus* spp. either through a combination of extensive morphological studies and genetic investigations.
- Once the taxonomy of *Somatogyrus* spp. is resolved, determine the appropriate status for this species.

Measures of Success

One way to measure success of conservation measures is to determine the amount of riparian buffer protected or replanted as a result of landowner education programs. Another measurement of success would be to determine whether local and county municipalities work to protect or maintain riparian buffers. Ultimate identification of *Somatogyrus* spp. would also represent a measure of success.

Snail

Physa species nov “A”

Contributor: Jennifer Price

Description

Taxonomy and Basic Description

This snail was recently discovered and is in the process of being described (Wethington and Dillon 2005). It may previously have been found in South Carolina and confused with *Physa acuta* (8.3 mm, 0.32 inches) and *P. hendersoni* (6.7 mm, 0.26 inches). However, this species is larger than either *P. acuta* or *P. hendersoni*; this undescribed snail is 12 mm (0.47 inches) in total length. Dillon (2004a) observed that this snail will produce sterile hybrid offspring with *P. acuta* in the laboratory; however, it did not hybridize with *P. hendersoni*.

Status

This snail was recently found at eight sites in Dillon’s (2004a) South Carolina survey, which indicates that it may not be particularly rare. However, we have very little information on this species. Until the taxonomy of this snail is completed and additional surveys are conducted, we will not be able to determine its status.

Population Distribution and Size

This undescribed snail was first discovered in a ditch on John’s Island in Charleston County and has been found at several sites on the coastal plain. This snail has also been found in one location in North Carolina. Because this species has previously been confused with others, it may be present in more locations than have currently been determined.

Habitat and Natural Community Requirements

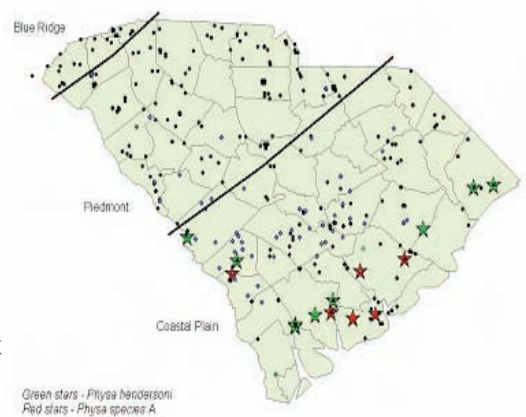
Physa sp. nov “A” has been found in seasonally drying ponds in forested swamps in the coastal plain where the water is not acidic. As stated above, this species can also be found in agricultural ditches; it was first discovered in a ditch on John’s Island in Charleston County. (Rob Dillon pers. comm., July 28, 2004).

Challenges

Little is known about the potential challenges to this snail. It may not be particularly threatened and does not appear to be restricted to pristine habitats. However, the fact that we know so little about its life history and habitat requirements make it a priority species for further research in South Carolina. Further, it is important to determine the taxonomic status of this unknown snail to fully determine its status.

Conservation Accomplishments

There are currently no known conservation accomplishments for *Physa* sp. nov “A.”



Conservation Recommendations

- Complete the description of this *Physa* sp. nov “A” and determine its taxonomic relationship with other species through consultation with malacological experts or genetic investigations
- Conduct studies to determine the habitat requirements of *Physa* sp. nov “A.”
- Conduct surveys to determine whether *Physa* sp. nov “A” is present at other sites in South Carolina.

Measures of Success

Publication of a formal description of this species will represent one measure of success. Determining the exact distribution and habitat/natural history needs of *Physa* sp. nov “A” would also be considered to be a success.

Ridged Lioplax

Lioplax subcarinata

Contributor: Jennifer Price

Description

Taxonomy and Basic Description

The ridged lioplax is a small snail, less than 35 mm (1.37 inches), with a thick spiral shell and whorls with a median low ridge.

Status

The ridged lioplax was originally reported to range from New York to South Carolina. A single specimen was discovered in South Carolina in July 2004 at Lee State Natural Area in Bishopville, Lee County. Two additional specimens were found on the Waccamaw River later that month in Horry County. The species is somewhat more abundant in other parts of its range. NatureServe (2005) identifies the ridged lioplax as S1 status in South Carolina, S3 status in North Carolina and S5 in Virginia, but presumed extirpated in New York.

Population Distribution and Size

Dillon’s survey in South Carolina (2004) did not locate any specimens of the ridged lioplax. The discovery of three individuals in Lee and Horry Counties suggests that it may be extremely rare in this state.

Habitat and Natural Community Requirements

The ridged lioplax is a burrowing species that prefers sandy substrates. Its greater abundance farther north suggests that it prefers cooler climates. One individual found in South Carolina was found in a shallow, clear water section of the Lynches River on a substrate composed of sand and medium-sized pebbles (Laura Kirk Park Interpreter, Lee State Natural Area, personal communication, July 29, 2004.). Two additional specimens were found on the Waccamaw River in an area with dark tannic waters, a muddy substrate, a wide riparian buffer and a stable streambank (T. Savidge, pers. comm., 2005).

Challenges

Based upon its moderate abundance elsewhere, it appears that the ridged lioplax is rare in South Carolina because it is at the edge of its range. However, one recently discovered specimen was found in a very clean stretch of the Lynches River along with other sensitive macroinvertebrates (Laura Kirk 2005). The additional specimens from the Waccamaw River were found in an area where freshwater mussel diversity was high; such diversity usually indicates excellent water quality (. Savidge, pers. comm., January 25, 2005). Therefore, it is possible that the species is sensitive to water quality. The fact that the ridged lioplax needs to burrow in sand instead of other, more fine-grained material also suggests that this snail may require highly oxygenated clean water environments (R. Dillon, College of Charleston, pers. comm., July 29, 2004).

Conservation Accomplishments

There are currently no known conservation accomplishments for the ridged lioplax.

Conservation Recommendations

- Conduct studies to determine the habitat requirements of the ridged lioplax.
- Conduct surveys to determine whether the ridged lioplax is present at other sites in South Carolina. Concentrate surveys based on the habitat requirements of this snail (in areas of pristine water quality with sandy bottoms).
- Develop a landowner education program to promote sound land stewardship practices that result in the reduction of non-point source pollution in waterbodies. Specifically focus education efforts in the vicinity of known occurrences for the ridged lioplax.
- Work with partners to establish appropriate recommendations for riparian buffer widths and minimization of impervious surfaces in South Carolina that will help protect stream health.
- Explore the need to determine special concern status for the ridged lioplax, based on survey results.

Measures of Success

Monitor the number of individuals that are reached through the landowner education program and survey those individuals to determine whether they implement stewardship practices conveyed in that program. Additional knowledge about the ridged lioplax will allow for proper management of this species.

CHAPTER 10: INSECTS

American Sand Burrowing Mayfly

Dolania americana

Contributor: W. Patrick McCafferty

Description

Taxonomy and Basic Description

The American sand burrowing mayfly was originally described by G.F. Edmunds and J.R. Traver in 1959 from South Carolina based on the aquatic larva, which was the only stage known at that time. Eggs were first described in 1964 by R.W. Koss and adults were first described in 1971 by W.P. McCafferty. This remains the only named species of the strictly American genus *Dolania*. It is a member of the Northern Hemisphere family Behningiidae (the tuskless burrowing mayflies), of the infraorder Palpotarsa, suborder Furcatergalia, order Ephemeroptera (McCafferty 2004). Behningiidae are one of the smallest families of mayflies, with a total of three genera and six species known worldwide.

The Ephemeroptera, or mayflies, are primitive insects that, along with the dragonflies (Odonata), are considered Paleopterous insects; as such, they are not able to fold their wings, as are all other modern insects. Mayflies are aquatic insects, with both the eggs and larvae residing in freshwater. As such, mayflies are a major component of communities of invertebrates that live on or in the bottom substrates of streams and shallow zones of lake and ponds. Mayflies are unique among insects in that in their life cycle, they have a fully winged pre-adult stage known as a subimago as well as a fully winged adult stage. In all other winged insects the fully winged condition is restricted to the reproductively mature adult stage. Both the subimago and adult stages do not feed and are terrestrial (aerial) rather than aquatic. The name of the order is based on the word “ephemeral” and is an allusion to the fact that most mayflies have a generally very short adult life span (less than an hour in some).

Eggs of mayflies are generally oval in shape and usually have a sticky covering or string-like attachment structures that help them become attached to bottom substrates after being deposited on the surface of water by females. The females of most mayfly species produce from 500 to 4,500 eggs. While the eggs of Behningiidae are the largest known for mayflies, as much as 1.0 millimeter (0.04 inches) in diameter, each female American sand burrowing mayfly carries only about 60 eggs, which is the lowest number known among mayflies (Fink et al. 1991).

Larvae of mayflies demonstrate a large degree of diversity ranging from sleek minnow-like swimming forms to extremely robust crawling forms to highly flattened clinging forms. Behningiidae larvae are relatively large at nearly 1.5 centimeters long (0.6 inches), somewhat flattened, and have a large number of atypical mayfly characteristics that are associated with their burrowing in coarse sand and their predaceous feeding habits. Compound eyes and antennae of mayflies are well developed. Mayfly mouthparts are on the underside of the head and show adaptations mainly for gathering small decaying material and diatoms, although some species have specializations for predation, filter feeding or scraping.

The Behningiidae are one of only a very few groups of mayflies that are predatory (Tsui and Hubbard 1979) and, in this respect, have unusually sharp mandibles and heavily muscled palps

for impaling and manipulating prey. All mayfly larvae have wingpads associated with their three-segmented thorax (a larger pair on the second thoracic segment and a smaller inconspicuous pair on the third thoracic segment), and these wingpads become darkened just prior to molting to a fully winged form. In Behningiidae, the first pair of legs is palplike, the second pair is broad with well-developed spination, and the third pair is very long and has considerable spination. Unlike all other mayflies, Behningiidae larvae lack claws at the end of the legs. The absence of claws is probably related to the fact that the Behningiidae do not use their legs to crawl, but instead the legs have various raptorial or protective functions. On the 10-segmented abdomen of mayfly larvae, pairs of gills (one pair per segment) are present, usually on segments 1 through 7 or 2 through 7, with some reduction in numbers in certain mayflies. In Behningiidae, gills 2 through 7 are well-developed, each with a narrow-elongate leaflike portion that is fringed on either side with long filaments. Unusual for mayflies in general, the gills of Behningiidae are held underneath the abdomen rather than at the sides or above.

Mayfly larvae have either two or usually three tails (as in Behningiidae) at the end of the abdomen. The long, armed hindlegs of Behningiidae are held along the sides just below the abdomen so that they protect the gills from abrasion while the larva is immersed in coarse sand. Within this so-called gill chamber that is formed by the body and legs, the gills beat freely and steadily to aid in the uptake of dissolved oxygen from the water. The head and mouthparts of Behningiidae are also protected from abrasion, mainly by strong tufts of spines laterally and dorsally in that area of the body. Such tufts of spines are not found in other mayflies.

Both the subimagos and adults of mayflies are referred to as alates (bearing wings). The alates are fragile forms with vestigial, non-functioning mouthparts, small antennae, large compound eyes (more so in the males) and a pair of large, net-veined, more or less triangular shaped forewings and a smaller pair of hindwings. The wings are held together directly above the body when at rest. Forelegs of male adults are very long and aid in holding the female from below when mating. The abdomen ends in either two or three well-developed, often very long tails (see illustration immediately below). Differences are subtle between the subimago and adult stages. The subimago has duller wings and cuticle and, in males, the forelegs, eyes and genitalia are not as well developed as they are in adults. Alates of Behningiidae are unusual mayflies in several respects. Except for only a few other mayflies, the female subimago does not molt to an adult stage and is therefore reproductively mature and mates as a subimago. This is not the case with the male, having both a subimago and adult stage. Also, the legs of the alate Behningiidae are reduced and non-functional, so that these mayflies are unable to perch or walk about as most other mayflies can. While the two lateral tails are very long, the middle tail is considerably shorter and thinner.

Mayflies generally have one, two or three generations per year. The American sand burrowing mayfly is unusual for mayflies in that it has a two year life cycle (Harvey et al. 1980). Alates of this species emerge from the water (hatch) consistently within about a 30-day period each spring or early summer, depending on the exact location of the populations. The hatch takes place in the pre-dawn hours, with males preceding females and soon thereafter molting to adults. Male adults mate with female subimagos as soon as the females begin to hatch. These insects may be the quintessential “ephemeral” mayflies in that, according to Peters and Peters (1984), this species emerges from the water, mates, lays eggs and dies within a few minutes.

Status

The American sand burrowing mayfly is known from Alabama, Florida, Georgia, Louisiana, North Carolina, South Carolina and Wisconsin. It currently has a global environmental ranking of apparently secure (G4). Although there are possibly six or more documented populations of the species in South Carolina based on different specific sites reported, it is ranked as vulnerable (S3) because it should be carefully monitored with respect to its somewhat unusual and specific habitat requirements and restrictions.

Population Distribution and Size

The American sand burrowing mayfly is known from up to four populations with overlapping generations on Upper Three Runs Creek in Aiken County, but also from the Savannah River proper in Aiken, Barnwell and Allendale Counties. For South Carolina, only quantitative population data exist for the species on Upper Three Runs Creek (Sweeney and Vannote 1982). At the time of emergence, based on counts of larval skins on the water, around 2,800 individuals emerged in 1978, around 600 in 1979, and over 100,000 in 1980. More recent data for population size estimates are not available.

**Habitat and Natural Community Requirements**

Little is known about the specific aquatic habitat requirements of the American sand burrowing mayfly at this time. Based on field observations and laboratory observations, one primary requirement is the presence of beds of coarse sand substrate wherein the larvae must reside. McCafferty (1975) showed that larvae burrow down in clean, well-aerated sand to a depth of 10 to 30 cm (4 to 12 inches), although it has been reported from shallower depths in the field (Tsui and Hubbard 1979). The gill chambers are maintained in coarse sand of 0.25 to 1.0 millimeters (0.001 to 0.03 inches), in diameter, but cannot be efficiently maintained in finer sand or silted substrates. The major food resource for the American sand burrowing mayfly is made up of midges that occur in this same habitat.

The aquatic insect fauna of Upper Three Runs Creek has been extensively documented (Morse et al. 1980, 1983). All 22 mayfly species reported from this stream have a global ranking of apparently secure (G4) or secure (G5) and are not considered at any level of risk at this time. However, with respect to mayflies that were expected but not found by Morse et al. (1980), those authors indicated that many hours of specialized sampling are needed to obtain even a small number of individuals of some species, including the American sand burrowing mayfly.

In addition to consuming a variety of sand-dwelling midge larvae (Diptera: Chironomidae), the American sand burrowing mayfly also preys on microcrustacea, biting midge larvae (Diptera: Ceratopogonidae), nematodes, and occasionally tartigrades. One competitor for the same food resources has been identified as a *Progomphus* dragonfly (Odonata: Gomphidae) (Tsui and Hubbard 1979). Some fish and whirligig beetles (Coleoptera: Gyrinidae) will prey on the American sand burrowing mayfly. Further, terrestrial predators of this species include nighthawks, sparrows, bats, dragonflies and spiders (Sweeney and Vannote 1982).

Challenges

Cedar Creek, which arises in Aiken, South Carolina, is the main tributary to Upper Three Runs Creek. It is expected that the considerable residential development along Cedar Creek has introduced sediments from excavation works and erosion, lawn-care chemicals from landscaping, and petrochemicals from roads. It has also led to reduced base flow rates and accentuated spates. The incursion or increase in artificial lights near the habitat is also a detriment to most mayflies in that they attract alates away from their natural breeding grounds, which incapacitate them and reduce population reproduction rates.

All reports of the American sand burrowing mayfly are from “clean” shifting sand in high quality water. Therefore, it is essential that water quality is maintained and that sedimentation be prevented. Such perturbations would alter necessary oxygen levels in the water and the coarse sand burrowing substrate required by the species and its prey. The fact that the American sand burrowing mayfly does not occur between upper Wisconsin/Minnesota and the lower southeast, as other sand dwelling mayflies such as *Pseudiron* and *Acanthametropus* do is probably because intervening riverine sand substrates are too fine, such as those associated with the Wisconsin River in lower Wisconsin, the Niabrara River in Nebraska, the Pecatonica River in Illinois and the White River in Indiana.

Conservation Accomplishments

Upper Three Runs Creek is protected at the Savannah River Site; however, a variety of off-site anthropocentric activities as discussed above have degraded water and substrate quality in Upper Three Runs Creek in recent years. The extent of such degradation and any direct or indirect effects it has had on the American sand burrowing mayfly at the Savannah River Site or elsewhere on the creek are unknown at this time, as is the degree to which any protection practices have offset the sum effects of such degradation.

Conservation Recommendations

- Determine water quality in Upper Three Runs Creek, both upstream of and at the location of the American sand burrowing mayfly habitat, protect or restore superior water quality depending on results from this survey.
- Protect critical habitats for the American sand burrowing mayfly from future development and further habitat degradation by following best management practices and protecting riparian areas.
- Promote land stewardship practices through educational programs both within and upstream of Upper Three Runs Creek.
- Encourage responsible land use planning.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Black Fly

Ectemnia invenusta

Contributor: Peter H. Adler

Description

Taxonomy and Basic Description

Ectemnia invenusta was described by Francis Walker in 1848 from adults collected in Canada. The species was originally described in the genus *Simulium* and later transferred to the genus *Cnephia* before it was finally established as a member of the genus *Ectemnia*. The larvae and pupae were not discovered until the late 1940s. Black flies are members of the family Simuliidae, in the order Diptera, suborder Nematocera.

Adult black flies are stout-bodied insects somewhat resembling a buffalo, with a wingspan of about 3 to 9 mm (0.12 to 0.35 inches). They are typically dark colored, but also can be gray, orange, yellow or iridescent. They are well-known pests of humans and their animals, their economic importance stemming from the female's requirement for a meal of bird or mammal blood to mature the eggs. However, only about 16 percent of the 255 species in North America are pests. The majority of species take blood inconspicuously from wildlife, and about 10 percent of the North American species do not feed on blood.

Females lay their eggs in streams and rivers; the larvae and pupae develop exclusively in flowing water. Larvae are beneficial elements of the food web of running waters, serving as prey for many aquatic organisms. They filter their food from the water current, using a specialized pair of head fans. Larvae spin a silken cocoon onto an object in the current and pupate within this silken shroud. The pupa is recognized by a pair of gills issuing from the anterior of the thorax. The adult splits the skin of the pupa and pops to the surface of the water in a bubble of air. Most species of black flies have specific habitat requirements often related to the rate of water flow.

Adult black flies are dark colored and among the largest black flies in North America. They have a costa with spinules and fine setae and a dorsally haired radius. Females have a frons about four times as long as its narrowest width, claws each with a large thumblike lobe, and an elongate wrinkled spermatheca. Males have a ventral plate with the body about two and one-half times broader than long and tapered posteriorly in ventral view, gonostyli each with two or three apical spinules, and numerous short parameral spines.

The black fly pupa has a gill of eight apically convergent filaments; the third pair of filaments from the dorsum arises from a very short stalk. The cocoon is slipper shaped with an irregular anterior margin, and is situated near the end of a silken stalk that is spun by the larva. The larva has flanges on the fifth through eighth abdominal segments. The polytene chromosomes of South Carolina populations were described by Moulton and Adler (1997). The sex chromosomes of South Carolina populations are undifferentiated and are, therefore, similar to those of Pennsylvania populations, but different from those in Canada (Adler et al. 2004).

Status

This species has no official status but is range restricted.

Population Distribution and Size

The genus *Ectemnia*, with its four constituent species, is restricted to North America. Three of these species occur in South Carolina. *Ectemnia invenusta*, although having the widest distributional range of the three species, is known from only one river in South Carolina, the Chattooga River separating Georgia and South Carolina, where it reaches its southernmost distribution limit (Adler et al. 2004). In the northern portion of its range (Canada and New England), The black fly produces large populations in the early spring.

However, the only known population in South Carolina (Chattooga River, Oconee County), although not quantified, is thin and difficult to sample in the swift, bitterly cold water of winter.



Habitat and Natural Community Requirements

Black fly larvae and pupae inhabit the rapids of the Chattooga River, where they attach their silken stalks to rocks. Only one generation is produced each year. Larvae hatch in the fall, beginning about October, and begin to reach maturity in January (Adler et al. 2004). The adults emerge in January and February. No natural enemies of this species have been recorded, although they surely exist. The adult females feed on the blood of birds such as Canada geese, mallards and ruffed grouse.

Challenges

The stability of the South Carolina population of black flies depends on the maintenance of water quality in the Chattooga River. Clear, cold, well-oxygenated, unpolluted river water is essential. Maintenance of South Carolina's black fly population is dependent on a protected riparian zone along the Chattooga River to maintain water quality of the breeding site. Maintenance of superior water quality in the Chattooga River will not only ensure ideal breeding grounds for this species but also for numerous other aquatic organisms, some of which (blepharicerid midges) also are known only from the Chattooga River. Other specific terrestrial factors are presently unknown.

Conservation Accomplishments

There are no specific conservation accomplishments for the black fly.

Conservation Recommendations

- Protect critical habitats for the black fly from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat for the black fly.
- Encourage responsible land use planning.
- Consider species needs when participating in the environmental permit review process.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Calvert's Emerald

Somatochlora calverti

Contributor: Wade B. Worthen

Description

Taxonomy and Basic Description

Calvert's Emerald was first described by Williamson and Gloyd (1933). It is in the suborder Anisoptera, family Libellulidae, and subfamily Corduliinae.

Like all dragonflies, the aquatic larvae and the aerial adults are predators. Eggs are laid in summer, and then the larvae proceed through a series of molts over the course of the next year (or few years). Each larva crawls from the water to the bank or surrounding vegetation to molt, and the adult emerges. Several hours are needed for the complete expansion and hardening of the wings; during this period the dragonfly is referred to as a 'teneral', and the wings are often pliable and somewhat iridescent.

As with all libellulids, the triangle of the forewing is farther from the arculus than the triangle of the hindwing (triangles in red, in photo to the left). In addition, the long axis of the forewing triangle is perpendicular to the long axis of the wing, whereas the long axis of the hindwing triangle is parallel with the long axis of the wing. There is a distinct anal loop but without a distinct "toe" (anal loop in yellow in photo); this is typical of the subfamily Corduliinae. The thorax has a strong blue-green metallic sheen.

Like many species of *Somatochlora*, the females have a "thorn-like" subgenital plate that projects ventrally, (see area circled in photo at right) perpendicular to the axis of the abdomen. Males have a large pale dorsal spot on abdominal segment 10 and long setae on the cerci, whereas females have brown streaks on their wings between the costa and radius, from the nodus to the pterostigma (Needham et al. 2000).

Status

This species is classified in the Natural Heritage designations as vulnerable (G3) and described as 'rare' and 'without threat' (Bick, 2003). This designation specifies 12 to 100 occurrences nationally.

Population Distribution and Size

This species is recorded from southeastern Alabama, the panhandle of Florida and South Carolina (Needham et al. 2000). Range maps include a narrow band through central Georgia to connect the Florida and South Carolina populations (Dunkle, 2000), but the species has not been collected from Georgia. In South Carolina, the species was collected in Allendale County on 19 August, 1977, from a small unnamed pond on SC Highway 641, one mile east of Sycamore, South Carolina by T.R. White and P.H. Carlson (White et al. 1980). Calvert's emerald was reliably identified by K.J. Tennessen (White et al. 1980).



Habitat and Natural Community Requirements

The larval habitat is unknown, but most authorities suggest boggy forest seepages (Needham et al. 2001). The thorn-like ovipositor suggests that females may lay eggs in wet sand, mud or algae in or near very shallow water (Huggins and Brigham 1982). Adults forage on midges and small insects along roads in forests, or high above treetops in open areas between tree crowns (Dunkle 2000). The flight season for Calvert's emerald is mid-June to late August (Dunkle 2000).

Challenges

Although no specific challenges can be defined for this species, there are several general activities that can affect dragonfly populations (Dunkle 2004). The primary impact to terrestrial habitats lies in habitat conversion. For this forest dwelling species, land clearing and development represent the most significant challenge.

Again, the specific larval habitat is unknown for this species, but forest seepage areas are implicated. These habitats are particularly sensitive to changes in aboveground vegetative cover that can have a profound effect on water temperature, flow rates and sediment type. So again, land clearing and development represent the primary challenge to the aquatic habitats that may contain Calvert's emerald larvae.

Conservation Accomplishments

There are no known conservation accomplishments for Calvert's emerald.

Conservation Recommendations

- Conduct surveys to determine the distribution of Calvert's emerald in South Carolina.
- Initiate intensive, yet non-destructive sampling efforts at the location in Allendale County where the state's only specimen has been collected.
- Explore the need to list Calvert's emerald in South Carolina, based on survey results.
- Identify and protect critical habitats for Calvert's emerald from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat for Calvert's emerald.
- Encourage responsible land use planning.
- Consider species needs when participating in the environmental permit review process.

Measures of Success

Determination of the range and preferred habitat for the Calvert's emerald would indicate a measure of success for this species.

Coyle's Purseweb Spider

Sphodros coylei

Contributor: Robert J. Wolff, Ph.D.

Description

Taxonomy and Basic Description

Purseweb spiders of the family Atypidae (“**atypical tarantulas**”) are members of the primitive mygalomorphs. The **atypical tarantulas** consist of only two genera; in the United States these are *Sphodros* and *Atypus*, and in Europe, Asia and Africa only *Atypus*. These are spiders in the suborder Orthognatha of the order Araneae. The related mygalomorphs in South Carolina include trapdoor and folding trapdoor spiders; all are rarely found. This may be due in part to their secretive habits, but is primarily due to their apparent need for fairly undisturbed woodland habitat with a good soil/leaf litter cover.

This species account is based on a single male found wandering in leaf litter in a woodland area within the boundaries of the town of Clemson, Pickens County, South Carolina. The genus as a whole is usually dark colored, with the carapace and legs appearing hairless and shiny. The legs may be similar or reddish in color. The abdomen has short hairs, and the spinnerets extend noticeably beyond the abdomen. The males are sometimes brightly colored and may be found wandering around looking for females in their tubes when mature, but the reddish-brown or dark-colored females are rarely found outside of the web. Atypical tarantulas have huge chelicerae for their size and relatively long spinnerets.

Atypus spiders live in silken tubes parallel to the surface of the ground, while *Sphodros* species usually prop their tubes against a tree trunk. A *Sphodros* web is very unique, consisting of a tube of silk, which extends out of the soil burrow up the side of a tree to about six inches. The web may be covered with dirt and other debris.

Status

Known only from its type locality in Clemson, it is important to study this and surrounding areas to see if this species still exists and determine its distribution and population size. Pickens County is one of the most studied counties in the state of South Carolina for its arthropods, but being so poorly known, it might be assumed that *S. coylei* is endangered. While this might prove to be a valid assumption, dedicated research directed toward this species' ecology, range and distribution is needed to determine its actual status.

Population Distribution and Size

Two additional species of trapdoor spiders in the same genera, *Sphodros atlanticus* and *S. rufipes*, have been reported from both North Carolina and Georgia, but not from South Carolina. An additional sister species, *S. niger*, has been reported from North Carolina, while *S. bicolor* has been reported from six counties in the coastal plain and lower piedmont of North Carolina.



Habitat and Natural Community Requirements

Coyle's purseweb spider is a predator. Purseweb spiders dig burrows at the base of trees and then build their unique web, tube-like in construction, up the side of the tree extending upward as far as six inches. The spider usually stays hidden in the web, biting through to capture insects that walk or land on the web. Because of these habits, undisturbed woodlands are critical for members of this genus. Future study should be directed at clearly defining these habitat requirements as they are largely unknown at this point.

Challenges

The greatest impact that affects all purseweb spiders, as well as other soil dwelling mygalomorph spiders, is habitat destruction, especially through urbanization and deforestation. While the specific habitat requirements, including the size of the forested area, leaf litter, soil type and soil condition are all unknown, the apparent rarity of these spiders indicates that they probably require fairly extensive habitat areas to assure species survival. Males leave their webs following maturity and wander to find females to mate with, but it is completely unknown how far they travel. Isolated populations may become non-viable if either the males fail to find females, or if the isolated populations are unable to sustain the inbreeding.

The impact of exotic, invasive species such as the red imported fire ant (*Solenopsis invicta*) may also have a significantly negative impact on these spiders that typically have little mobility. An additional challenge for this species is kudzu; this creeping vine suffocates the soil underneath the trees it climbs and grows on.

Our lack of knowledge regarding the spiders of South Carolina may be one of the challenges that might prevent us from protecting species.

For a more complete discussion, see Gertsch and Platnick (1980).

Conservation Accomplishments

Any protection of large forested areas should help to assure habitat quality. Contiguous forest areas are vital to allow the continued survival of purseweb spiders and their mygalomorph relatives. The protection of the Jocassee Natural Gorges area along the South and North Carolina borders might be critical for several species of spiders.

Conservation Recommendations

- Conduct surveys to determine the distribution of Coyle's purseweb spider in South Carolina.
- Explore the need to list Coyle's purseweb spider in South Carolina, based on survey results.
- Protect critical habitats for Coyle's purseweb spider from development and further habitat degradation by following best management practices.
- Promote land stewardship practices through educational programs.
- Expand education programs to include the importance of spiders in ecosystems throughout South Carolina.

Measures of Success

Further study may prove these species to be relatively rare, but with stable populations. New habitat information may also change assumptions, such as some species being able to survive in grassy areas (Wolff, pers. obs.). Both Virginia and Connecticut each list a purseweb spider on their endangered/threatened list of arthropods.

Diana Fritillary

Speyeria diana

Contributor: Brian Scholtens

Description

Taxonomy and Basic Description

The Diana fritillary (Cramer 1775) is a member of a large genus in the subfamily Heliconiinae of the family Nymphalidae. The genus was named in honor of the famous German lepidopterist Adolph Speyer and the species epithet honors Diana, the Roman goddess of light and life (Opler and Krizek 1984). The species was originally described from specimens taken near Jamestown in Virginia. This eastern Virginia population of *S. diana* has been presumed extirpated since sometime in the 1950's. The genus has been reviewed with updated taxonomy by Howe (1975), Scott (1986), and Opler and Krizek (1984) (for eastern species).

Most species of the genus *Speyeria* occur in western and northern North America (Scott 1986). The species is distributed throughout the middle and southern Appalachians in forested areas and west to the Ozark Mountains in Missouri, Arkansas and extreme eastern Oklahoma (Opler and Krizek 1984; Opler and Malikul 1998; Carlton and Nobles 1996). In South Carolina, the known distribution of the Diana fritillary is limited to counties in the southern Appalachian and upper piedmont ecoregions.

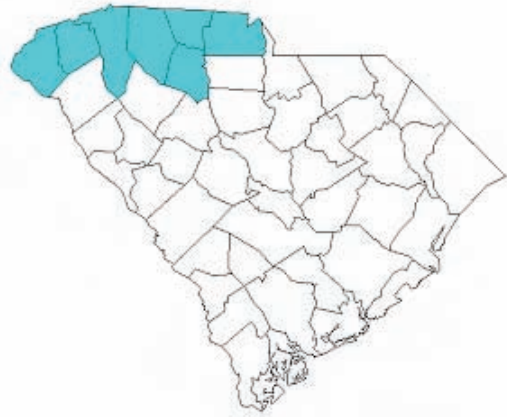
The Diana fritillary is a uniquely dimorphic species of *Speyeria*. Males show the typical fritillary color, but have the orange largely accentuated along the outer margins of the wings, washing out most of the typical outer wing markings. The inner part of the wings is dark, mostly brownish black. The underside is a beautiful burnt orange, with no silver spots as in many *Speyeria*, and much of the typical pattern is obliterated. The only species likely to be confused with Diana males (and mainly just in flight) is *Speyeria cybele*, the great spangled fritillary. It is similar in both size and color, but shows the typical fritillary pattern, with silver spots on the underside of the hindwings. Females, in contrast to the males, are dark blue-black. The typical fritillary pattern is still visible, but indistinct because of the dark ground color. There are lighter blue spots and patches near the edge of the wing (Opler and Malikul 1998). The female color pattern is thought to mimic *Battus philenor*, the pipevine swallowtail, a toxic butterfly that occurs throughout the range of the Diana fritillary. In addition to female Dianas, the red spotted purple (*Limenitis arthemis astyanax*), spicebush swallowtail (*Papilio troilus*), female black swallowtail (*Papilio polyxenes*), and the dark morph of the female eastern tiger swallowtail (*Papilio glaucus*), all are apparently mimics of the pipevine swallowtail, and all co-occur with the Diana fritillary. Both sexes of the Diana fritillary are rather large butterflies, with wingspans of 88 to 112mm (3 to 4 inches) (Opler and Malikul 1998).

Status

The Diana fritillary is known from seven counties in South Carolina, but is primarily restricted to the mountains and the upper piedmont of these areas. In the mountain regions, the species is likely to be stable, but its status in the upper piedmont is unknown.

Population Distribution and Size

Historically, the Diana fritillary occurred throughout the Southern Appalachian Ecoregion and probably into the piedmont. In North Carolina, the species was recorded from the piedmont and, in Virginia, populations once occurred in the coastal areas (Opler and Malikul 1998). Relatively stable populations probably still occur in several of the counties in the Southern Appalachian Ecoregion of South Carolina. The species was confirmed in the Pickens Ranger District of the Sumter National Forest in 2004 (Scholtens 2004). No estimates of population size have been made.

**Habitat and Natural Community Requirements**

This species is a specialist of forested areas, in contrast to most other eastern members of the genus, which are usually found in more open areas. The Diana fritillary and its congeners feed on violets (*Viola* spp.) as larvae, with *S. diana* feeding on several woodland species. Larvae emerge from eggs laid on the ground in the fall. They overwinter as first instars, very young juveniles; insects typically mature at or near instar five. They begin feeding in the spring and complete development by late spring. They then pupate in the leaf litter, undergo metamorphosis and emerge as adults, generally starting in June. Males are typically the first to emerge, with females following one-and-a-half to two weeks later. During the first part of the summer, males are almost exclusively seen at flowers and actively flying through the habitat. Females become much more apparent later in the summer, starting in late July as they spend more time searching for oviposition sites. Both use a variety of nectar plants as adults, and have been recorded feeding on such sources as milkweed (*Asclepias* spp.) (Opler and Krizek 1984), buttonbush (*Cephalanthus occidentalis*), coneflower (*Echinacea* spp.), and compassplant (*Silphium laciniatum*) (Moran and Baldrige 2002). In the Sumter National Forest in South Carolina during July, the most important nectar source is apparently a common mint (*Pycnanthemum incanum*) (Scholtens 2004). Adults often are seen in openings and along roadsides as they feed on flower nectar, but seldom far from their woodland habitat.

Challenges

Diana fritillary populations have apparently been declining over much of their historical range, but the causes are not well known. Populations of woodland violets are healthy and in most localities, plenty of adult nectar sources are present. One possible cause of declines is the use of BT-based sprays to control gypsy moths. “BT” refers to *Bacillus thuringiensis*, a naturally occurring bacteria widely used in various types of applications as a very effective natural insecticide. One study has shown that Diana fritillary larvae are highly susceptible to these sprays (Peacock et al. 1998). If this hypothesis is true, populations south of the gypsy moth front

should not be affected, while those north of the front would be. Recent surveys in Arkansas have shown that Diana fritillaries are more widespread than originally thought and populations are likely stable in that area (Moran and Baldrige 2002).

Conservation Accomplishments

Conservation study of the Diana fritillary is in its infancy. Populations have been surveyed in several states to determine distribution and status (Lewis 2001). No specific management efforts are known to exist. In South Carolina, a survey was recently performed in the Pickens District of Sumter National Forest, confirming the presence of the species in the forest (Scholtens 2004).

Conservation Recommendations

- Conduct surveys to determine the distribution of the Diana fritillary in South Carolina.
- Monitor any identified populations of the Diana fritillary, particularly before gypsy moth invasions in the vicinity of those populations.
- Determine the effect of gypsy moth control efforts on the Diana fritillary.
- Explore the need to list Diana fritillary in South Carolina, based on survey results.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Elephant (or Treehole) Predatory Mosquito

Toxorhynchites rutilus rutilus

Toxorhynchites rutilus septentrionalis

Contributors: Bradley James Goettle and Peter H. Adler

Description

Taxonomy

The largest mosquitoes (Diptera: Culicidae) in the world are members of the genus *Toxorhynchites*, found primarily in tropical, forested areas. This generic name replaced *Megarhinus*, which is pre-occupied (Stone 1948).

The taxonomy of the 88 *Toxorhynchites* species and subspecies (Jones and Schreiber 1994; Walter Reed Biosystematics Unit 2001) is quite difficult and in need of revision in the American hemisphere. *Toxorhynchites rutilus rutilus* was described in 1896 from a male and several females from Georgia and Florida and from a wrongly associated female from North Carolina (Jenkins 1949). *Toxorhynchites septentrionalis*, previously identified as *T. rutilus*, was first described in 1906 from 13 males and 11 females from Virginia, West Virginia, District of Columbia, Maryland, North Carolina, Mississippi and Louisiana (Jenkins 1949).

Adult males of the two subspecies differ significantly only in leg markings (Michener 1945; Jenkins 1949). These two brilliantly colored day-flying mosquitoes are considered subspecies (Carpenter and Jenkins 1945; Jenkins 1949) for the following reasons: the distributions of the two forms overlap in part of their ranges; a complete series of intergrades between the two forms occurs throughout the zone of overlap in ranges; the only known character separating the two forms is a color difference of the males, which is subject to variation; no significant differences

have been found to separate the two forms in the male genitalia, larvae, pupae, or females, even from reared correlated series of specimens; and the life histories, habitats, and breeding habits of the two forms are similar.

Basic Description

Toxorhynchites are unusually large mosquitoes; the wingspan may exceed 12 mm (0.4 inches) and the body length may exceed 7 mm (0.2 inches). Adults are frequently covered with iridescent scales and the proboscis has a pronounced 90-degree downward curve.

All known species produce multiple generations per year (Bates 1949; Pratt 1959). In the United States, *Toxorhynchites* generally overwinters as late larval instars. Diapause is controlled by day length rather than temperature. In the extreme southern portions of New England, *Toxorhynchites septentrionalis* undergoes a life cycle typical for a number of container-breeding mosquitoes (Bates 1949). This type of life cycle is characterized by having non-desiccation resistant eggs laid directly on water in container habitats; larvae developing in natural or artificial containers; multiple generations each year; and overwintering in the larval stage.

Mosquitoes in the genus *Toxorhynchites* are predaceous as larvae on the immature stages of other mosquito species and often turn cannibalistic. Larvae are generally dark brown or reddish, with conspicuous hairs on the abdomen. The head capsule has a pair of powerful mandibles. Fourth-instar larvae can be more than 2 cm (0.8 inches) in length.

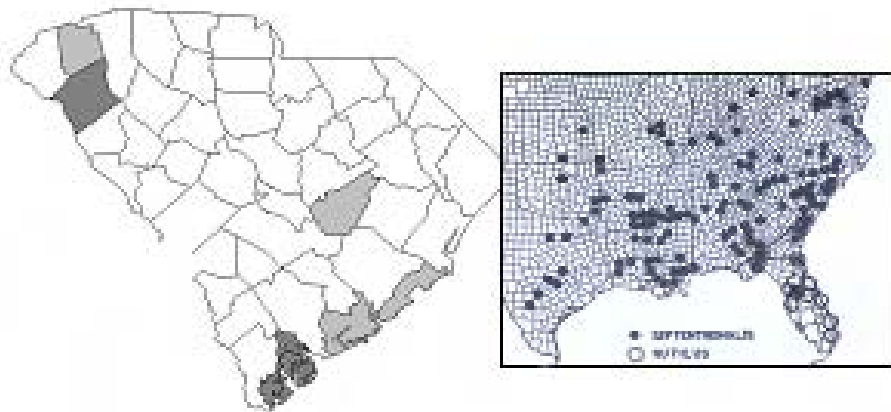
Status

These species currently have no state or federal listing status.

Population Distribution and Size

Toxorhynchites rutilus

rutilus is found throughout peninsular Florida and southern and coastal Georgia north to South Carolina (Basham et al. 1947; CUAC 2005; Jenkins 1949; Jones and Schreiber 1994). *T. r. septentrionalis* is found from New York to Kansas south to Texas and northern Florida (CUAC 2005; Jenkins 1949; Jones and Schreiber 1994).



Population sizes for larvae of these species are typically low in number. For example, each larval predatory mosquito population, such as a population of larvae in water collecting in a discarded tire, usually consists of only a few larvae. Cannibalism is not uncommon, especially in smaller containers; however, containers such as discarded tires with ample food supplies may support half a dozen or more similarly sized larvae.

Habitat and Natural Community Requirements

Adult predatory mosquitoes feed on nectar and other naturally occurring carbohydrate sources but never take blood meals, leading many entomologists to recognize this mosquito's potential to reduce pest and disease-bearing mosquitoes.

The large larvae are found in the water in tree holes (Jenkins and Carpenter 1946), the bases of bromeliads, artificial receptacles, rodent-eaten coconut husks and bamboo stems that hold water. In addition, human-discarded items such as tires, buckets and cans are excellent larval habitats used by pest mosquitoes. These pest mosquito species include those capable of transmitting the causal agents of yellow fever, dengue, and other diseases (PHEREC). Larvae depend on movement for prey location, feeding on the living macroinvertebrates in flooded treeholes, bromeliads and human-made containers. They may eat as many as 400 larval mosquitoes during larval development; cannibalism is not uncommon, especially in small containers. Larval behavior is especially intriguing for biocontrol because killing of pest larvae without feeding has been reported (Jones and Schreiber 1994).

Predatory mosquitoes in the genus *Toxorhynchites* are the most common arthropods that have been used for control of "container-breeding" mosquitoes. The combination of carnivorous larvae and innocuous adults is very attractive in biological control, though limited studies in the United States have not shown continuous larval control with this predator. Successful biological control has been reported using *Toxorhynchites* species from Japan, Southeast Asia, the Caribbean and the United States (Jones and Schreiber 1994).

Toxorhynchites rutilus larvae left a few *Wyeomyia* larvae untouched in feeding experiments, no matter how many they were offered (Frank et al. 1984). Predatory mosquito larvae may conserve their prey in the manner of stock-rearers (Reiter 1985) and might, therefore, be unsuitable as biocontrol agents where survival of the prey is limited by food availability. Predatory mosquito adults will lay their eggs in most types of water-filled containers (Jones and Schreiber, 1994). However, under natural circumstances, these species do not lay enough eggs to keep pest and vector populations in check. Studies that have used predatory mosquitoes to reduce pest mosquitoes in Florida have relied on rearing and releasing additional adults of *Toxorhynchites* to boost naturally occurring populations and get ahead of pest mosquito production (PHEREC).

One of the advantages of a *Toxorhynchites* release program is that the adult mosquito can disperse and lay eggs in areas most likely to escape treatment with insecticides. This method of biological control can result in favorable press coverage and often gives a mosquito control district the opportunity to stress ecologically sound methods while controlling mosquitoes.

Biological control using predatory mosquitoes seldom results in complete control of the targeted population. *Toxorhynchites* release programs need to be timed ahead of estimated increases in mosquito nuisance/vector populations, and the use of adults has the added requirement of nectar availability to complicate timing.

Challenges

The typically low population numbers of these beneficial predators make *Toxorhynchites* highly susceptible to insecticides, and care must be exercised in timing the release of *Toxorhynchites* and application of insecticide sprays.

Although *Toxorhynchites* alone is unlikely to reduce pest or vector species below operational thresholds, it can be a valuable management tool in areas where containers and treeholes

contribute substantially to the standing crop of mosquitoes. Their large size creates the opportunity for them to serve as focal points for public awareness campaigns aimed at the cleanup of human-made containers that are used as breeding sites by pest mosquitoes. However, problems using *Toxorhynchites* for biocontrol include the high labor costs of mass rearing, the short “shelf life” of the eggs (they hatch in fewer than two days) and the high labor costs of distribution.

Conservation Accomplishments

There are no conservation accomplishments to date in South Carolina for *Toxorhynchites* species.

Conservation Recommendations

- Where feasible, promote the use of predatory mosquitoes to assist in managing pest mosquito populations.

Measures of Success

As further research and management needs are identified, projects will be initiated to address those needs. Discovery of new populations could be considered a success.

Forestiera Lace Bugs

(No common names)

Leptoypha elliptica

Leptoypha ilicis

Contributor: Alfred G. Wheeler

Description

Taxonomy and Basic Description

Both adults and nymphs of the family Tingidae are strictly phytophagous. Lace bugs are mostly host restricted, developing on plants of only one genus or several related genera. They are found mainly on woody plants, the nymphs feeding on lower surfaces of leaves. Their feeding on mesophyll tissues usually results in a bleached or chlorotic appearance of the upper leaf surface and dark spots of excrement on the lower surface. Some lace bugs feed on herbaceous vascular plants and species of one genus (*Acalypta*) feed mainly on mosses.

Lace bugs associated with small trees and shrubs of the genus *Forestiera* (olive family; Oleaceae) include two morphologically similar species of *Leptoypha*. McAtee described *L. elliptica* from Texas in 1917; *L. ilicis* was described in 1919 from Georgia by Drake. Only recently was the specific name of the latter species shown to be a misnomer. This lace bug was named *ilicis* because of its assumed host association: *Ilex* sp. Its actual hosts are species of *Forestiera*, the plant mentioned in the original description having been misidentified. *Forestiera* species bear a superficial resemblance to certain species of *Ilex* (holly; family Aquifoliaceae).

Leptoypha species are small (about 3 mm long or 0.12 inches), elongate or narrowly oblong, and straw yellow to reddish brown. A hood (prothoracic covering of the head) and paranota (lateral expansions of pronotum), which characterize many lace bugs, are lacking. Also absent is the translucent lacy appearance of the forewings (hemelytra) that is typical of the Tingidae; elevations of the forewings also are absent. *Leptoypha elliptica* adults are 2.8 to 3 mm (0.11 to 0.12 inches) long, broadly elliptical, widest at the middle of the forewings, which are broadly

rounded at their tips. *Leptoypha ilicis* is more elongate, the body nearly subparallel, and about 2.2 mm (0.08 inches) long.

Nymphs have not been described, but those of other *Leptoypha* species are light brown, oblong or elliptical, flattened, with the dorsal (upper) surface covered with granulate setae or hairs. The margins of the thorax and abdomen bear short, stout spines; the head has two or three apical spines.

Status

No federal or state designation has been given to *Leptoypha elliptica* or *L. ilicis*. These species have no official status but are range restricted. They are known only from the Savannah River Bluffs Heritage Preserve near North Augusta in Aiken County, where they were found on upland swamp privet (*Forestiera ligustrina*). *Leptoypha elliptica* was observed in 1992 and in 2001, whereas a co-occurring population of *L. ilicis* was found only in 2001.

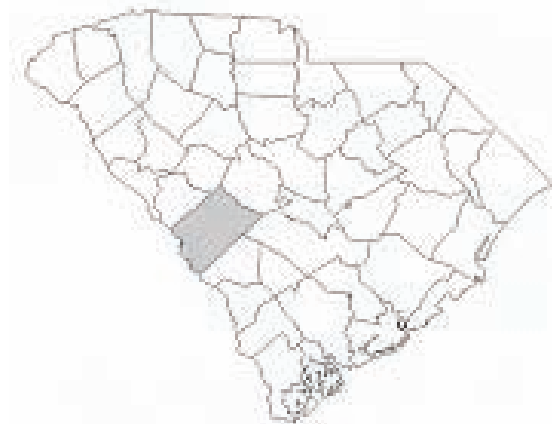
Upland swamp privet is considered rare in South Carolina where it is known only from Aiken and Edgefield counties. It is also rare in Georgia and absent in North Carolina and Virginia. (Weakley 2004). Elsewhere, the lace bugs also feed on upland swamp privet and swamp privet (*F. acuminate*) (Wheeler 2002) and might use the latter plant as a host in South Carolina. Although swamp privet is recorded from eight counties (Aiken, Allendale, Barnwell, Beaufort, Dorchester, Fairfield, Hampton and Jasper), it is an uncommon plant in South Carolina. It is also uncommon in Georgia and absent in North Carolina and Virginia (Weakley 2004).

Population Distribution and Size

The ranges of both lace bugs generally coincide with those of their forestiera hosts. Swamp privet is found sporadically from southern Indiana and central Illinois, west to the eastern portions of Kansas, Oklahoma, and Texas and east to South Carolina, Georgia and Florida. Upland swamp privet has a more restricted range: central Kentucky and Tennessee to eastern Texas, southern South Carolina, southwestern Georgia, southern Alabama and northern Florida.

Leptoypha elliptica has been recorded from Florida, Georgia, Illinois, Indiana, Kentucky, Missouri, South Carolina, Tennessee and Texas.

The known range of *L. ilicis* is similar: Florida, Georgia, Illinois, Indiana, Kentucky, Missouri, Oklahoma, South Carolina, Tennessee and Texas (Wheeler 2002).



Estimates of population size are not available for either lace bug. The author's fieldwork in South Carolina and elsewhere suggests that densities are less than for most other tingids associated with woody plants. The intensity of foliar chlorosis typically is less than that associated with the feeding of many other lace bugs of trees and shrubs.

Habitat and Natural Community Requirements

As specialist herbivores on upland swamp privet and swamp privet, *L. elliptica* and *L. ilicis* are restricted to habitats and communities that harbor their host plants. In South Carolina, suitable habitats for swamp privet are swamp forests, particularly over calcareous substrates; upland swamp

privet is found in upland forests or slopes along streams, mainly on calcareous rocks or shell middens (Weakley 2004). Two rare species of the genus in South Carolina, Godfrey's privet (*F. godfreyi*) and wild olive (*F. segregate*), need to be surveyed as additional possible hosts of these two lace bugs.

Challenges

Any reduction in the size of upland swamp privet and swamp privet populations will adversely affect herbivores, such as the two species of *Leptoypha*, that feed only on members of this plant genus. Maintenance of South Carolina populations of the lace bugs depends on preservation of host-plant populations. Upland swamp privet and swamp privet and their specialist herbivores, are potentially threatened by habitat fragmentation, alteration, and loss due to urban sprawl, increased recreational use and competition from invasive species.

Conservation Accomplishments

Even though the lace bugs have not been targeted for conservation, designation of their sole area of known occurrence in the state at Savannah River Bluffs Heritage Preserve has provided protection for one of their hosts, upland swamp privet.

Conservation Recommendations

- Protect critical habitats for lace bugs from habitat degradation.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Moretti's Protoptila Caddisfly

Protoptila morettii

Contributor: John C. Morse

Description

Taxonomy and Basic Description

Protoptila morettii was described by John Morse in 1990 from male and female adults collected in South Carolina. Males measure 3.2 to 3.5 mm (0.13 to 0.14 inches) from front of head to tips of folded wings, with forewings each 2.7 to 3.0 mm (0.11 to 0.12 inches) long. Females measure 3.1 to 4.1 mm (0.12 to 0.16 inches) from front of head to tips of folded wings, with forewings each 2.9 to 3.8 mm (0.11 to 0.15 inches) long. The eggs, larvae and pupae of this species remain unknown. Species of *Protoptila* are members of the subfamily Protoptilinae, family Glossosomatidae, order Trichoptera.

The Trichoptera, or caddisflies, are holometabolous insects that are most closely related to Lepidoptera, or moths. Trichoptera eggs, larvae and pupae usually are fully submerged in water and depend on oxygenated water for respiration. Adult caddisflies are aerial/terrestrial, but are rarely found far from water. Adults generally resemble those of their Lepidoptera cousins except, rather than being covered by scales, Trichoptera wings are typically clothed with hair, which is presumably important in repelling water, hence the Latin name *trichos* (hairy) and *ptera* (wings). Trichoptera larvae generally resemble those of Lepidoptera except that caddisflies never have fleshy, crochet-bearing prolegs on middle abdominal segments.

Eggs of caddisflies are round or elliptical and are typically imbedded in a gelatinous matrix called spumaline, with usually several hundred eggs in a single egg mass. Because of the spumaline, little is known about the surface sculpture of the eggs themselves.

Larvae of caddisfly species vary in shape. Those of Glossosomatidae are tapered at the ends with the mouthparts often oriented nearly in line with the body axis. Mouthparts are always have simple chewing mandibles and antennae are usually inconspicuous. A single eye is present on each side of the head that consists of a tight cluster of stemmata, whereas Lepidoptera larvae generally have six widely spaced stemmata. On the caddisfly thorax, the pronotum is always sclerotized and meso- and metanota may or may not be sclerotized; *Protophila* larvae have three lightly sclerotized plates on the mesonotum and a pair of small lateral plates on the metanotum. Three pairs of five-segmented legs are always present, each with a single claw. An epimeron called the “fore trochantin” at the anterior base of each front leg is small and inconspicuous in Glossosomatidae. On the abdomen, a pair of fleshy anal prolegs is partially fused to the body in Glossosomatidae, each bearing a lateral sclerite and single hook-like anal claw. Glossosomatidae larvae have a band of minute spines on the ventral side of the second abdominal segment or a pair of patches of such spines, not seen in other families. Sclerites are usually absent from abdominal segments except that larvae of Glossosomatidae and a few other families have a single median tergite on abdominal segment IX. The larva of Glossosomatidae lives in a portable case of sand grains and silk that is domed dorsally and flat ventrally, the head and abdomen protrude on the ventral side from beyond a transverse strap of fine sand.

The pupa is exarate; although the soft, adult-like appendages are pressed tightly against the body, they are not fused with the body. The mandibles are usually long and adapted for cutting the silken cocoon and pupation shelter. Paired hook plates are present on various caddisfly segments dorsally, apparently used to help the pupa maneuver in the cocoon or shelter; in Glossosomatidae, they occur on the terga of at least the fourth through the seventh abdominal segments. The pupa of Glossosomatidae is contained in a brownish semipermeable cocoon attached at the ends inside the dome-like larval case that has been modified to serve as a pupation shelter by the removal of the ventral strap.

The adult caddisfly mouthparts have no coiled proboscis. Instead, the labium is more or less specialized as a haustellum for sponging liquids. The antennal flagella are long and conspicuous and thread-like. Setal warts are variously shaped and positioned dorsally on the head and thoracic nota of caddisflies; Glossosomatidae adults have a pair of long warts on the mesoscutum and another pair on the mesoscutellum. Tibiae and tarsi are equipped with apical and preapical spurs and spines in specific patterns; Glossosomatidae have two preapical and two apical spurs on each middle and hind leg and usually two apical spurs on each front leg, but Protophilinae have no spurs on the front legs or these are hairlike. Wings have relatively few crossveins, but most longitudinal veins are present; fore wing anal veins anastomose, looping anteriorly on each other. Male and female genitalia (abdominal segments IX, X, and possibly XI) typically have some external parts that are species-specific and may function as tightly fitting premating isolating mechanisms in copulation.

Thirteen species of *Protophila* are known from the United States and Canada. The male of Moretti's protophila caddisfly resembles those of the Nearctic species *P. lega* Ross, *P. maculata*, and *P. palina* in the slender arms of the apical fork of abdominal sternum VIII and in the unique general shape of abdominal segment X. It differs from these, however, in that Moretti's protophila caddisfly has a longer and (in lateral view) straighter sternum VIII with more divergent apical

arms, longer downcurved apical processes of segment X, and slender paramere spines each with its apex abruptly downcurved. The female Moretti's proptoptila caddisfly resembles that of these other three species in the long ventral plates of abdominal sternum VIII, the dome-like band internally above the processus spermathecae, and the long slender apodeme arising from the apex of the venter of the genitalia. It differs from these, however, in that this species has a longer internal ventral apodeme and a pair of dark longitudinal posterior folds of the processus spermathecae that extend anterad only to the level of the posterior edge of the opening of the ductus spermathecae (Morse 1990).

Status

There is only one population known, and it is under significant threat. This species has a global ranking of critically imperiled (G1) ranking. In South Carolina, this species has no official status, but is range restricted.

Population Distribution and Size

Moretti's proptoptila caddisfly is known from only Upper Three Runs Creek on the Savannah River Site in Aiken County, South Carolina. Numerous caddisfly collections made throughout South Carolina since 1969 have failed to find other populations of this species, including intensive sampling in the lower reaches of Upper Three Runs Creek (Floyd et al. 1993). Eleven collecting trips were undertaken specifically to find additional populations of this species in seven streams in the major catchment basins of the sandhills of South Carolina from April through July 1988, but none were found. Over 600 adults of this species were captured at ultraviolet light traps set beside Upper Three Runs Creek at Savannah River Site Road 8-1 from 17 March through 15 October during 1976 through 1984 (Morse 1990). No attempts to collect the species from Upper Three Runs Creek at the original upstream site have been made since 1984; therefore, the current status of the species is unknown.



Habitat and Natural Community Requirements

The immature stages of Moretti's proptoptila caddisfly have never been captured, so that the specific habitat requirements of the species are unknown. Larvae of other species of *Protoptila* graze on periphyton (algae, diatoms, fungi and other biofilm on the surfaces of stones and rooted plants), with mouthparts adapted for scraping these materials from the substrate. Larvae of *Protoptila* live in streams that are somewhat warmer, often larger and slower flowing than other members of Glossosomatidae (Wiggins 1996).

Upper Three Runs Creek has been studied intensively, so that the freshwater insect community is well known (Morse et al. 1980, 1983; Morse 1990; Floyd et al. 1993). Nearly 1,000 species of freshwater insects have been captured in or beside Upper Three Runs Creek and its tributaries since 1976 (unpublished data). Over 123 of these species are caddisflies (Floyd et al. 1993). Besides Moretti's proptoptila caddisfly, twenty others caddisfly species in Upper Three Runs Creek are considered rare, endemic or of limited distribution (Floyd et al. 1993; Morse et al. 1998).

Challenges

The principal tributary of Upper Three Runs Creek is Cedar Creek, whose headwaters arise in the suburbs of the city of Aiken. Since 1984, when the most recent attempts were made to capture specimens of this species, considerable residential development has occurred along this tributary, probably introducing sediments from construction, fertilizers and pesticides from lawns, and petrochemicals from roadways. The resulting reductions in pervious surfaces in the watershed probably also has reduced base flow and accentuated storm surges in the stream. Similar development has occurred along the Upper Three Runs Creek main stem, although to a lesser degree. The status of Moretti's protoptila caddisfly after 20 years of such impact is unknown.

The stability of the only known population of Moretti's protoptila caddisfly and of the other 20 species of rare caddisflies depends on the maintenance of water quality in Upper Three Runs Creek. Clear, cold, well-oxygenated, unpolluted river water is essential. The maintenance of a relatively steady flow also is necessary to promote natural plant growth in the stream; since the substrate is mostly sand and there are no rocks, these plants provide about the only suitable surfaces from which Moretti's protoptila caddisfly probably feeds and the principal habitat for most other aquatic insects in Upper Three Runs Creek (English 1991).

Conservation Accomplishments

The place where Moretti's protoptila caddisfly has been shown to live is currently protected within the Savannah River Site. However, the quality of the habitat is more directly affected by off-site, upstream activities than by on-site activities.

Conservation Recommendations

- Determine water quality in Upper Three Runs Creek, both upstream of and at the location of Moretti's protoptila caddisfly habitat; protect or restore superior water quality depending on results from this survey.
- Protect critical habitats for Moretti's protoptila caddisfly from future development and further habitat degradation by following best management practices and protecting riparian areas.
- Promote land stewardship practices through educational programs both within and upstream of Upper Three Runs Creek.
- Encourage responsible land use planning.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Moth species (No common name)

Agnorisma bollii

Contributor: John A. Snyder

Description

Taxonomy and Basic Description

Moths of Family Noctuidae constitute the largest family in the insect order Lepidoptera. Subfamily Noctuinae has long been recognized, but there has been argument since at least the 1960s as to its

exact composition. The author follows the method of Lafontaine (1998), dividing the subphylum into two tribes, the Agrotini and the Noctuini. All of the Noctuinae share a common wing vein pattern: an easily observed absence of one of the four possible cubitus veins in each of the hindwings.

The moth pictured above has been variously placed within three closely related genera of tribe Noctuini. The earliest description was by Grote in 1880, in which the name *Agrotis hilaris* was proposed. Shortly thereafter (in 1881) Grote moved the species to a different genus and published the name *Xestia bollii*. This stood until 1998 when Lafontaine created the separate genus *Agnorisma* to house three very similar species, *bugrai*, *badinodis*, and *bollii*. These three species are most easily distinguished from close relatives by the presence of a dark-brown collar on the anterior margin of the thorax and by the absence of a jagged or toothed appearance of the postmedial line of the forewing.

Agnorisma bollii, with a forewing length of between 14 and 16 mm (0.55 to 0.65 inches), can be distinguished from the other two species of the genus by the presence of a scattering of white scales over the otherwise brown forewings and on the dorsal thorax and head (Lafontaine 1998). This gives the wings and body a slightly grayish cast over the medium brown background. There is remarkably little size, color or wing-pattern variation among specimens of the same sex. Males can be rather easily distinguished from females by their antennae: males are bipectinate (having two margins toothed like a comb) and females are biserrate (having double saw-teeth).

Status

Within South Carolina, *A. bollii* has been collected from only one location in Greenville County. It has no official status but is range restricted.

Population Distribution and Size

This moth is apparently rare throughout its range. Lafontaine (1998) reports its occurrence only in several states west of the Appalachian range and in the Chesapeake Bay region of Maryland. The online database of noctuids in the National Museum of Natural History reports specimens from only the following states: Maryland, Ohio, Kentucky, Arkansas and Kansas.

The Furman University Zoological Collection houses four specimens of *A. bollii* that were collected in South Carolina in 1999 and 2000, far from the above-mentioned regions. All of these were collected at a blacklight trap in Greenville County in a suburban residential location within 300 meters (328 yards) of the southwestern base of Paris Mountain (coordinates: N 34°56.107' W 82°25.589', NAD27 CONUS). The species has also recently been found in the northern tier of where were collected in October and November, a hallmark of this apparently univoltine species.

A thorough search of appropriate university and private collections of the southeast failed to uncover any other specimens collected in South Carolina or in the two neighboring states of Georgia and North Carolina. The size of the Greenville County population has not been determined. It is not known whether the South Carolina population is a recent arrival or a



remnant of a once-widespread population. The Clemson University Arthropod Collection has many examples of moths collected in the Upstate from 1925 onward, but none of this species; this may indicate that it is just now spreading to the southeast.

Habitat and Natural Community Requirements

Nothing is known of the larval host plant(s) of this species, or indeed, of the larva itself. The known locations for the species in South Carolina and Georgia would seem to indicate that it prefers the piedmont and foothills terrains, but its occurrence in the northern and midwestern regions of the United States, often far from mountainous terrain, indicates our lack of knowledge concerning the community requirements of the organism.

Challenges

The obvious challenge in South Carolina is the extreme rarity of the species coupled with our profound ignorance of its habitat requirements both here and throughout its range.

Conservation Accomplishments

There are no known conservation accomplishments for *A. bollii* at this time.

Conservation Recommendations

- Investigate the habitat requirements, especially the host plant(s) for *A. bollii*.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Pointy-lobed Firefly

Photinus acuminatus

Contributor: James E. Lloyd

Description

Taxonomy and Basic Description

Fireflies of the genus *Photinus* occur throughout North and South America and currently number about 250 described species; this number may more than double when the fireflies of the rain forests of South America are worked up taxonomically. About 50 species are presently known from North America. Among them is the large twilight-flashing *Photinus pyralis* (L.), the lawn species most commonly chased by children as it dips and flashes within their reach.

The pointy-lobed firefly was described by John Wagener Green from a single male specimen from Pisgah Mountain, North Carolina, and a single female from Newberry, Florida, in his revision of the genus (Green 1956). His revision was revolutionary in that it appreciated the taxonomic value of certain features of male genitalia as well as other formerly overlooked characters. In addition to permitting the simple and clear separation of previously confused rather common species, genitalia characters revealed the presence of rare forms. The pointy-lobed firefly was one of these rare forms; the female, though from a distant locality, was associated with the male by the presence of non-genitalic distinctive features seen in the male. In general, the physical appearance of this species more closely resembles *Photinus* species of Green's Division II than it does other species of Division I; the female is similar in dorsal view.

Photinus fireflies may be distinguished from other lightningbug fireflies of eastern North America by their simple claws and absence of a median, longitudinal keel on the first thoracic segment. Females may be distinguished by their lantern, the segment of abdomen that glows, which occupies a small median area of one ventral abdominal plate. Females of a few species have greatly reduced wings and wing-covers (elytra), however females of the pointy-lobed firefly have normal wings and elytra and are expected to be able to fly.

Little is known about *Photinus* development and life history. Most *Photinus* species have a single generation per year, but exceptions occur in certain Florida species. Females probably lay eggs in soil at the bases of grass and herbs. Known larvae of all Lampyridae are predaceous and emit glows from two lanterns at the posterior tip of the abdomen. The lanterns are typically visible as two small, pale bulges. *Photinus* larvae are generally subterranean, though occasionally are found above ground on damp nights or on silt at pond margins. They seem to be earthworm specialists, though probably prey on other soft-bodied organisms including snails and slugs.

The pointy-lobed firefly belongs to Green's Division I (1956), which is defined by the absence of ventrobasal processes of the median lobe of the genitalia. Its genitalia are distinctive, and most confidently identified by the tiny (acuminate) point at the tip of each lateral lobe. This firefly has black elytra outlined with vivid pale yellow margins that exceed the width of the up-flexed margin laterally. The ventral lateral areas are dark. Total length is 7 to 8 mm (0.27 to 0.31 inches).

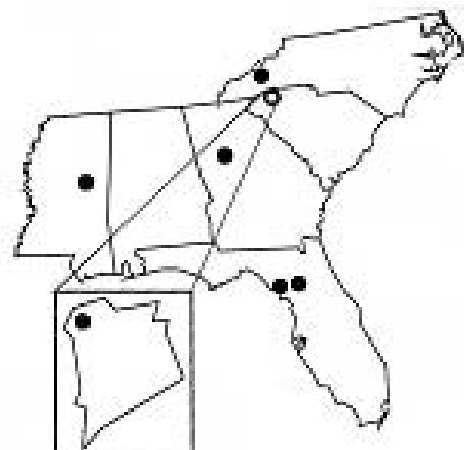
These fireflies were observed flashing at the edge of a cypress-head near the Suwannee River, southwest of Old Town, Florida (June 1968). Flashing behavior was similar to that observed in other Division I species. It occurred at twilight, and flashing activity was of short duration each evening. The male flash pattern is a single, sharp, bright flash of perhaps 100 millisecond duration, and apparently shorter than that of other known nearctic *Photinus*. Flash patterns were emitted at about 2 second periods, at 74° F. At this temperature the short female response flash was emitted at a delay of about 300 milliseconds.

Status

No federal or state status is given to the pointy-lobed firefly. However, extensive field observations of flashing fireflies throughout southeastern United States have revealed only six populations; several of these appear to have disappeared.

Population Distribution and Size

The pointy-lobed firefly occurs (occurred?) only in the southeastern United States, and has been recorded from only six localities: two in Florida; one in North Carolina; one in Pickens County, South Carolina, near the Junction of Routes 11 and 178; and one each in Georgia and Mississippi. The South Carolina site was near a roadside marsh, in shrubs and herbs under a large deciduous tree; only three specimens were found. Populations near Old Town, Florida consisted of 20 to 50 flashing individuals; while these sites have been visited on several occasions since their discovery, no pointy-lobed fireflies have been seen there for three decades. Nor have any been found in Newberry, Florida, one of Green's original localities.



Habitat and Natural Community Requirements

As presently known, Division I *Photinus* fireflies are nearly all mesic forest and forest-margin (ecotone) species, with some populations thriving at the edges of lawns and mowed roadsides, along streams, and at the edges of agricultural fields. The pointy-lobed firefly seems to fit this pattern.

Challenges

The rarity of pointy-lobed fireflies across such a broad range suggests that this firefly was once widely distributed. There are several challenges to the existence of fireflies today and because populations of the pointy-lobed firefly are already greatly reduced or disappearing entirely, the consequences may be even more serious. Various sources of chemical pollution have been recognized which may affect fireflies, both juveniles and adults, and both daytime and nocturnal species.

Nocturnal fireflies such as the pointy-lobed firefly will, in addition, be negatively affected by light pollution. Light pollution sources include sky glow (cloud reflection) and point sources such as street and porch lights, traffic headlights, and various others. Increased general illumination in the natural environment is analogous to noisy static in the signal channel of fireflies, making it more difficult to see and be seen by potential mates. Point sources are potentially distracting beacons in the cases of species that are adapted to use points of light in the night sky for oriented travel through space. Both general illumination and point source redirection may result in the loss of individuals that might otherwise move among local populations (gene flow) as well as founders of new and replacement local populations. The loss of habitat coupled with intrusive light pollution produces a formidable obstacle to the continuance of healthy firefly populations.

Among natural threats to adult fireflies is predation by females of several species in the firefly genus *Photuris*. These predators use aggressive mimicry, in which they mimic the signals of prey-species females and attract signaling, mate-seeking males to eat. An aerial attack ensues in which the predatory fireflies aim their attacks at the flashes of flying males. Alteration of natural ecology may have brought predator and prey populations into closer ecological contact, increasing the amount of predation.

Though the pointy-lobed firefly is not aquatic, it and most other fireflies live in damp habitats of various types. Such habitats are lost through the lowering of water tables, which, in recent years, is a widespread phenomenon affecting many areas of the country. This, of course results in the loss of marshes, damp woodlands and small streams. Also, terrestrial habitats that are flooded by rising waters of marshes and streams may carry surface and other pollutants from adjacent human activities. Farm chemicals, animal waste, and human waste from failing pumping stations and/or septic tanks may wash over terrestrial as well as aquatic habitats during local flooding. This may poison fireflies and their prey.

Conservation Accomplishments

None specifically exist for this species.

Conservation Recommendations

- Determine the presence or absence of the pointy-lobed firefly in South Carolina. Concentrate first survey efforts in areas where the firefly was previously seen.
- Protect the habitat of any identified populations of the pointy-lobed firefly.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs. Discovery of new populations could be considered a success.

Pyramid Ants

Dorymyrmex bureni

Dorymyrmex medeis

Contributor: Timothy S. Davis

Description

Taxonomy and Basic Description

Pyramid Ants are easily identified in the field by their distinctive cone shaped mounds with an entrance hole in the center. In South Carolina, two species have been collected and identified. Taxonomically, the Pyramid ants are in the subfamily Dolichoderinae. The Dolichoderine ants are distinguished as having a single “hump” or node between the thorax and gaster and the absence of a stinger. The genus *Dorymyrmex* is distinguished by the presence of a distinct mid-dorsal cone shaped protuberance. It should be noted that over the years the genus name has shifted from *Doyrmyrmex* to *Conomyrma*, back to *Dorymyrmex*. Hence, some papers from the mid 1980’s will bear the *Conomyrma* name.

The best treatment of the identification of the pyramid ants in the Southeastern United States currently is a paper by James Trager published in 1988. While color is rarely a good character for identifying ants, this character works well with pyramid ants. *D. bureni* is a light red to yellowish ant. *D. medee* is dark brown almost black in color. Another important character is the shape of the mesonotum. In *D. bureni* the mesonotum is smooth with out a sharp angle. *D. medee* the mesonotum is bears a sharp angle.

There are nearly 9,000 species of ants that have been described on a world-wide basis. As would be expected, the biology and life histories of these ants are nearly as diverse as the group itself. Understanding the biology and life history of a given species is critical to decisions made regarding the management and/or conservation of an ant species.

Status

Only two intensive studies have been conducted in South Carolina in the last century. M. R. Smith published a list of ants from collections around Clemson College in 1918, and a subsequent list of species that had a been sent to him for identification throughout his career in 1934. In 1976 Van Pelt and Gentry conducted an intensive survey of ants at the Savannah River Plant. A study conducting 243 pitfall transects throughout the entire state of South Carolina was conducted in 2000 and 2001. This collection due to its method is largely limited to ants that forage on the surface.

With so little information it is very difficult to judge the status of any ant species. *D. bureni* is frequently found throughout the state. *D. medee* is found throughout the state, but much more rarely than *D. bureni*. When *D. medee* is found the numbers of nests and ants can be quite large in a localized area.

Population Distribution and Size

Pyramid ants are distributed from Maryland and Virginia south to Florida and west to Mississippi, Louisiana and Texas.

Habitat and Natural Community Requirements

Pyramid Ants are often thought of as a “weedy” type species. This is due to the fact that they quickly inhabit and prefer highly disturbed areas. They are most often found in pastures, open fields, open scrub, sandhills, dunes, lawns and roadsides. They particularly favor sandy soils such as are found in the lower half of the state.

One of the primary benefits of these ants is their role as natural predators against other undesirable ants. They are predators of numerous arthropods. Close observation of their nests will often reveal “bone piles” around the outside edges of the nests. One of the interesting achievements of the species is their ability to exist in close proximity to the invasive red imported fire ant. It is common to actually see this species attacking individual foraging fire ants and newly mated fire ant queens. An analysis of the contents of the bone piles reveals a great percentage of their prey to be fire ants.

Challenges

The primary challenge to this species is their ability to survive near fire ants and the public attitude against ants in general. Many treatments for fire ants can also be devastating to pyramid ant populations. Fire ants and pyramid ants partition themselves by foraging at different temperatures. There is some overlap, but baiting when the surface soil temperature is below 100°F will reduce the impact upon the pyramid ants. Testing to be certain the fire ants are actively foraging will also allow the fire ant, by force of numbers to get the lion share of the bait and reduce the impact upon this beneficial species.

Some of the granular products such as fipronil also seem to have little impact upon the pyramid ant due some of the differences in foraging behaviors. Fire ants forage primarily within the soil itself. Pyramid ants, on the other hand, forage primarily on the surface of the soil. With fipronil, the toxin binds to the organic matter in the soil forming a toxic layer. Pyramid ants do not come in contact with large amounts due to their foraging behaviors.

Conservation Accomplishments

One study conducted at McEntire Air National Guard Base and Fort Jackson used a combination of traditional chemical controls and the release of *Pseudacteon tricuspis* and *Thelohania solenopsae*. The results were quite interesting for the native ant species.

The control sites saw no change in the overall composition of the ant population. The chemical treatment alone initially saw a reduction in both native ant species and fire ants. Within 18 months the fire ant population had recovered to the previous levels and almost zero native ants were collected. The treatment site with both chemicals and biological controls present saw an initial drop in both populations. The native ants were the first to recover from the treatments. Nearly three years after the initial treatment, fire ants had not yet returned to the treated site, the biological controls were established and found in high numbers surrounding the treated site. It is hypothesized that the introduction of disease and parasitoid activity against the fire ant population allowed the native ant population to better compete and exclude the fire ants for a longer period of time.

Conservation Recommendations

- Educate the public regarding which ants are desirable and which are not.
- Encourage the use of ant treatments that are friendly to the desirable species and target the undesirable species.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Sandhills Earth Boring Scarab Beetle

Mycotrupes retusus

Contributor: Phillip Harpootlian

Description

Taxonomy and Basic Description

The genus *Mycotrupes*, belongs to the family Geotrupidae (Earth-boring dung beetles). Until recently the family Geotrupidae was primarily considered a subfamily of the Scarabaeidae. *Mycotrupes* is a small, strictly North American genus, comprised of five widely scattered species found from South Carolina through central Florida (Howden 1955; Olson et al. 1954; Smith 2003). The central Florida endemic, *M. pedester* is considered imperiled (Kern, 2001).

Geotrupes (Mycotrupes) retusus was described by LeConte in 1866. The subgenus *Mycotrupes* was subsequently elevated to genus status by Olson and Hubbell (1954). No subspecies are recognized.

The adult Sandhills earth boring scarab beetles range from 10 to 16 mm (0.4 to 0.6 inches) in length, are dull granulate black, and have the elytral suture fused, making them flightless (Harpootlian, 2001). Adult males generally have a pronounced apical depression on the pronotum and a small cephalic protuberance on the head (Harpootlian 2001); females lack the cephalic protuberances and the pronotum is evenly convex.

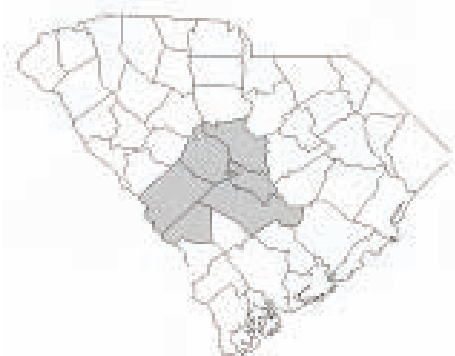
Little is known about the ecological requirements for the larvae of this species. They are caterpillar-like in appearance and, like many scarab species, typically feed on plant roots. They will feed underground until they metamorphose and pupate into adults.

Status

Currently, this species has no state- or federally-listed status.

Population Distribution and Size

The Sandhills earth boring scarab beetle is a South Carolina endemic, restricted to the deep xeric sands of the southern fall-line sandhills (Harpootlian 2001). The sandhills topography encompasses the majority of the midlands of South Carolina and extends in a northeasterly direction into North Carolina (USEPA 2002).



This beetle occurs in both Aiken and Sesquicentennial State Parks, as well as the Aiken Gopher Tortoise Preserve and the privately owned Hitchcock Woods near downtown Aiken (Harpootlian 2001).

Population size has not been determined. Their habit of spending most of their life cycle underground would make population assessments very labor intensive.

Habitat and Natural Community Requirements

Larval food sources for the Sandhills earth boring scarab beetle are presently unknown, but scarab larvae are known to feed on a wide variety of plants and many species are significant economic pests in landscaping, golf courses, gardens and agricultural crops.

Adult sandhills earth boring scarabs are cold adapted and spend most of their lives underground in burrows that are often 0.8 to 1.9 m (3 to 6 feet) deep (Harpootlian 2001). They are most active above ground from September to April for short periods after drenching rain. The primary natural community requirement appears to be deep, well drained sand (Harpootlian 2001).

Challenges

Paving or landscaping adversely affects access to the surface and, ultimately food sources for the Sandhills earth boring scarab beetle. Additionally, contaminated runoff from impervious sources can challenge this beetle. Agricultural pesticides can also pose a threat to the Sandhills earth boring scarab beetle.

Conservation Accomplishments

State parks in South Carolina protect at least two viable populations (Harpootlian 2001).

Conservation Recommendations

- Protect suitable habitat for the Sandhills earth boring scarab beetle.
- Promote land stewardship practices through educational programs both within and upstream of Upper Three Runs Creek.
- Encourage responsible land use planning.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

Smokies Needlefly

Megaleuctra williamsae

Contributor: Boris C. Kondratieff

Description

Taxonomy and Basic Description

Megaleuctra williamsae was described in 1941 by John F. Hanson from a single adult male specimen collected in 1938 from Greenbriar Cove, Great Smoky Mountains National Park. Baumann (1973) described the adult female and since their descriptions, both have remained in the genus *Megaleuctra* with no synonymy (name change or revision) for either. The genus

Megaleuctra was erected by Neave in 1934, and contains six species, all found in North America.

Recently, the placement of the genus *Megaleuctra* into the family Leuctridae (needleflies) has been questioned. However, until research is published, based on molecular evidence, *Megaleuctra* is treated as a relict taxon in the family Leuctridae.

Complex male genitalia, showing very long, narrow, cylindrical subanal probe, which aids in identifying this species.

The Smokies needlefly larvae ranges from 12 to 14 mm (0.5 to 0.6 inches) in body length. General body color is brown, with the legs yellowish. The head is wider than the pronotum. The male genitalia is complex with a very long, and narrow, cylindrical subanal probe; the processes on the tenth dorsal plate are flattened laterally and project dorsally; the ninth ventral plate has a broad posterior lobe, a widely notched margin at apex and is abruptly bent downward at base; and the vesicle is large. The ninth sternum of the female is formed into a long, narrow ovipositor.

Adult needleflies are slender, brown to black stoneflies ranging from 4 to 15 mm (0.2 to 0.6 inches) in length. Adults have one-segmented cerci and typically, the wings are rolled around the body at rest. Distinct from all other Holarctic genera, the genus *Megaleuctra* can be easily distinguished from all other needleflies by the large size, 12 to 15 mm (0.5 to 0.6 inches) in length, and the presence of six veins in the hindwing anal region. This genus is among the rarest of all North American stoneflies, with only two eastern United States species: *Megaleuctra flint* is known from Pennsylvania, Virginia and West Virginia, whereas *M. williamsae* is known from North Carolina, South Carolina, Tennessee and Virginia.

The stoneflies, more than any other order of insects, are typical inhabitants of running waters. Nearly all species occur exclusively in streams, and most are restricted to running water habitats of mountainous regions of the world. Usually, water temperatures of these streams are below 25°C with high dissolved oxygen levels. These requirements allow them to serve as an excellent indicator of water quality. They are one of the three orders collectively known as the “EPT” orders of aquatic insects known to be demonstrably affected by declining water quality (Ephemeroptera, the mayflies; Plecoptera, the stoneflies; and Trichoptera, the caddisflies). The water quality ratings for wadeable creeks and streams are calculated using the presence/absence and relative abundance of these “EPT” and other aquatic insects.

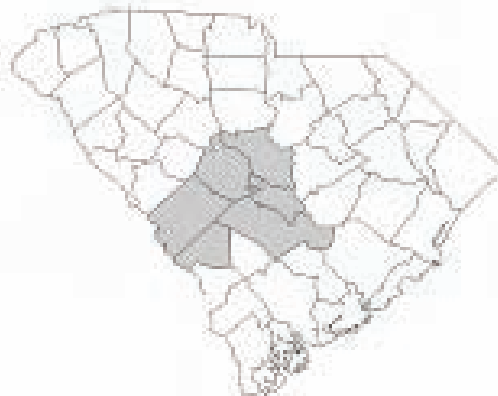
Status

The Smokies needlefly is globally ranked as imperiled (G2). This species is currently not ranked in South Carolina, but is under review. The Smokies needlefly is considered critically imperiled (S1) in North Carolina, imperiled to critically imperiled (S1/S2) in Tennessee and imperiled (S2) in Virginia.

Population Distribution and Size

The Smokies needlefly has been infrequently recorded from the higher elevations of western North Carolina and South Carolina, eastern Tennessee and southwestern Virginia (Mount Rogers area). Several South Carolina records are available from Oconee County.

Population size has not been determined, but this species occurs as small populations, usually less than 20 nymphs per site.



Habitat and Natural Community Requirements

Most stonefly nymphs are herbivores, feeding principally on plant detritus. Even the young nymphs of many carnivorous species feed on fine detritus before switching to animal prey. The families Perlodidae, Perlidae and Chloroperlidae are predominantly predators as older instars. Although some species emerge in autumn, most stoneflies transform to adults in spring or early summer. Mature nymphs often congregate at emergence sites such as piles of rocks, bridge abutments and woody debris. The exuviae (cast skins) of the nymphs are often abundant and can be seen attached to these sites.

Stonefly nymphs occur most commonly in lotic habitats with rocky bottoms with high dissolved oxygen concentrations. Some species are restricted to seeps and springs, others to high gradient coldwater streams.

The nymphs of the Smokies needlefly are restricted to high elevation springs and seeps in relatively undisturbed forested areas (Stewart and Stark 2002). Nymphs sprawl in accumulations of decaying leaves and other debris that is covered with a thin film of flowing water.

Challenges

A major challenge to the Smokies needlefly is deforestation, which would result in opening of the canopy of seeps and springs, increasing water temperature and likely reducing food inputs.

Acid deposition, primarily from precipitation, may alter pH conditions of the habitats, potentially eliminating populations. Diversions of surface waters or removal of ground water may alter below ground hydrological patterns of the seeps and springs.

Conservation Accomplishments

There are no conservation accomplishments to date for this species.

Conservation Recommendations

- Identify extant populations of the Smokies needlefly and ensure the protection of the multiple specific habitat types for this species.
- Protect critical habitats for the Smokies needlefly from future development and further habitat degradation by following best management practices and protecting riparian areas.
- Promote land stewardship practices through educational programs.
- Encourage responsible land use planning.

Measures Of Success

As research and management needs are identified, projects will be initiated to address those needs.

White Beach Tiger Beetle

Cicindela dorsalis media

Contributors: Janet C. Ciegler and Joey Holmes

Description

Taxonomy and Basic Description

For many years, tiger beetles were considered to be in a family by themselves, the Cicindelidae. Recent research has shown, however, that they are more correctly placed in the subfamily Cicindelinae in the Carabidae, the ground beetles. *Cicindela* is the largest genus in the subfamily, having more than one thousand species worldwide.

Cicindela dorsalis was named by Thomas Say in 1817 and *Cicindela media* by John LeConte in 1857; currently, these two are considered subspecies of the same species. *C. dorsalis media* occurs along the southeast coast of the United States, including South Carolina and *C. dorsalis dorsalis* occurs along the northeast coast. Two other subspecies, *C. dorsalis saulcyi* and *C. dorsalis venusta*, are found along the coasts of Florida, the Gulf of Mexico and Mexico (Boyd 1982).

The white beach tiger beetle ranges from 10.5 to 13.5 mm (0.41 to 0.53 inches) in length. Like all tiger beetles, its legs and antennae are long and slender and its jaws are large. The elytra (wing coverings) are white with narrow sinuous bronze markings; the head and pronotum are bronze. The pronotum and sides of the under surface are densely covered with white hairs. The sides of the elytra of males are nearly parallel whereas females are somewhat more broadly rounded. The pale coloration renders the beetle well camouflaged on the light sand where it lives.

Status

The northern white beach tiger beetle, *C. dorsalis dorsalis*, is on the federally threatened list because of extensive destruction of its habitat. This subspecies historically ranged from Massachusetts to the Chesapeake Bay and is now found only in the Chesapeake Bay area. Even there, the narrow beaches, 3 to 10 meters (9.8 to 32.8 feet) in width, are barely wide enough to support this beetle. The related subspecies in South Carolina, the southern white beach tiger beetle (*C. dorsalis media*), is being extirpated in parts of its range as well; however, there is no federal or state ranking for this species.

Population Distribution and Size

This beetle historically ranged from southern New Jersey to Miami, but its range has been diminished at both extremes. In South Carolina, it once occurred on all wide sandy beaches, but no longer is present where human development or severe erosion have destroyed appropriate habitat, such as in the city of Myrtle Beach (Knisley and Schultz 1997). It still may be found on those beaches that are relatively undisturbed, including Waites Island, Cherry Grove Beach, Huntington Beach, Isle of Palms, Folly Island, Seabrook Island and Edisto Beach; the largest population is at Seabrook Island where the dunes are most extensive. It occurred on Hunting Island as recently as 2002 but the beach has undergone severe erosion so its current status is in doubt.

Population size for the white beach tiger beetle has not been determined in South Carolina.

Habitat and Natural Community Requirements

The adult white beach tiger beetle is a predator; the adults run actively on the sand to catch prey that includes small insects. Larvae are also predators, hiding in burrows with only their jaws protruding to catch unwary insects or a variety of small animals of suitable size that come within their reach. Therefore, larvae need a safe place for development above the high tide line; both stages require a large enough expanse of naturally shifting ocean beach so that sufficient prey is available.

Challenges

Loss of habitat represents the most significant challenge to South Carolina's white beach tiger beetle. Building and road construction, deposition of dredge spoil, extensive driving on the beach and heavy foot traffic can destroy the natural qualities of a beach so as to make it uninhabitable by beach tiger beetles. Erosion can narrow or eliminate the sandy beach and severely impact the beetles. Construction of groins and bulkheads reduces natural movement of the sand and suitability for these tiger beetles (Knisley and Schultz 1997).

Water quality offshore needs to be moderately clean and free from toxic substances (such as oil spills) so that aquatic and semi-aquatic animals are available as prey for tiger beetles and so that larvae are not poisoned in their burrows (Knisley and Schultz 1997).

Conservation Accomplishments

Efforts to save the endangered least terns on our public beaches also contribute to an environment suitable for tiger beetles. This effort is largely fencing off tern nesting areas and informing the public about the necessity to protect the terns. Actions to protect the dunes themselves, such as keeping people off the dunes, preventing sea oats collection and prohibiting structures such as groins and bulkheads all contribute to a good habitat for these beetles.

Conservation Recommendations

- Conduct surveys for the white beach tiger beetle to track its continued decline and/or return to available habitat.
- Work with appropriate state, local and non-governmental agencies and coastal municipalities and communities to reduce current and future impacts of development on beach environments.
- Educate the public about the importance of beach dune habitat and initiate participative projects such as dune vegetation plantings.
- Encourage planned development projects in coastal zones, particularly on barrier islands to reduce associated impacts of development on the long-term health of sandy beach habitats in South Carolina.
- Discourage building or repair of seas walls and groins on South Carolina's beaches to allow more natural movement of sand and, ultimately, more natural beach renourishment.
- When feasible, remove dams and reservoirs that block flow of sand and sediment from upland areas to allow for more natural beach renourishment.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs. If the white beach tiger beetle makes a comeback in areas that were previously void of the species, we will consider this a success.

Zigadenus Sawfly

Rhadinoceraea zigadenusae

Contributor: David R. Smith

Description

Taxonomy and Basic Description

Sawflies, sometimes called “broad-waisted” wasps, belong to the Order Hymenoptera along with wasps, bees and ants. The *Zigadenus* sawfly is in the family Tenthredinidae, one of four families in the superfamily Tenthredinoidea, which is contained in the suborder Symphyta, the sawtails and horntails.

Sawflies are distinguished from other Hymenoptera by the abdomen being broadly joined to the thorax, not with a wasp-like constriction in the middle. Most are fly-like in appearance, but have four wings, compared to two wings in flies. The female’s ovipositor cuts into plant tissue for insertion of eggs and is saw-like; thus, the common name “sawflies.”

All sawflies are phytophagous in the larval stage, with the larvae being caterpillar-like in appearance, but are differentiated from caterpillars (Lepidoptera larvae) by the presence of only one ocellus (light sensing organ) and usually more prolegs on the abdomen. Over 1,000 species are known in North America and over 8,000 species are known worldwide (Smith 1979). Hosts include a wide variety of plants including ferns, grasses, pines and other conifers, oaks, hickories, poplars, elms, willows, roses, cherries, pears and blackberry. Many species are significant economic pests in gardens, agricultural crops and forests.

Larval sawfly, *Rhadinoceraea zigadenusae*, feeding on *Zigadenus* flowers; Photo by D.R. Smith.

A sawfly feeding on star lilies (*Zigadenus*; Liliaceae) was not discovered until 1990 and was named *R. zigadenusae* after the food plant (Smith and McDearman 1990). A second species also feeding on *Zigadenus* was discovered later in the mountains of West Virginia and named *Rhadinoceraea sodesensis* (Smith and Barrows 1995). Other species of *Rhadinoceraea* also feed on Liliaceae, primarily *Veratrum* spp.

Adults of the *Zigadenus* sawfly are about 7 to 8 mm (0.27 to 0.3 inches) in length, entirely black and have uniformly black wings. Larvae are pale green with a black head and black tubercles on the body. Larvae feed on the inflorescence (floral cluster on an axis) of the food plant, which is unusual for sawflies. Most sawfly larvae feed on foliage; inflorescence feeding is known in only a few other sawflies.

Status

Currently, this species has no state- or federally-listed status.

Population Distribution and Size

The *Zigadenus* sawfly was described from adults reared from larvae feeding on *Zigadenus densus* in Mississippi. Populations of larvae also have been found in Alabama, North Carolina and South Carolina, and it is believed that it occurs wherever the host plant is found from Mississippi to Florida



and north along the coast to Virginia. One population has been recorded from South Carolina in Jasper County at Switzerland on 17 May 1987. The larvae were discovered on *Z. densus* in recently burned longleaf pine savanna (Smith and McDearman 1990).

Since the *Zigadenus* sawfly probably occurs in pine savannas and flatwoods, as well as bogs in many localities in the mid-Atlantic coastal plain and southeastern plain regions of South Carolina, the sawfly also may occur there. Its occurrence at only one locality is undoubtedly a reflection of lack of collecting.

Habitat and Natural Community Requirements

Larvae of the *Zigadenus* sawfly feed on the inflorescence of *Zigadenus densus*. Adults fly in the spring, usually from late April to May, which coincides with the time the plant is beginning to flower. They are very short-lived, probably a week or less. Females insert eggs into the primary inflorescence stalk where they apparently lay one egg per plant. Larvae hatch in about a week and bore a small exit hole in the stalk. Young larvae typically go to and enter a flower bud where they feed on the developing stamens and pistils. Older larvae consume open flowers and secondarily feed on fruits. When mature in late May, larvae burrow shallowly into the soil to pupate. There is one generation a year, with their emergence and feeding coinciding with the flowering of the host plant, *Zigadenus densus*.

Survival of the *Zigadenus* sawfly is entirely dependent on the survival of the host plant. Preservation of the natural community requirements of *Zigadenus densus* is thus the most important factor in the continued survival of the sawfly.

Challenges

Destruction of habitats of the only known host plant, *Zigadenus*, would result in adverse impacts to the survival of the *Zigadenus* sawfly. Urban development, logging or other disturbance of the plant communities that destroy pine savannas, flatwoods and bogs are a challenge to both the plant and this sawfly species.

Conservation Accomplishments

There are no known conservation accomplishments for the *Zigadenus* sawfly at this time.

Conservation Recommendations

- Maintain and conserve natural savannas and bogs to ensure the continued survival of *Zigadenus*.

Measures of Success

As research and management needs are identified, projects will be initiated to address those needs.

CHAPTER 11: MARINE INVERTEBRATES

Atlantic Ghost Crab

Ocypode quadrata

Contributor: David Knott

Description

Taxonomy and Basic Description

In 1787, J.C. Fabricius formally described the Atlantic ghost crab from specimens collected in Jamaica, originally calling it *Cancer quadrata*. Following Linnaeus' development of the modern scientific method of naming organisms, the name '*Cancer*' was commonly applied to a variety of crustacean taxa, not just crabs, by taxonomists and carcinologists. *Ocypode quadrata*, also known for some time as *O. albicans* or the "fleet-footed one of white," was characterized by Phillips (1940) as "an occult, secretive alien from the ancient depths of the sea." Since the time he wrote that romanticized Description, much has been learned about this conspicuous inhabitant of the ocean beach community.

A true crab, or brachyuran, the ghost crab belongs in the family Ocypodidae, which also includes the fiddler crabs. Worldwide, there are roughly 20 species of ghost crabs, but *O. quadrata* is the only one found on the east coast of the United States. The species is a small straw-colored or grayish-white crab, measuring about 5 cm (2 inches) across the back at maturity. *Ocypode* has the greatest terrestrial adaptation of any crab in South Carolina, returning only occasionally to the water to wet its gills. It can also moisten its gills by extracting water from damp sand, using fine hairs near the base of its walking legs to wick ground water up onto the gills through capillary action (Ruppert and Fox 1988). Despite this semi-terrestrial existence, the ghost crab's link to the sea is a critical one that provides not only moisture for its gills, but also the necessary means for development of larvae that are hatched from eggs that the females release at the water's edge.

Status

The ghost crab is not presently included in federal lists of threatened or endangered species and there is no present-day human exploitation of this species. Having few terrestrial predators or competitors, a flexible feeding behavior and the ability to endure starvation for long periods, *Ocypode quadrata* is an ideal top carnivore in a simple, filter-feeding based food chain of the dune and fore beach ecotone (Wolcott 1978). As such, it may prove to be a useful indicator of the health of that environment.

Population Distribution and Size

In his treatment of decapod crustaceans of the Atlantic coast of the United States, Williams (1984) reported a range for *Ocypode quadrata* that extends from Block Island, Rhode Island to Santa Catarina, Brazil, including the Gulf of Mexico, the Caribbean and Fernando de Noronha, 200 miles off the Brazilian mainland. It is also found in Bermuda, and the last larval stage has been observed as far north as Woods Hole, Massachusetts; however, adults do not reside at that latitude.

Although rarely seen in the winter, during the rest of the year *O. quadrata* is common or abundant on outer beaches and on more protected harbor beaches near coastal inlets along the coast of South Carolina (Fox and Ruppert 1985). Rarely has the species been the target

of quantitative study in our state and, despite its abundance, nothing is known of trends in its population status here. Quantitative measures of the population size in South Carolina are non-existent, although estimates based on burrow counts or nocturnal transect counts could provide a good measure of abundance (Wolcott 1978). Such efforts have not been undertaken across a wide geographic area within the state.

Habitat and Natural Community Requirements

While they have long been considered beach scavengers, a careful study of ghost crab behavior showed that on oceanfront beaches they are more likely to subsist on a diet of the common filter-feeding inhabitants of the swash zone, like the clam, *Donax*, and the mole crab, *Emerita talpoida* (Wolcott 1978). However, there is also evidence that they may be effective scavengers of organic matter; on more protected beaches their prey is believed to include eggs and nestlings of the loggerhead turtle, *Caretta caretta* (Dodd 1988).

Ghost crabs are largely nocturnal in nature and it is rare to catch a glimpse of them during the day. Most feeding activity occurs at night, which reduces predation by visual predators like shore birds and gulls that might otherwise be capable of exerting considerable pressure on populations of this species. In the event that they do leave their burrow during daylight, their ability to change color to match the sand where they live lessens their chances of being seen on such a foray.

The burrows dug by ghost crabs may be up to 1.3 m deep (4 feet). Their habits of periodically closing the burrow opening with sand during the hottest part of the day and of remaining within the burrow through the colder months provide sufficient protection from the climatic extremes that fully aquatic species rarely encounter. These burrows, which take different shapes beneath the sand, are found from near the high tide line to a distance as great as 400 m (0.25 mile) from the ocean. A distributional gradient based on crab age is typical for this species, with younger crabs generally burrowing closer to the shore than older individuals (Williams 1984).

Challenges

Berry (1976) reported that, because of their burrowing and scavenging habits, ghost crabs might be adversely affected by increased oil tanker traffic and the resultant increase in the amount of stranded oil on ocean beaches. Contact with the oil, although it appears not to be acutely toxic to the crabs, may cause a reduction in the breeding rate and increased mortality at molting.

The decline in undeveloped beachfront habitat may represent the greatest threat to the ghost crab. In South Carolina, coastal regions claim a significant portion of the state's tourism; in 1996 these coastal areas accounted for 56 percent of the state's visitors (SCDNR and NOAA 2000). Spending time at the beach is a highly popular activity among tourists during their visit to the coast. Alterations to the upper intertidal zone caused by residential or commercial development of coastal areas and other beach construction may eliminate *Ocypode* from its natural habitat, either by direct mortality or by displacement to less optimal habitat. Such development, undertaken to accommodate increased recreational uses of the beaches, has been cited as the cause of the elimination of the ghost crab *O. stimpsoni* from the coastal Chinese region of Rizhao (Gao and Xu 2002).

In a recent study conducted in North Carolina, Peterson et al. (2000) found significant deleterious effects on ghost crab populations resulting from beach nourishment and bulldozing activities on eroding beaches. Although these short-term responses to erosion are considered to be preferable to "hardening" the shoreline by construction of seawalls and groins, Peterson et al. (2000)

demonstrated a clear impact, not only on ghost crabs but also on the abundance of their principal prey items. These erosion control measures are readily permitted and widely practiced on barrier islands in the southeastern states (Leonard et al. 1990; Peterson et al. 2000); for that reason, erosion control measures present a potential but undefined threat to the well-being of ghost crab populations in South Carolina.

Even well meaning conservation efforts targeting other species may present a threat to ghost crabs. Previous turtle protection efforts, for example, have included measures to destroy ghost crabs when its burrows were found in close proximity to loggerhead turtle nests (*Caretta caretta*), based upon wide-spread reports of predation. The true impact of such predation on the loggerhead population, however, has not been adequately assessed; there is recent evidence that this level of predation is insignificant (Thompson 1995; Von Harten et al. 2002; Sundin undated).

Conservation Accomplishments

Mathews et al. (1980) previously recognized the importance of protecting the beach/dune ecosystem in South Carolina. Five of the top 14 areas in South Carolina identified by the U.S. Fish and Wildlife Service as needing preservation measures included barrier islands with pristine dune habitat.

Although not directed specifically at conservation of ghost crabs, a 2004 judicial ruling will keep 75 acres of oceanfront property in Georgetown County uninhabited, which will ensure the preservation of that critical habitat for the Atlantic ghost crab. The ruling serves to maintain the suitability of this pristine acreage as prime habitat for sea turtles and numerous species of shorebirds, as well as ghost crabs.

Acquisition and conservation easements on undeveloped uplands and coastal islands in the ACE Basin drainage area have resulted in the protection of roughly 140,000 to 160,000 acres through conservation measures on public and private land (Mike McKenzie, ACE Basin Committee Chairman, pers. comm., 2004). The ACE Basin National Estuarine Research Reserve includes four barrier islands, assuring protection of significant ghost crab habitat on Otter, Pine, Edisto and Morgan Islands. Some additional protection is afforded by state ownership of four oceanfront parks (Hunting Island, Edisto Beach, Huntington Beach and Myrtle Beach) that include substantial amounts of suitable ghost crab habitat, although beach maintenance efforts at some of them may have the negative impacts noted above.

Although numerous beach nourishment studies conducted in the past failed to include assessment of impacts on ghost crabs, this oversight has recently been recognized; measures are underway to include such evaluations at several sites in South Carolina in the near future (Pam Jutte, SCDNR, pers. comm., 2005). Peterson et al. (2000) recently conducted such a study of nourished and bulldozed beaches in North Carolina.

Conservation Recommendations

- Assess impacts of beach nourishment projects on Atlantic ghost crab populations in South Carolina.
- Investigate the impact, if any, that ghost crab predation may have on loggerhead turtle populations.
- Establish estimates of population size and determine trends for ghost crabs in South Carolina by widespread and long-term monitoring of ghost crab abundance, incorporating both unaltered and developed areas along the entire coastline.

- Work with municipalities and private landowners to schedule beach renourishment activity so that it is completed prior to the warm season, when *Donax* and *Emerita* (two primary food sources for ghost crabs) return in large numbers to intertidal beaches.
- To mitigate impacts to ghost crabs associated with beach bulldozing practices, encourage municipalities and private landowners to implement dune stabilizing techniques such as planting grasses.
- Develop either a state or federal management plan for the Atlantic ghost crab.
- Continue SCDNR participation in Emergency Response training programs to ensure that the Department 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 design of aftermath shoreline assessments.

Measures of Success

If the burrow-counting census methods of Wolcott (1978) were used in conjunction with other periodic beach monitoring efforts (e.g. horseshoe crab surveys), a cost-effective program of data collection could be undertaken that would initially provide a baseline assessment of the ghost crab population size. Ultimately this could be used to follow population trends, provide data necessary for determining what conservation measures, if any, are needed and enable managers to make informed decisions on how useful this species might be as an indicator of the overall “health” of the dune and fore beach ecotone. The measurement of success will be stable population trends for the Atlantic ghost crab and increased conservation of front beach habitat in South Carolina.

Brief Squid

Lolliguncula brevis

Contributor: David Whitaker

Description

Taxonomy and Basic Description

The brief squid was first identified by Blainville (1823) from specimens collected in Brazil. The scientific name was changed twice before Steenstrup (1881) returned the species to its original *Lolliguncula brevis*. This squid is relatively small, rarely exceeding 120 mm (4.7 inches) in mantle length; the standard measure of size is body without head and arms. Having rounded fins, the body is less streamlined than most oceanic squids. The brief squid is unique among cephalopods because it is an osmoconformer; that is, its body salinity matches ambient water salinity. Further, this species is capable of tolerating salinities as low as 8.5 ppt (parts per thousand), although it is more common in higher salinities (Hendrix et al. 1981; Laughlin and Livingston 1982).

Ogburn-Mathews and Allen (1993) found the brief squid to be the third most numerous component of trawl and seine samples collected in North Inlet, South Carolina. However, these researchers only found the species in estuarine waters from April through December. Squid were consistently collected together with bay anchovies, perhaps indicating a predator/prey relationship between the two species.

Brief squid are relatively common in the nektonic community (water column) and make up a considerable portion of the estuarine biomass. Accordingly, the species is assumed to be important prey for carnivorous fishes, particularly given the popularity of squid as fish bait. Squid are also known to be cannibalistic, with adults feeding on juveniles (Whitaker 1978). As the squid increases in size, its prey preferences change. Small squid feed on benthic crustaceans and possibly small fish or fish larvae, whereas larger squid often feed on small fish, probably schooling species such as anchovies and silversides. In confinement, the species survives well on grass shrimp (*Palaemonetes* spp.) and small fishes such as killifishes (*Fundulus* spp.), livebearers (Poeciliidae) and sheepshead minnow (*Cyprinodon variegatus*) (Hanlon *et al* 1983.)

Status

As a common component of the nearshore and estuarine nektonic community of South Carolina, this species represents a considerable portion of the estuarine biomass and probably occupies a critical role in the estuarine food web. It is considered an indicator species for the health of this community type.

Population Distribution and Size

The geographic range of this species is from Maryland through Rio de la Plata, Argentina (Voss 1956). The species is common throughout the coastal waters of South Carolina, with all age classes, from small juveniles to adults, having been collected in trawl samples throughout the coastal zone. Because the species has planktonic juvenile stages, there is presumably a single population distributed along the South Carolina coast; however, this has not been specifically investigated. Unfortunately, there are inadequate long-term data sets to evaluate the population size and no long-term survey exists that can be used to assess population trends. Anecdotal information suggests the species has not declined significantly in abundance since the 1950s when the first scientific trawl samples were consistently taken.

Habitat and Natural Community Requirements

Squid are most commonly found in salinities in excess of 17 ppt and are generally confined to the lower portions of estuaries where salinities are relatively high. No specific critical habitats have been established for the brief squid. The species is thought to be largely a nektonic inhabitant, although it seems to be associated more with bottom waters than with surface waters. Vecchione (1991) found catch rates of the squid's paralarvae (a planktonic form that is anatomically identical to the adult) to be higher in bottom samples compared to samples taken in the upper portion of the water column. Ogburn-Mathews and Allen (1993) found the species to be more abundant over mud bottoms versus sand bottoms within inlets. Bartol *et al.* (2002) noted that in Chesapeake Bay, the brief squid was more common in central channel depths of 10 to 15m (33 to 49 feet) than in deeper waters.

Precise information on spawning locations is unknown. However, egg strings have been found in trawl samples taken in Charleston Harbor (pers. obs.). Cephalopods typically attach egg strings to solid objects such as oyster shells, clam shells or other bare, solid objects. Egg strings have been observed on shallow mud flats in South Carolina, presumably attached to molluscan shells (M. Maddox, SCDNR, pers. comm., 18 March 1980).

Challenges

Although the brief squid is relatively common in trawl and seine samples collected in South

Carolina, there is no estimate of population size or trend. Additionally, the factors that may negatively affect brief squid populations and basic aspects of its life history are still unknown. Due to the prevalence of brief squid in the marine environment, it is an excellent indicator of the health of that environment.

Shrimp trawlers occasionally catch brief squid (pers. obs.); however, they are not likely captured in quantities that would threaten the sustainability of the species. The vast majority of squid utilized as bait and food in South Carolina is of the genus *Loligo* because it is larger in size and of a preferred texture; it is imported from California. Reported commercial landings of *L. brevis* in South Carolina have averaged less than a thousand pounds per year, probably all bycatch from the shrimp trawl fishery. The species has been part of the shrimp fishery bycatch for over fifty years and there appears to be no negative impacts upon the population due to trawling; however, population trends have not been specifically monitored (N. Jenkins, DNR Fisheries Statistics Program, pers. comm., 21 March 2005).

Brief squid probably rely on relatively clean water and appear to be linked to mud bottom habitats that are common in South Carolina. Hard structures for attachment of egg strings are important for the species and oyster and clam shell is abundant on estuarine bottoms. Reductions or alterations in river flow rates through out-of-basin transfers or diversions may negatively impact the brief squid. Presuming the species is estuarine-dependent, adequate quantities of fresh water flowing into estuaries may be necessary to maintain viable populations; although the species is common in North Inlet, which is a small system with very little freshwater inflow. Pollutants associated with terrestrial runoff are likely to be problematic for brief squid populations.

Additionally, substantial alteration to intertidal and subtidal mud flats, particularly resulting in siltation covering shell and hard structure could reduce optimal substrate for egg string attachment.

Conservation Accomplishments

In the 1950s, South Carolina closed most estuarine waters to shrimp trawling. Additionally, the state's sounds and bays, which were periodically opened on a limited basis, were permanently closed to trawling in 1986. Shrimp trawling is known to produce bycatch of brief squid; therefore these closures may have contributed to some level of conservation of stocks. The state has also prohibited the use of small mesh gill nets and "stop nets" (nylon mesh nets used to entrap fish) in most estuarine waters. It is presumed that these gear types could have contributed to mortality of brief squid when they were in use.

Conservation Recommendations

- Examine long-term trends in brief squid population size and relate those trends to environmental and other factors such as predator/prey relationships.
- Determine spawning seasons, spawning locations and recruitment mechanisms for brief squid.
- Determine brief squid predator/prey relationships.
- Determine effects of pollutants on distribution, reproduction, growth, maturation, and longevity of brief squid.
- The DNR and other resource management agencies should examine regional water use

plans to assure that adequate quantities of water are provided to coastal estuaries during the appropriate seasons.

- Work with municipalities and counties to include Best Management Practices (BMPs) in development plans throughout the coastal zone. Such plans should include installation of retention ponds, modified septic systems and stream bank protection measures. Poorly designed, existing storm water systems should be retrofitted to updated designs.

Measures of Success

Once threats and conservation actions are better identified through the above-mentioned survey and research needs, a management plan for brief squid can be developed. This plan would represent a measure of success for this species. Further, improved water quality will benefit many sensitive marine species.

Cannonball Jellyfish

Stomolophus meleagris

Contributors: DuBose B. Griffin and Thomas M. Murphy (SCDNR)

Description

Cannonball, or cabbagehead, jellyfish (*Stomolophus meleagris*; L. Agassiz 1860), also known as jellyballs, belong to the class Scyphozoa and order Rhizostomeae. Agassiz (1860) described and illustrated the medusa of cannonballs using specimens collected from Wassaw Island, Georgia and Charleston, South Carolina. The hemispherical bell reaches 20 to 25 cm (8 to 10 inches) in size and is bordered with brown pigment. It has short, protruding oral arms with secondary mouth folds (scapulets) at the base of the bell covered with mucus for trapping small prey. *Stomolophus meleagris* means “many mouthed hunter.” The mucus is also thought to be a response to disturbance rather than for feeding (Phillips et al. 1969; Larson 1976).

Status

The cannonball jellyfish is not a state or federally listed species; however, cannonballs are ecologically important because they are the major prey base for the endangered leatherback sea turtle (*Dermochelys coriacea*) and warrant conservation.

Population Distribution and Size

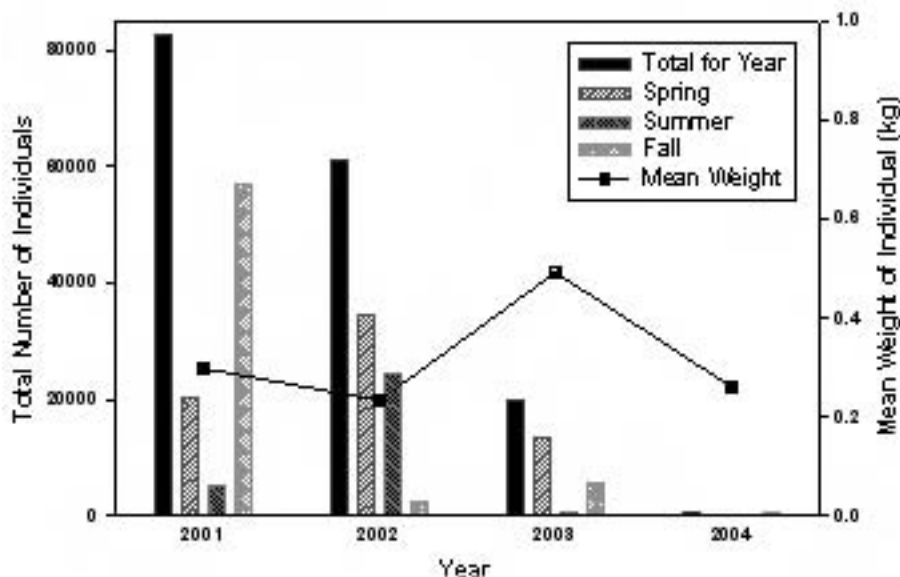
Cannonball jellyfish have been reported from New England to Brazil in the western Atlantic (Kramp 1961; Larson 1976), from southern California to Ecuador in the eastern Pacific and from the Sea of Japan to the South China Sea in the western Pacific (Kramp 1961; Omori 1978). They are one of the most abundant scyphomedusae along the southeastern and Gulf coasts of the United States (Mayer 1910; Kraeuter and Setzler 1975; Burke 1976; Calder and Hester 1978). Their success is based in part on their ability to grow rapidly and take advantage of ephemeral secondary production (Larson 1986).

Current distributions of most populations are undocumented. However, numerous reports of their occurrence in the southeast exist. Mayer (1910) reported them as abundant during the winter and spring off the coast from Florida to South Carolina. Brooks (1882) and Gutsell (1928) reported them in North Carolina as very abundant in June and July and common throughout the summer in the sounds and ocean. In South Carolina and Georgia, they are reported as the most common scyphomedusae occurring sporadically year round (Kraeuter and Setzler 1975; Calder and Hester 1978).

The seasonal cycle of cannonball jellyfish is described by Rountree (1983) as the following:

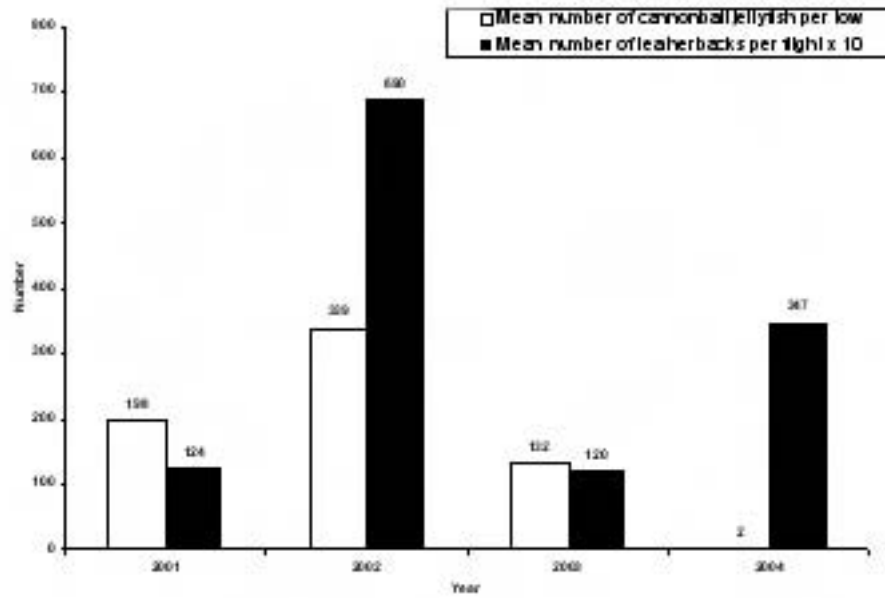
“Small populations of large adults appear offshore in the spring and move inshore by early summer. The origin of these populations of adults has not been determined, but it seems likely that they are survivors from the previous season (Kraeuter and Setzler 1975). It is also possible that they are early spawned medusae from more southern waters which are carried north by prevailing spring ocean currents...Kraeuter and Setzler (1975) found the young medusae move out from estuarine waters into more saline waters as they grow. Two concurrent events are therefore hypothesized: 1) first generation populations move from offshore in the spring to inshore waters in the summer and finally into brackish waters in the fall; 2) second generation populations move out from estuarine waters beginning in the mid-summer and continuing through the fall.”

The South Carolina Department of Natural Resources (SCDNR) has been conducting surveys in the South Atlantic Bight since 1986 through a program called the Southeast Area Monitoring and Assessment Program – South Atlantic Shallow Water Trawl Survey (SEAMAP-SA). Tows were conducted each year in spring (April to May), summer (July to August) and fall (October to November) in shallow coastal waters from Cape Hatteras, North Carolina to Cape Canaveral, Florida. From 1989 to 2000, only the presence or absence of cannonball jellyfish was recorded on each individual tow. During this time, cannonballs were present in 43 percent of the tows during all three survey seasons. Beginning in 2001, total numbers of cannonballs were counted and recorded for each tow (102 tows per season; J. Boylan and P. Webster, SCDNR, pers. comm.). These data are presented in the following bar graph. Since 2001, there has been an apparent steady decline in the relative abundance of cannonballs with very low catch rates observed in 2004. The reason(s) for this decline are unknown; however, anomalously low summer water temperatures in the coastal waters in summer 2003 may be related.



Tow counts of cannonball jellyfish from 2001 – 2004

In another study, density and distribution of leatherback sea turtles were associated with



Annual shifts in abundance of leatherback and cannonball jellyfish observations, 2001 – 2004.

abundance and distribution of cannonball jellyfish. Mean numbers of leatherbacks observed for each sampling event in each year was related to the density of cannonball jellyfish observed from 2001 through 2003. However in 2004, cannonballs were in unprecedented low numbers and leatherbacks were still observed. These data are presented in the graph below. Numbers of cannonballs observed from 2001 through 2003 provided a relative index for leatherback abundance (S.R. Murphy unpub. data).

Habitat and Natural Community Requirements

Cannonball jellyfish are found in estuarine and saline waters. Temperature and salinity measured during the SCDNR SEAMAP-SA tows (unpub. data) indicate they are found in waters with an average temperature of 23.1°C (74°F) and in salinities from 17.7 to 36.5 parts per thousand (ppt) with an average of 33.8 ppt. Cannonballs feed on zooplankton, primarily bivalve veligers, a mollusk larval stage (Larson 1991). They have also been shown to prey on all stages of red drum larvae (Duffy et al. 1997). However, they do not sting humans (Calder and Proden 1977). Cannonballs are strong horizontal and directional swimmers (Shanks and Graham 1987). They are known for their symbiotic relationships with other marine species, specifically 10 species of fishes as well as juvenile longnosed spider crabs (*Libinia dubia*). These symbionts feed on both the zooplankton taken in by the jellyfish and on the host's medusae. Symbionts may also use the bell for protection (Corrington 1927; Gutsell 1928; Phillips et al. 1969; Rountree 1983).

Challenges

Since cannonball jellyfish are dependent on the abundance of zooplankton in nearshore waters, any activity, marine or terrestrial, that could affect water quality, should be considered a detrimental to this species. Such problems include harmful algal blooms, oil spills and nonpoint source pollution. Also, cannonball jellyfish's dependence on bivalve veligers suggests a relationship with the health of bivalves.

The potential exists for cannonball jellyfish to be adversely affected by commercial fishing. Currently, South Carolina does not regulate a commercial cannonball jellyfish fishery. However, this fishery does exist in other portions of the cannonball's range. Japan imports 5,400 to 10,000 tons of jellyfish products valued at 25.5 million dollars annually (Omori and Nakano 2001). Currently, 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). A fishery in Florida has processed cannonball jellyfish since 1992 (Rudloe, 1992) and a commercial trawl fishery for cannonball jellyfish in Georgia exists (M. Dodd, GADNR pers. comm.). Rising demand in Japan and Southeast Asia may create an international market for cannonball jellyfish from South Carolina coastal waters. Any development of commercial fisheries for cannonballs must consider its affect on this species' role in the food web of coastal ecosystems, as well as the affects on endangered leatherback sea turtle through incidental mortality in trawls and reduction of their food resources. Life cycles of cannonball jellyfish involve federal and state waters; therefore, cannonballs should be managed on a regional scale (S.R. Murphy unpub. data).

Conservation Accomplishments

In 1989, SCDNR began surveying cannonball jellyfish during SEAMAP-SA tows. These surveys have provided an index of relative abundance of cannonball jellyfish in coastal waters along the southeastern United States, which has led to a better understanding of this species. In addition, current regulations requiring the use of turtle excluder devices (TEDs) in shrimp trawling nets has also provided protection to cannonball jellyfish. Although required to reduce incidental catch of turtles, TEDs also excludes cannonballs greater than 10 cm (4 inches), thus increasing survival. TEDs have been required for shrimp trawls since 1990.

Conservation Recommendations

- Determine the distribution of cannonball jellyfish in state waters and how this species affects the distribution of leatherback sea turtles.
- Examine basic life history and determine source of the spring recruitment of cannonball jellyfish.
- Determine effect of temperature, salinity and rainfall on spring reproduction.
- Determine southeastern population structure through genetic analysis of cannonballs.
- Continue to monitor population trends through SCDNR SEAMAP-SA sampling of cannonballs.
- Determine the maximum sustainable yield for a harvest fishery.
- More fully examine the species role in predator-prey dynamics.
- Encourage municipalities to adopt Best Management Practices (BMPs) that protect water quality and bivalve health by reducing nonpoint source runoff from highways, agricultural fields and housing developments.
- Monitor effectiveness of existing BMPs such as setbacks, retention ponds, and vegetated buffers for preventing nutrient and contaminant runoff into coastal waters.

- Examine relationship between bivalve populations and cannonball reproduction.
- If a fishery develops in South Carolina for cannonball jellyfish, it should be monitored and regulated to avoid overexploitation and appropriate harvest techniques should be identified that are protective of other marine species.
- Facilitate the development of a regional management plan for cannonballs.
- Develop an education program that stresses the importance of cannonball jellyfish to coastal ecosystems and that they are harmless to humans.

Measures of Success

Determining the distribution, life history, habitat needs and southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect cannonball jellyfish and associated predator/prey relationships. In the event that more protective BMPs are implemented, SEAMAP data can be used to indicate whether these measures have affected cannonball jellyfish populations. Producing a regional management plan for this species would greatly benefit the cannonball jellyfish throughout the southeastern coastal area.

Colorful Sea Whip

Leptogorgia virgulata

Contributors: Stacie Crowe, Anne Blair and Pam Jutte

Description

Taxonomy and Basic Description

The colorful sea whip was first described by Lamarck (1815) and named *Leptogorgia virgulata*. Gorgonians, or soft corals, such as the sea whip belong to the suborder Holaxonia. These colonial cnidarians are so named because they lack the permanent, rigid skeleton of hard corals. As octocorallians, they possess eight tentacles. Branches in gorgonians are arranged around a central axis. *Leptogorgia virgulata* colonies are moderately branching into whip-like stalks. Polyps alternate in rows along two sides of each branch; rows are separated by distinct grooves on older main branches. The color of the colony is variable and may range from shades of purple, red, orange, yellow or white. Sea whip polyps are translucent to white. The typical adult size of the colorful sea whip is 15 to 60 cm (6 to 24 inches) (Ruppert and Fox 1988).

Status

No long-term studies have been done to assess the population status of the colorful sea whip. However, this species commonly colonizes hard substrata and provides valuable habitat for many commercially and recreationally important fishes such as snapper (*Lutjanus*), grouper (*Epinephelus*), porgy (*Calamus*) and black sea bass (*Centropristis striata*) (Van Dolah et al. 1987).

The colorful sea whip also serves as the home or prey for several specialized associates including the Atlantic wing oyster (*Pteria colymbus*), brown barnacles (*Conopea galeata*), a tissue-feeding nudibranch (*Tritonia wellsi*) and the shrimp, *Neopontonides beaufortensis* (Patton 1972; Ruppert and Fox 1988).

The colorful sea whip is only one of many coral species that grow on hard bottom substratum in high salinity areas of South Carolina's estuaries and coastal shelf habitats. Therefore, it serves as

an indicator species and is representative of the sessile epifauna that form essential reef habitats utilized by many economically valuable or ecologically important species. The colorful sea whip was selected over other fauna because it is one of the most pervasive and abundant species inhabiting hard bottom substratum.

Population Distribution and Size

The colorful sea whip is a common shallow water gorgonian species that occurs over a latitudinal range that extends from 60°, from Brazil to the Chesapeake Bay and perhaps as far north as the “Bay of New York” (Bayer 1961). This species inhabits estuaries and coastal sites up to 20 m (66 feet) or more in depth (Van Dolah et al. 1987; Blair 2003).

Research indicates that the colorful sea whip is a dominant octocoral in the coastal shelf areas off all of the Southeastern states (Van Dolah et al. 1987). It is commonly found in high salinity estuarine habitats where tidal scour has exposed hard substrata (Van Dolah, unpub. data).

The colorful whip coral is relatively common in estuarine, coastal and offshore habitats in South Carolina. However, there are no known estimates of population size or population trends. Additionally, factors that may limit the population are unknown.

Habitat and Natural Community Requirements

Sea whips grow abundantly on shell live bottoms in sounds and tidal creeks but can also be found on floating docks, rock jetties and oyster reefs (Ruppert and Fox 1988). They are also familiar constituents of hard-bottom reefs, which are a common topographic feature of the continental shelf off the southeastern United States. Sea whips are also found on artificial reefs constructed in this region.

Unlike many gorgonian species, the colorful sea whip does not reproduce asexually through cloning or fragmentation. Fertilization is external and larvae spend 3 to 20 days in the plankton before settlement and metamorphosis. All recruits are derived from the successful settlement and survival of planktonic larvae, which require adequate substrata such as low-relief rocky outcrops or extensive hard bottom (Gottelli 1991).

Challenges

Occasionally, the colorful sea whip is damaged by shrimp trawl nets; studies have found that the overall effects were a loss of 3.9 to 38 percent during respective census periods (Van Dolah et al. 1987; Tilmant 1979).

Another potential problem for sea whip populations is offshore disposal of dredged material. A current study is investigating changes in sponge and coral communities at select hard bottom reef sites adjacent to the Charleston Ocean Dredged Material Disposal Site (ODMDS). Findings to date suggest that sessile invertebrates, including the colorful sea whip, are experiencing natural fluctuations in community structure and suffering limited, if any, impacts from the large-scale disposal operations occurring at the ODMDS (SCDNR unpub. data). However, coral populations that are located closer to disposal activities in other areas could be negatively impacted with respect to burial or decreases in the aerial extent or damage of the coral beds.

A study of the physiological effects of dredged material disposal on the oxygen metabolism of a related gorgonian octocoral, *Leptogorgia hebes*, was completed in 1992 by the EPA in conjunction with the University of Georgia’s Department of Ecology. The results of the study suggested that while coral recovery from single episodes of low-level sediment exposure is

likely, recovery is more difficult from repeated low-level exposures or single episodes of high-level exposure. Both long-term responsiveness and immediate short-term productivity rates were inhibited by exposure to sediment concentrations above 100 mg/l [15 NTU (nephelometric turbidity units)] (Porter 1993). Because dredging occurs frequently in the Charleston area, the potential exists for this activity to adversely affect the population size or reproductive ability of whip corals.

Populations of the colorful sea whip that inhabit sounds and tidal creeks may be subjected to increased sedimentation rates, nutrient levels (eutrophication) or contaminants due to terrestrial runoff from suburban, urban, industrial and agricultural areas. The physiological impacts from exposure to elevated sediment concentrations in nearshore populations are described in the previous section. The possible effects of exposure to eutrophication could include impacted growth rates, reproductive ability or mortality (Jones and Endean 1976).

Conservation Accomplishments

The state's inshore waters, including sounds and Bull Bay, that were historically open to shrimp trawling were closed in 1986. Sea whips are common in these high salinity estuaries. Since 1978, SCDNR has monitored offshore dredge material disposal in Charleston in an effort to minimize the effects of dumping on hard bottom reef communities. Likewise, 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 conditions as well as provides estimates of the overall condition of state waters (Van Dolah et al. 2004).

Conservation Recommendations

- Conduct mapping studies of bottom habitats to better define the location of hard bottom reef areas that include sea whips.
- Examine long-term population trends of sea whips.
- Further investigate relationships with commensal or cryptic species that live in association with sea whips.
- Establish detailed baseline monitoring to allow for a better understanding of the impacts of offshore dumping on hard bottom reef habitats.
- Conduct studies on the impacts of increased sedimentation rates, nutrient levels and contaminant levels on estuarine populations.
- Educate commercial trawl fishermen on the damage trawling causes about hard bottom reef species and collaborate with the shrimp industry to avoid trawling near sea whip communities.
- Cooperate with the United State Army Corps of Engineers to reduce sedimentation and burial of coral assemblages near disposal sites.
- Work with communities and municipalities to reduce runoff by improving and implementing Best Management Practices (BMPs).
- Work with partners to develop ways to reduce nutrient runoff that exacerbates the effects of eutrophication.
- Develop and enforce a management plan for protecting live bottom communities in South Carolina state waters.

Measures of Success

Once the information regarding population distribution and trends in state waters have been documented, development of both population models for live bottom communities and a conservation plan for sea whip in South Carolina would benefit this species. Documenting stable population trends for sea whips and other members of live bottom communities within South Carolina waters would be the ultimate measure of success for this community.

Coquina Clam

Donax variabilis

Contributor: Larry DeLancey

Description

Taxonomy and Basic Description

This small species of clam, described by Say in 1822 (Adamkewicz and Harasewych 1996), is well known to most beach goers where its shells are found in abundance. Live coquinas are often exposed by retreating waves on sandy oceanic beaches and seem to be more active in the warmer months. This bivalve possesses wedge-shaped shells, generally less than 2.5 cm (1 inch) in length, and is characterized by variously colored bands radiating along the shells (Miner 1950). It is a member of the bivalve family Donacidae, with coquinas being larger and more abundant than *D. fossor* along sandy beaches in the southeastern U.S.

Status

The seemingly abundant coquina clam is considered an indicator species for the sandy beach-ocean front habitat. This filter-feeder is an important link in food webs, feeding on small particles such as unicellular algae and detritus and, in turn, being consumed by fish such as pompano (*Trachinotus carolinus*) and “whiting” (*Menticirrhus* spp.), as well as shorebirds (Finucane 1969, Nelson 1986, DeLancey 1989, Wilson 1999). Coquina clams can also be consumed by humans (Miner 1950).

Population Distribution and Size

The coquina clam ranges from Virginia, down the Atlantic coast, through the Gulf of Mexico and into Texas (Ruppert and Fox 1988). It is common on most ocean front beach types that occur in South Carolina. The prevalence of coquina clams in this habitat makes it an excellent indicator of the health of this ecosystem.

Although current population status for these species is unknown, it appears to be common or abundant on the beaches in South Carolina. Surveys in South Carolina and the southeastern U.S. have consistently documented the occurrence of coquinas since at least the 1940s and found that it is among the most abundant macroinvertebrates present in the intertidal area during spring, where numbers exceeded 1000 per square meter (93 per square foot) (Pearse et al. 1942, Shealy et al. 1975, Knott et al. 1983).

Habitat and Natural Community Requirements

The coquina clam is among several taxa that are uniquely adapted to live and feed in the waves as the tides ebb and flow on sandy, ocean front beaches. It can be seen rapidly burrowing, often

in groups, as waves recede down the beach. Like most bivalves, coquinas are filter feeders, ingesting phytoplankton, bacteria, and other small suspended particles in the surf. The sandy beach ecosystem is one of the most familiar to the public and, like other littoral habitats, is extremely dynamic, being eroded or accreted (built up) often in a period of months. Although many organisms feed in the surf zone, this clam has unique adaptations to this habitat type, making the coquina clam a key habitat indicator species.

Challenges

Rising sea levels, global warming, and beach erosion are the greatest Challenges to the long-term sustainability of sandy beach habitat for species such as the coquina clam. The natural supply of sand borne by rivers from sources in the mountains has been curtailed by construction of dams and reservoirs throughout the 20th century (Komar 1998). Although beach renourishment projects restore sand to eroded beaches, these efforts can decimate populations of coquina clams and other sand dwelling invertebrates as they are buried under tons of sediment. Populations may take at least one to two years to recover following renourishment (Reilly and Bellis 1983; VanDolah et al. 1994).

Rapid coastal development is also a problem for coquinas and other front beach dwelling creatures because of the associated human activity in sensitive dune areas, potential increased erosion from groins and temporary seawalls and disruption of sand flow. As mentioned earlier, harvest by humans could negatively impact coquina clams (Velez et al. 1985).

Conservation Accomplishments

Under South Carolina's Beach Front Management Act of 1990, activities such as groin and seawall construction that may accelerate erosion have been greatly curtailed. This act and current administrative policy have attempted to discourage beachfront development by denying building permits and reducing funds for renourishment. In addition, intertidal beach habitats are currently protected from most construction by municipal or state setback laws (South Carolina Coastal Council 1979). There have been significant strides made in the education of the public concerning protection of dunes and stabilizing vegetation. In addition, many beaches in South Carolina do not permit motor vehicles access because of the damage these vehicles can cause.

Most monitoring efforts for beach invertebrates have been conducted as part of environmental impact studies required by the U.S. Army Corps of Engineers and S.C. Ocean and Coastal Resource Management (OCRM) for beach renourishment projects (references). Future research and monitoring activities hopefully will continue to provide at least short-term estimates of abundance for coquinas and other oceanic sandy beach organisms that can be compared to previous studies.

Conservation Recommendations

- Periodically conduct assessments of beach invertebrates and their communities to determine their condition.
- Prepare impact models of coastal zone dynamics on build-up and erosion of beaches.
- Work with coastal municipalities and communities to reduce future impacts of development on beach environments.
- Work with appropriate state, local and non-governmental agencies to discourage development on beachfront properties.

- Educate the public about the importance of beach dune habitat and initiate participative projects such as dune vegetation plantings.
- Encourage planned development projects in coastal zones, particularly on barrier islands to reduce associated impacts of development on the long-term health of sandy beach habitats in South Carolina.
- Continue to investigate and document the effects of rising sea levels and global warming on beach habitats.
- Discourage building or repair of seas walls and groins on South Carolina's beaches to allow more natural movement of sand and, ultimately, more natural beach renourishment.
- When feasible, remove dams and reservoirs that block flow of sand and sediment from upland areas to allow for more natural beach renourishment.

Measures of Success

Normal surf zone dynamics will cause beaches to accrete, erode and move up and down the coast over periods of decades. The most obvious sign of success for species such as the coquina clam is the continued presence of healthy beaches with adequate, natural supplies of sand.

Fiddler Crabs

Mud Fiddler Crab *Uca pugnax*

Sand Fiddler Crab *Uca pugilator*

Redjointed Fiddler Crab *Uca minax*

Contributor: Elizabeth Wenner, Ph.D.

Description

Taxonomy and Basic Description

Fiddler crabs are true crabs in the infraorder Brachyura. The Brachyura are the most advanced of the decapods. The crab body is generally short, wide and flat, and is characterized by having a reduced abdomen that lacks a tail fan and is flexed under the body. In all but a few small groups, all five pairs of walking legs are large and the first pair are always claws. The majority of brachyuran species pass through a number of planktonic larval stages with the megalopal stage being the last larval stage before settlement to the crab form. The megalopa stage resembles the adult; however, the abdomen hasn't yet folded under the body. Fiddler crabs are in the family Ocypodidae characterized by having eyes that are set close together and at the end of long stalks.

Mud Fiddler Crab

Fiddler crabs are easily recognized by their square body and marked difference in size between the right and left claws of males. As the male grows to maturity, the relative weight of its cheliped, or large claw, changes from two percent to 65 percent of its total body weight. In most fiddler crabs, males can have their enlarged claw on the left or the right side; the chance of either claw being enlarged is usually 50:50 in the population. In all fiddler species, fights between males of the same handedness are very different to those between opposite handed males. When facing each other, males with different handedness have their claws lined up in the same direction while males with the same handedness have their claws lined up in the opposite direction. It may be easier for different handed males to judge each other's size, but it may be easier to interlock claws when they face in opposite directions.

Sand Fiddler Crab

Mud fiddlers, *Uca pugnax*, have an H-shaped depression in the middle of the carapace and their eyestalks are long and thin. They are brown in color, with the front of the shell and eyestalks ranging from blue to turquoise. The large claw of the male is usually yellowish orange to yellowish white and its walking legs are dark and banded. The palm of the large claw in males has an oblique ridge of small granules on the inner surface that extends from the lower margin to the wrist cavity (Williams 1984, Crane 1975).

The sand fiddler's (*Uca pugilator*) carapace is typically a pinkish-purple color, with a bright patch of purple in the center of the carapace. The legs range in color from orange to brown. The inside of the male's large claw lacks a row of tubercles, which can be used in distinguishing sand fiddlers from other *Uca* species.

Red-jointed fiddlers (*Uca minax*) are larger than the other two species. The joints of the male's large claw are red and a row of tubercles line the inner face of the palm. The merus (fourth segment) of the second walking leg lacks dense pubescence (soft down or short hairs) on the ventral margin.

Status

Although fiddler crabs have no directly quantifiable commercial value, they do occupy an important role in the ecology of salt marshes and are a good environmental indicator as they are sensitive to environmental contaminants, especially insecticides. Their population densities are an example of the high productivity of coastal marshes. Their burrowing activity can erode or undermine marsh banks and can affect aeration of sediments, which increases the growth of marsh grasses. These activities stimulate the turnover and mineralization of important nutrients. They are also important regulators of cordgrass-derived production and decomposition. Fiddler crabs are often used as fishing bait, especially for sheepshead and black drum and are an important food source for other estuarine animals such as clapper rails and other marsh birds (Grimes et al. 1989), blue crabs and many other species.

Population Distribution and Size

Mud fiddlers range from Massachusetts to Florida and are common in marshes along the southeastern coast. The sand fiddler occurs along the Atlantic and Gulf coasts from Massachusetts to western Florida. Red-jointed fiddler crabs are found along the east and Gulf coasts of the United States from Cape Cod to Texas. South Carolina is well within the natural range of all three species and they can be found throughout the state's coast (Ruppert and Fox 1988).

Fiddler crabs are extremely abundant in South Carolina; however, assessments of fiddler crab populations are few. It would be impossible to count these small creatures, so surrogate measures of fiddler crab density can be made from counting burrows. Fiddler crab burrow density was measured along a transect from the forest to the creek bank in North Inlet, SC. Burrow density ranged between 40 and 300 burrows per m² (4 and 28 burrows per square foot) with highest densities at the creek bank (McCraith et al. 2003). Standing stock of the mud fiddler at North Inlet, SC was estimated at 29 g/m² dry weight (Krebs et al. 1974). In Georgia, the density of crab populations was reported as 27 crabs per m² (2.5 crabs per square foot) (Teal 1958).

Habitat and Natural Community Requirements

Fiddler crabs are one of the most conspicuous inhabitants of the marsh surface and intertidal zone. They often can be seen foraging in large groups along creek banks when the tide is out.

Mud Fiddler Crab

The mud fiddler prefers a muddy marsh environment where the substrate is relatively free of heavy plant roots, yet stable enough to allow for the construction of burrows, which can be up to 60 cm (23 inches) deep.

Male fiddler crabs wave their oversized claw up and down to attract the attention of females for mating and to intimidate potential male competitors. They also stomp their walking legs and make noises with them in an effort to attract mates. Such displays reach a peak during spring tides and mating occurs thereafter inside the male's burrow. The female remains inside the burrow during the two-week incubation period and then comes out to release her eggs, which are swept out to sea by neap tides, especially weak tides that occur during quarter moons.

After hatching, larvae go through several developmental stages (five zoeae and a megalopal or first post larval stage) over the two-week period that they are adrift in the ocean. They are then transported back inside estuaries on the subsequent spring tide. Larvae are predatory and feed on zooplankton in the water column. They remain pelagic for some time after reaching the megalopal stage, gradually adopting a benthic existence.

Adult fiddler crabs feed on organic material extracted from mud, which is rolled into small balls after the food is removed and deposited back onto the substrate. They appear different from pellets formed during burrow excavation; excavated pellets are much larger than feeding pellets. Mud fiddlers are adept at regulating their metabolism over a wide range of temperatures, which may explain their widespread abundance.

Sand Fiddler Crab

The sand fiddler is an abundant species on sandy and muddy intertidal areas near salt marshes and banks of tidal creeks. Burrows are constructed along the edges of marshes. However, the sand fiddler may occur on the marsh surface when substrate contains more sand than mud. Sand and mud fiddler populations may intermingle and large populations can be seen feeding in the intertidal areas bordering marshes along tidal creeks in the southeast. The sand fiddler's burrow is unbranched and dug at an angle to the surface. The biology of the sand fiddler is similar to that already described for the mud fiddler. Sand fiddler crabs have specialized spoon-shaped bristles on its maxillipeds (an appendage used in feeding) that enable the crab to remove algae and other organic matter from sandy sediments. Once the sediment has been "cleaned" by the fiddler crab, the mouthparts form the inorganic matter into balls which are deposited around the openings of burrows (Williams 1984; Heard 1982).

Red-jointed Fiddler Crab

The red-jointed fiddler crab occurs in low salinity and freshwater tidal marshes. It is generally found on mud and sandy substrates with high organic content. This species can withstand low oxygen conditions. Red-jointed fiddler crabs may move near terrestrial areas away from the intertidal zone of marshes. Feeding habits and biology are similar to other fiddler crabs occurring in the southeast.

Challenges

Contaminants, such as polychlorinated biphenyls (PCBs) and insecticide/fertilizer mixtures, will adversely affect the health of fiddler crab populations (Krebs et al. 1974). Fiddler crabs apparently concentrate these toxins from seawater or food. Fiddler crabs accumulate PCBs from

contaminated sediments and detritus and can transfer them to aquatic, avian, and terrestrial food webs when preyed upon by fishes, birds, and small mammals. When Dieldrin was concentrated in crab tissues, it impaired locomotion, killing crabs at the higher concentrations (Krebs et al. 1974). Chemical contaminants can drastically reduce populations of fiddler crabs in the marsh (Krebs et al. 1974). Fiddler crabs have been found to be sensitive to mercury (DeCoursey and Vernberg 1972) and cadmium (O'Hara 1973). Heavy metals such as mercury, copper, and zinc are toxic to fiddler-crab larvae, causing a significant delay in larval development as well as deformities.

Spraying marsh habitats for mosquito control can also cause a significant decrease in the natural fiddler crab populations down wind of the pesticide application area (Rookery Bay NERR 1996). Studies in Florida have shown that the mortality of fiddler crabs can be markedly reduced when high-pressure nozzles are used in combination with the mosquito adulticide, Dibrom. Methods that reduce the size of the pesticide droplets not only improve the effectiveness of a pesticide to kill mosquitoes but also significantly reduce the amount of pesticide needed (Rookery Bay NERR 1996).

Nonpoint source runoff from residential areas, roads, and golf courses can have a negative impact on marsh creek ecosystems and impact water quality. Any one discharge may involve only small amounts of chemicals that are diluted by the receiving streams, but when combined with other chemicals from multiple other discharges, significant concentrations of pollutants may result. Pollution may disrupt the food web in the salt marsh by killing off some species and prompting others to greatly increase in number.

Conservation Accomplishments

Nonpoint-source pollution is difficult to control. A remedy to the problem of nonpoint source pollution that has been adopted in many communities in South Carolina is maintenance of buffer zones and retention ponds (George et al. 2001). Studies have shown that fiddler crab populations respond in a positive way when wetlands are restored and good water quality maintained (Knott et al. 1997).

Conservation Recommendations

- Assess burrow density before and after impacts to marsh habitat to evaluate recovery of marsh habitat.
- Evaluate the effects of mosquito control on fiddler crab populations in South Carolina.
- Conduct studies to investigate the use of high-pressure nozzles in combination with the mosquito adulticide, Dibrom to determine the effectiveness of this method in reducing mortality of fiddler crabs.
- Encourage continued use of best management practices (BMPs) to reduce nonpoint source pollution runoff.

Measures of Success

By evaluating the effect of mosquito adulticides and application technology on fiddler crab populations, South Carolina Department of Natural Resources (SCDNR) would be able to recommend changes in application techniques to the South Carolina Department of Health and Environmental Control (SCDHEC), which will result in a stable fiddler crab population. In addition, by monitoring population trends in fiddler crabs, SCDNR will be better able to assess the health of and protect marsh habitat for all fish and wildlife species.

Grass Shrimp

Daggerblade Grass Shrimp (*Palaemonetes pugio*)

Marsh Grass Shrimp (*P. vulgaris*)

Brackish Grass Shrimp (*P. intermedius*)

Contributors: Loren Coen and Elizabeth Wenner

Description

Taxonomy and Basic Description

These small decapod shrimp are collectively known as ‘carideans.’ Common names include grass shrimp, jumpers, glass shrimp, popcorn shrimp, glass pawns and hardbacks.

Grass shrimp have a well-developed ‘horn’ or ‘rostrum’ (hence the name of one of the species, daggerblade) with teeth along the dorsal and or ventral surfaces. The presence and position of these and other nearby teeth are used to separate out the species in the genus. An important distinguishing characteristic is their lack of claws on the third pair of walking legs and their diminutive size. They are rarely larger than 5 cm (2 inches); this differentiates them from commercial shrimp. Because of their morphological similarities and the need of a dissecting scope to view key characters, the species are often misidentified. Grass shrimp are nearly transparent. Males can be separated from females by the presence of the ‘appendix masculina’ attached to the ‘appendix interna’ of the endopod of the second pair of pleopods. Also, the endopod of the first pleopod is larger in males versus females. A significant positive correlation between female length and egg number has been also observed as it has in many decapod crustaceans (Hines 1982; Anger et al. 2002).

Spawning occurs from February through October, although this may vary with location. More than one brood may be produced during the spawning season. During mating, which occurs within seven hours of molting, the male transfers a spermatophore to the female. The eggs are fertilized externally as they are extruded. The female attaches the eggs to her pleopods, where they remain until hatching 12 to 60 days after they are fertilized. Ovigerous females, those carrying eggs, are easy to recognize because the eggs are visible through the female’s carapace. Egg incubation varies among species and is shorter in the southeast. Females molt again after spawning, thereby producing another brood. Grass shrimp larvae undergo a series of developmental stages (10 zoeae and a postlarva). Juvenile grass shrimp mature when they are perhaps 1.5 to 2 months old or about 15 to 18 mm (0.6 to 0.7 inches) long; they live from 6 to 13 months. Older, overwintering individuals usually spawn early in the year and die by the following winter. Most young-of-the-year spawn late in the fall as adults. Postlarvae that survive fall and winter spawn the following spring. Because some grass shrimp populations reproduce two broods each year, length-frequency distributions may be polymodal (two or more peaks), with growth rates difficult to characterize. Growth rates vary somewhat between species, sexes, habitats and times of year. In colder coastal waters, growth patterns are different; salinity also affects growth (Anderson 1985).

Grass shrimp eat a wide variety of foods, but are considered by many to be primarily detritivores. However, they can be quite carnivorous in captivity, where they are often cannibalistic (pers. obs.). Grass shrimp also are predators of meiofauna and small infaunal polychaetes, oligochaetes and nematodes (Bell and Coull 1978; Smith and Coull 1987; Gregg and Fleeger 1998).

Status

Grass shrimp are not state or federally listed; however, they are an important species from an ecological perspective because they serve as a link for energy transfer between trophic levels in the coastal food web. Their feeding on the epiphytic algae that occur on marsh grass assists with the mechanical breakdown of organic material (Orth et al. 1984) and the fecal pellets from the unused part of their diet are rich in nutrients and, therefore, an important component of energy cycling in estuarine ecosystems. Marsh grass shrimp are hosts to several ectocommensals, including the bopyrid isopod *Probopyrus pandalicola*, as well as microsporidians, trematodes, coccidia and leeches (Anderson 1985). Marsh grass shrimp have been extensively documented as prey of fishes and other carnivores. They are instrumental in transporting energy and nutrients between various estuarine trophic levels: primary producers, decomposers, carnivores and detritivores (Haertel-Borera et al. 2004). Grass shrimp are consumed in large quantities by commercially important fishes and forage species, including spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*) and mummichogs (*Fundulus heteroclitus*) (Heck and Thoman 1981; Anderson 1985; Wenner 1990; Posey and Hines 1991; Wenner and Archambault 1996; C. Wenner pers. comm.).

Population Distribution and Size

Grass shrimp are found in large numbers in estuarine waters along the Atlantic and Gulf coasts, where they occur from Massachusetts to Texas. Although there are many freshwater members of the genus, the three species considered here are common in estuaries and tidal creeks in South Carolina waters.

Although there are no estimates of population size of grass shrimp in South Carolina, they are amongst the most widely distributed, abundant and conspicuous of the shallow water benthic macroinvertebrates in our estuaries, often reaching hundreds to thousands per meter (Coen and Luckenbach 2000; Leight et al. 2005; L. Coen unpublished data).

Habitat and Natural Community Requirements

Grass shrimp are very common estuarine species in southeastern marshes and tidal creeks where they are usually associated with beds of submerged or emergent vegetation, oyster reef habitats or structures such as oyster shell, fouling communities, woody debris (Ruiz et al. 1993), docks or pilings (Coen et al. 1981). Marsh grass shrimp (*P. vulgaris*) tolerate somewhat higher salinities than its congener, the daggerblade grass shrimp (*P. pugio*). This has lead some to suggest a separation of the two species based on preferred habitat, although biotic interactions such as competition for food and space may be more important (Thorp 1976; Coen et al. 1981). Grass shrimp are eurythermal. In estuarine waters, daggerblade grass shrimp can survive at temperatures from 5 to 38°C (41 to 101°F); however, optimal temperatures range from 18 to 25°C (65 to 77°F). Marsh grass shrimp are more tolerant of high salinity water and less tolerant of low salinity water than daggerblade grass shrimp. Although salinities as low as 3 parts per thousand (ppt) have been lethal to adult marsh grass shrimp, they have been collected in freshwater (Anderson 1985).

Although brackish grass shrimp are also considered euryhaline, they have typically been collected from waters with salinities of 5 to 39 ppt. The two freshwater species, *P. paludosus* and *P. kadiakensis*, often live in brackish waters. *P. paludosus* was reported in salinities of 0 to 10 ppt (Anderson 1985).

Grass shrimp can inhabit very shallow areas near their margins, but have been reported at depths as great as 15.2 m (50 feet). In winter, during temperature lows and in summer, when water temperatures approach seasonal highs, daggerblade grass shrimp may move from shallow to relatively deeper water. The extent of the movement of grass shrimp among various depths often coincides with the distribution of oyster shell substrates, which, in some waters, are preferred by both daggerblade grass shrimp and marsh grass shrimp. They are abundant in these structured estuarine and marine habitats as they provide abundant food and protection from predators such as fish (Thorp 1976; Coen et al. 1981; Heck and Thoman 1981; Heck and Crowder 1991).

Challenges

The main challenge to conserving grass shrimp is the degradation of habitat associated with extensive development along the South Carolina coast. Estuaries and tidal creeks are increasingly being affected directly and indirectly through runoff and spraying, to name just a few. As epibenthic predators and sediment disturbers, grass shrimp can significantly alter infaunal community structure. For example, in North Carolina, a sharp decline in the abundance of marsh grass shrimp due to predation by mummichogs (*Fundulus heteroclitus*) may have changed marsh infaunal composition (Anderson 1985).

Because grass shrimp often rely on aquatic vegetation or other structured habitats (Boesch and Turner 1984), activities that reduce structural complexity can negatively affect grass shrimp populations (Thorp 1976; Coen et al. 1981; Heck and Thoman 1981; Heck and Crowder 1991; Weaver and Holloway 1974). In West Bay, Texas, dredging, bulkheading and filling of coastal marshes caused a permanent loss of intertidal vegetation (Trent et al. 1976). The reduction of detrital input into the adjoining aquatic systems caused a noticeable decrease in abundance of grass shrimp. Coen et al. (1999a,b) found that juvenile grass shrimp were collected in much higher numbers (20 to 60 times greater) over marsh than other adjacent estuarine habitats (mud or oyster reefs).

Changes to water regimes that alter salinity or dissolved oxygen through diversion or redirection may also alter grass shrimp abundance patterns.

Grass shrimp have been used extensively by researchers in South Carolina and across the U.S. as a bioassay organism for contaminant and toxicological research (Mayer 1987; American Public Health Association (APHA) 1975); a great deal of information is available regarding mortality and sublethal effects. Researchers conducting toxicological work with the genus *Palaemonetes* have noted that grass shrimp adults are generally more sensitive than fish (Scott et al. 1994; Strozier 1996; Van Dolah et al. 1997); however, this may vary greatly upon the toxicant (Scott et al. 1987). Grass shrimp larvae are also generally more sensitive to many organophosphates (Lund 1997; Lund et al. 2000; Key and Fulton 1993; Key et al. 1998b). Overall, grass shrimp appear to be more sensitive to organophosphate and pyrethroid insecticides and less sensitive to several organochlorine insecticides at high versus low salinities (Scott et al. 1989; Fulton and Scott 1991; Key and Scott 1993). Concentrations of heavy metals (mercury, cadmium, and chromium) are acutely toxic to adult grass shrimp, usually in the order of 100 to 1,000 parts per billion. Work in Charleston by NOAA and other scientists at Fort Johnson have focused on grass shrimp as an invaluable model organism (Scott et al. 1992, 1994; Key and Fulton 1993; Fulton 1993, 1997; Cochran and Burnett 1996; Lund 1997; Finley et al. 1999; Wirth et al. 2001; Bolton-Warberg 2005; Leight et al. 2005).

Conservation Accomplishments

Extensive research on grass shrimp population dynamics has been conducted around sites with known pollution sources in South Carolina, including suburbanized Murrells Inlet, Charleston Harbor, North Inlet, the Broad and Okatee Rivers (Van Dolah et al. 1999) and the ACE Basin. Thus, an extensive historical database (1985 to present) exists for grass shrimp population dynamics within South Carolina. Egg number per female has also been compared among tidal creeks, rivers and intertidal habitats to evaluate impacts.

Conservation Recommendations

- Determine species' associations, critical habitats and population abundance patterns for grass shrimp.
- Determine grass shrimp predator/prey relationships.
- Determine effects of contaminants on reproduction, growth and longevity of grass shrimp.
- Protect important habitat like fringing marsh and oyster habitats from direct and indirect impacts from development and increase our directed restoration efforts. Oyster habitats have only recently begun to be appreciated for their unique ecosystem services (see Oyster Habitat document and references therein).
- In order to conserve grass shrimp habitat, protect aquatic vegetation by directing dredge and fill operations away from intertidal marshes.
- Partner with NOAA-NOS to develop and implement ways to use grass shrimp as an indicator of ecosystem health.
- Work with municipalities to encourage the use of BMP's that reduce non-point source runoff and reduce acute and chronic effects on grass shrimp.
- Encourage use of conservation buffers that intercept pollutants to mitigate the movement of sediment, nutrients and pesticides within nonpoint source pollution.
- Develop and implement a nutrient management plan (NMP) by farmers would be helpful in minimizing nutrient loss while maintaining yield, decrease the flow of nutrients into waterways, and reduce eutrophic effects.
- Work with communities and municipalities to reduce runoff by improving and implementing Best Management Practices (BMPs).
- Develop and implement a management plan for grass shrimp.

Measures of Success

By implementing the above recommendations, SCDNR will be able to protect important marsh habitat and monitor water quality. The measurement of success will be to observe stable populations of grass shrimp (during annual surveys) that should result from this proactive management approach.

Hard Clams

Mercenaria mercenaria

M. campechiensis

Contributors: Nancy Hadley and Loren Coen

Description

Taxonomy and Basic Description

Members of the genus *Mercenaria* are bivalve mollusks in the Veneridae family. Common names for *Mercenaria mercenaria* (Linnaeus 1758) include hard clam, quahog, quahaug, northern quahog, littleneck clam and cherrystone clam, although the latter two are actually referring to commercial size classes. The sister species, *M. campechiensis*, is commonly known as the southern quahog.

The hard clam has two thick, equal-sized valves that are elliptical in shape and marked with conspicuous concentric rings (Eversole 1987). The valves are joined dorsally by a dark brown external ligament just below the anteriorly-inclined umbo. Opposite the hinge is a distinct heart-shaped lunule. The external shell is generally tan-colored or off-white and may have reddish markings (*notata* form). The internal shell is white or pale yellow with a dark purple margin. The prominent adductor muscle scar may also be purple.

The body of the hard clam is surrounded by a mantle that secretes the shell. The clam filters through a pair of siphons fused at the bases. The incurrent siphon has sensory tentacles that are involved in food selection. The siphons are generally creamy white, but the margins may be colored in a range of yellows, browns, purples or reds. The clam has a large hatchet-shaped foot that is used for digging.

Clams may live for up to 46 years (Peterson 1986) and reach a size of 150 mm (5 inches) although the mean size is usually 60 to 70 mm (2 to 3 inches) (Stanley and Dewitt 1983).

Status

Hard clams are not state or federally listed; however, clams and other filter feeders are very ecologically important in marine ecosystems. Filter feeders affect nutrient cycling in estuarine habitats and improve water quality by removing suspended particles along with phytoplankton (Officer et al. 1982; Dame 1996; Dame et al. 2001; Newell 2004). A large adult clam filters an average of seven to eight liters (2 gallons) per hour. They also readily ingest bacteria, viruses and other water-borne pathogens that can cause human health problems. Although clam stocks appear to be in good shape based on high densities observed in some locations, they are a high priority for conservation in marine ecosystems.

Hard clams are harvested both recreationally and commercially and are the most valuable commercially harvested clam in the United States (Pritchard 2004). In South Carolina, the hard clam also supports a mariculture industry producing an estimated 'farmgate' value of 6.5 million dollars (J. Whetstone, SC Sea Grant Marine Extension Service, pers. comm., January 2005). There were 40 hard clam mariculture permits active in South Carolina in 2004. Wild stock commercial landings were down slightly in the 2004 season, but this is thought to be due to the soft clam market and displacement by maricultured clams rather than an actual resource decline (W. Anderson, pers. comm., January 2005). Kraeuter and Castagna (2001) provide a recent review of the hard clam fishery status and aquaculture.

Population Distribution and Size

Mercenaria mercenaria is found from the Gulf of St. Lawrence to the Atlantic coast of Florida. This species has been introduced to other areas of the United States, notably Humboldt Bay, California (Murphy 1985), Washington State and Puerto Rico. It has also been introduced into Great Britain and Southern Brittany where it is well established, as well as the Mediterranean (France, Italy, Sicily, the Adriatic Sea) and China. A sister species, *M. campechiensis* (Gmelin 1791), is distributed primarily along the Atlantic coast from North Carolina to Florida and in the Gulf of Mexico (Dillon and Manzi 1989b). A subspecies, *M. mercenaria texana* (Dillon and Manzi 1989a) is found primarily along the Gulf coasts of Texas and Louisiana. *M. mercenaria* and *M. campechiensis* readily hybridize where their ranges overlap. Both *M. campechiensis* and hybrids have been reported in South Carolina (Dillon 1992; Dillon and Manzi 1992), but only as a small percentage of the population. Kraeuter and Castagna (2001) provide a recent review of the biology of the hard clam.

Hard clams are contagiously distributed (randomly clumped) in South Carolina estuarine waters at relatively low densities of 6 to 24 per square meter (Dame 1979; Rhodes et al. 1977; Anderson et al. 1978). A statewide survey in the 1970's (Anderson et al. 1978) estimated that 10 percent of estuarine waters in South Carolina contained clams, predominately at low densities (less than four per square meter). Most of the clams in this survey (68 percent) were in substrates composed of sand and shell; the fewest specimens were found in mud and sand mixtures. Small clams may be found in saltmarsh where the rhizomes provide protection from predators. Larger clams are often found in association with oyster reefs, burrowed under and adjacent to oyster clusters (Anderson et al. 1978). Larval clams (70 to 350 microns in length) are planktonic; they drift with currents and may be distributed considerable distances from where they were spawned (Wood and Hargis 1971).

Habitats and Natural Community Requirements

Hard clams occupy intertidal as well as subtidal habitats. They burrow into the substrate to various depths; they can go as deep as 20 cm (8 inches), but more commonly burrow to a depth of 1 to 2 cm (0.4 to 0.8 inches) (Roberts et al. 1989; Eversole 1987). Hard clams are found in a variety of substrates including sand, mud, shell and mixtures of these. However, studies have demonstrated a preference for courser substrates that may relate to associated water currents (Stanley and Dewitt 1983). They are often most abundant where there is an overlying layer of shell or coarse sand (Anderson et al. 1978) which provides predator protection. Although clams are infaunal, they can 'migrate' horizontally, as well as vertically (Toll et al. 2003). Adult clams have been shown to repopulate a harvested area in a relatively short period of time (Toll et al. 2003).

The hard clam is a moderately euryhaline 'osmoconformer.' Although it has been found in salinities ranging from 4 to greater than 35 parts per thousand (ppt) (Eversole 1987), growth is best at salinities between 24 and 28 ppt. However, clams can tolerate long periods of reduced salinity by closing their valves (Eversole 1987). Clams are tolerant of low dissolved oxygen and have been known to survive three weeks at 1 mg/l (Stanley and Dewitt 1983). Clams, especially larvae and juveniles, are sensitive to pH outside the range of 7.0 to 8.75 (Calabrese and Davis 1966).

Growth and reproduction in hard clams is largely controlled by temperature. Hard clams usually reach sexual maturity at a size of about 35 mm (1.4 inches) shell length. In South Carolina, clams usually spawn intermittently from May through October when water temperatures reach or exceed 24 degrees C (75 degrees F). The planktonic larval stage may last as long as two

weeks during which time the larvae may be distributed widely by currents and winds. At the end of this stage, the clam metamorphoses to the adult form and rapidly burrows into the substrate (MacKenzie et al. 2002).

Challenges

High turbidity, which can be a result of runoff, dredging and boating activities, as well as natural causes such as storm-induced flooding and winds, can negatively impact hard clams (reviewed in Ward et al. 1994; Coen 1995; Ward and Shumway 2004). As with other filter-feeding bivalves, high turbidity may interfere with feeding by potentially clogging or even limiting the time that hard clams attempt to feed (Stanley and Dewitt 1983).

Clams, like other filter feeders, can be adversely affected by blooms of certain types of phytoplankton (microalgae) (Gainey and Shumway 1988; Shumway and Cucci 1987; Shumway 1990). Most phytoplankton blooms result from a combination of physical, chemical and biological mechanisms and interactions that are only partially understood. Some phytoplankton species produce toxins and, in a bloom situation, can adversely affect other organisms. Even when such blooms do not harm the filter-feeding organisms, the toxins can accumulate in the filter-feeders and reach levels that can endanger consumers, including humans. Harmful algal blooms have increased in frequency and become more widely distributed in the last few decades; this suggests that human activities may be affecting bloom occurrence or distribution (Hallegraeff 1993; WHOI 2004). A specific concern with clams occurs when healthy bivalves from 'open' approved areas that have experienced harmful algal blooms are transferred to other bays or creeks that have not experienced such blooms. Such transfer is of interest because many of the phytoplankton species that cause harmful algal blooms can survive digestion (Shumway et al. 2002).

Mariculture-related importations of clams or other bivalves could inadvertently introduce new predators or diseases into South Carolina waters. The SCDNR has documented twenty-seven other species, including oyster drills and a number of crab species, at least one of which is not indigenous to South Carolina, in hard clams transferred from Florida as part of a mariculture operation. Mariculture operations could also potentially modify the local population's genetic structure (Metzner-Roop 1994; Arnold et al. 2003). Recent research has suggested that hard clam populations may differ in susceptibility to certain diseases (Ford et al. 2002; Ragone-Calvo and Bureson 2002; Camara et al. 2004; Ragone-Calvo et al. 2003). Clams imported for mariculture in South Carolina could be strains more susceptible to certain diseases. Interbreeding with local populations could result in increased susceptibility of native stocks to disease.

Relatively few diseases have been reported in *M. mercenaria*. The most notable is the parasite QPX, (Quahog Pathogen Unknown), which was originally observed in the 1950s in New Brunswick, Canada, where it caused observable mortalities. More recently, significant mortalities from epizootics have been observed in hard clam aquaculture plantings in parts of Atlantic Canada, Massachusetts, New Jersey and Virginia (Smolowitz et al. 1998; Whyte et al. 1994; Ragone-Calvo et al. 1998; Ford 2001). Recent mortalities in wild populations of clams have been noted near Raritan Bay (Bobo et al. 2004)). However, no die-offs or instances of QPX have been observed in the Chesapeake Bay proper or south of Virginia. To date, the parasite has only been detected in near-market to market-sized clams (perhaps one to three years old). Recent research suggests that South Carolina clam populations may be more susceptible to QPX

mortality than northern populations which may have developed some resistance through repeated exposure (Ford et al. 2002, Ragone-Calvo and Bureson 2002). QPX has not been reported in South Carolina, either in wild or aquacultured populations (Bobo et al. 2004). Importations for mariculture from areas of QPX infestation could spread this disease into local waters where it could be a threat to wild populations as well as cultured clams.

Conservation Accomplishments

The South Carolina Department of Health and Environmental Control (DHEC) restricts harvest of shellfish, including clams, in approximately 30 percent of estuarine waters in South Carolina for human health reasons. There have been no outbreaks of human disease related to clam consumption in South Carolina.

The South Carolina Department of Natural Resources (SCDNR) regulates importations of hard clams and other bivalves for placement in South Carolina's waters for mariculture purposes. Importation from areas of known diseases, such as QPX, is restricted. Disease testing is required prior to importation. Shipments are inspected for the presence of predators, non-native species and other undesirable associated organisms (SCDNR 2004).

The SCDNR regulates and monitors the commercial clam fishery, including annual compilation of fishery statistics. The SCDNR also assess State Shellfish Grounds on an annual basis to evaluate clam and oyster population status and determine which State Grounds may need to be temporarily closed to allow populations to recover.

The South Carolina Task Group on Harmful Algal Blooms has many initiatives underway to investigate harmful algal blooms (HABs) in the state, including their interactions with filter-feeders, such as hard clams.

Conservation Recommendations

- Regularly update importation policies of cultured clams to reflect changes in threats to native clams. Continue to regulate and monitor mariculture activities because they have the greatest potential for introducing diseases or non-indigenous predators and for affecting the native population genetic structure.
- Monitor for signs of the QPX disease in wild and cultured clam populations.
- Continue to monitor population status through surveys and analysis of fishery trends.
- The Task Group on Harmful Algal Blooms should continue to investigate the causes of harmful algal blooms and possible effects on hard clams and other mollusks.
- Work with appropriate agencies to improve and implement Best Management Practices (BMP) in order to protect water quality and prevent turbidity caused by urban and agricultural runoff.

Measures of Success

Determining that populations of hard clams are stable through annual fishery statistics and population monitoring within South Carolina would result in a measure of success. Another way to measure success is absence of disease in native clam populations. Further, absence of human health problems associated with consumption of clams would indicate successful conservation

Horseshoe Crab

Limulus polyphemus

Contributor: Elizabeth Wenner, Ph.D.

Description

Taxonomy and Basic Description

Despite their name, horseshoe crabs are not true crabs. The horseshoe crab, *Limulus polyphemus*, is the only member of the Arthropoda subclass Xiphosura found in the Atlantic. Unlike true crabs, which have two pairs of antennae, a pair of jaws and five pairs of legs, horseshoe crabs lack antennae and jaws and they have seven pairs of legs, including a pair of chelicerae. Chelicerae are appendages similar to those used by spiders and scorpions for grasping and crushing. In addition, horseshoe crabs have book lungs, similar to spiders and different from crabs, which have gills. Thus, horseshoe crabs are more closely related to spiders and scorpions than they are to other crabs. Their carapace is divided into three sections: the anterior portion is the prosoma; the middle section is the opithosoma; and the “tail” is called the telson. Horseshoe crabs have two pairs of eyes located on the prosoma: one anterior set of simple eyes and one set of lateral compound eyes similar to those of insects. In addition, they possess a series of photoreceptors on the opithosoma and telson (Shuster 1982).

Horseshoe crabs are long-lived animals; after attaining sexual maturity at 9 to 12 years of age, they may live for another 10 years or more. Like other arthropods, horseshoe crabs must molt in order to grow. As the crab ages, more and more time passes between molts, with 16 to 19 molts occurring before a crab becomes mature, stops growing and switches energy expenditure to reproduction. Adult horseshoe crabs feed on a variety of bottom-dwelling organisms including marine worms, shellfish and decaying animal matter. The larvae and juvenile stages are preyed upon by many species of fish and birds and adult horseshoe crabs are known to be a food item for the threatened loggerhead sea turtle, *Caretta caretta* (Keinath et al. 1987).

Horseshoe crabs are also harvested for use in biomedicine. A clotting agent in the crab’s blood, known as *Limulus* Amoebocyte Lysate (LAL), is used to detect microbial pathogens in medical intravenous fluids, injectable drugs and supplies (Rudloe, 1983). Biomedical companies purchase large crabs, which are harvested by trawlers or by hand from spawning beaches. The crabs are transported to the LAL production facility, bled, then transported back to the general harvest vicinity and released alive. LAL is currently used worldwide as the standard (FDA required) test for microbial contamination in injectable pharmaceutical products (Walls and Berkson 2000). Horseshoe crabs have also been used in eye research and the development of wound dressings and surgical sutures. In addition, horseshoe crabs are currently the primary bait used in the whelk and eel fisheries along the Atlantic coast (ASMFC 1998).

Status

This species is not currently listed as threatened or endangered; however, horseshoe crabs are an important species, both commercially and ecologically. Ecologically, horseshoe crabs are an important component of coastal food webs. In particular, horseshoe crab eggs are the primary source of fat for at least 20 species of migratory shore birds (Harrington 2001). Larval and juvenile crabs are also food for many species of fish and invertebrates, while adult crabs are favored by loggerhead sea turtles and sharks (Keinath et al 1987). In addition, horseshoe crabs have been shown to be a controlling factor in benthic species composition through their feeding

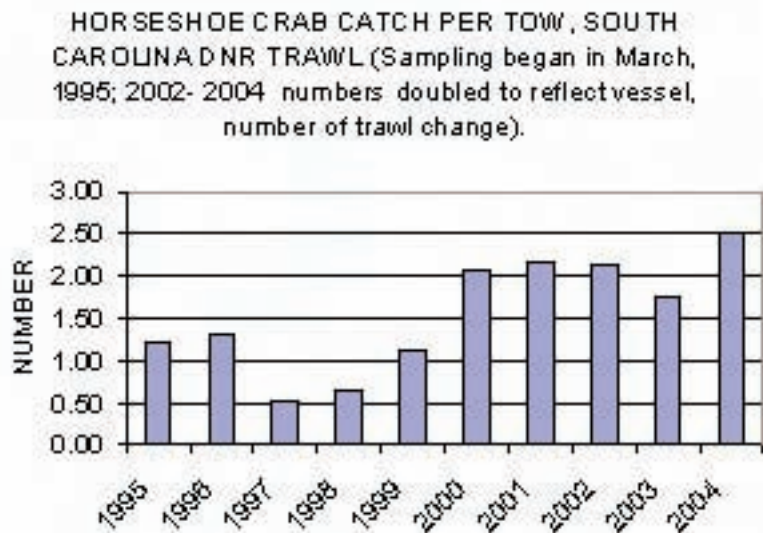
activities. There is great concern about the harvest of horseshoe crabs in the mid Atlantic and how it affects the red knot, *Calidris canutus*, another imperiled species (Piersma and Barker 2000).

Population Distribution and Size

Horseshoe crabs are relatively common in trawls in South Carolina. Based on research trawl collections, we are able to get some ideas of relative abundance. However, there is no estimate of population size at this time.

The range of the horseshoe crab extends from northern Maine to the Yucatan Peninsula. They are particularly abundant in Delaware Bay, the center of their distribution, and in coastal areas between Virginia and New Jersey. Different

populations of horseshoe crabs are thought to inhabit every major estuary along the Atlantic coast. Each population can be differentiated from the others based on size of adult crabs, the color of their carapace and pigments present in their eyes. In South Carolina, horseshoe crabs can be found in shallow estuarine areas and offshore habitats near the continental shelf.



Habitat and Natural Community Requirements

Adult horseshoe crabs are benthic animals. Early each spring, as estuarine water temperature approaches 20°C (68°F), adult horseshoe crabs move inshore to seek suitable spawning habitat along intertidal beaches of the sea-islands. The characteristics associated with preferential spawning locations are the presence of large intertidal sand flats near the spawning beach, a depth to reducing layer greater than 30 cm (12 inches) from the surface and accretional, rather than erosional, sediments (Thompson 1999).

Throughout the spring, females with males attached to their carapace follow flooding tides high onto the beach, where they excavate nests and deposit thousands of eggs. During mating, the male grasps the female's carapace and fertilizes her eggs as she deposits them in the nest cavity. Oftentimes, other unattached "satellite" males may also fertilize some of the eggs. Mating and nesting coincide with high tides. Nests are excavated by the female on the intertidal zone of sandy beaches and eggs are laid in clusters. Spawning activity is especially heavy during nighttime spring tides. Females nest several times per season, usually returning to deposit more eggs on subsequent high tides. After approximately two weeks, depending on temperature, moisture and oxygen levels, larval horseshoe crabs emerge from the nest. Larval horseshoe crabs are semi-planktonic for about three weeks before their transition to a benthic existence. They then settle to the bottom and assume a benthic existence, typically spending their first two years in intertidal sand flat habitats near beaches where they were spawned. Adults return to deeper estuary bays and continental shelf waters after the breeding season (Thompson 1999).

Challenges

Resource managers are concerned that the health of horseshoe crab populations along the northeastern coast of the United States is impacted by overharvest (Widener and Barlow 1999; ASMFC 2001). New fishery regulations have been promulgated through individual states and the Atlantic States Marine Fishery Commission (ASMFC) fishery management plan for the East Coast (ASMFC 1998). In South Carolina, the harvest of horseshoe crabs is limited to the LAL industry and a permit has been required since 1991. Recent studies suggest that between 10 and 20 percent of crabs harvested for LAL production do not survive, even though the Food and Drug Administration mandates that they be returned to the water alive. The main challenge to conservation in South Carolina is providing high quality habitat for horseshoe crabs.

Conservation Accomplishments

A fishery management plan is now in place for horseshoe crab through the ASMFC. States must comply with goals of the plan and provide updates on horseshoe crab status. In states that allow harvest of horseshoe crabs for bait, stringent reductions have reduced the harvest from high levels seen in the late 1990s to hopefully more sustainable levels. Crabs in the ACE Basin were once harvested in small numbers; however, South Carolina prohibited this activity in 1991. This has been accomplished by improved monitoring and management of the commercial fisheries, effort reduction, state catch quotas, and seasonal and area closures. Increased funding has led to establishment of a long term trawl survey and standardized methodology for beach spawner and egg surveys, most of which takes place in Delaware Bay and offshore. Basic research has increased in recent years, and public awareness has been heightened to support conservation measures.

Conservation Recommendations

- Determine the long-term trends in horseshoe crab spawning stock size and how those relate to environmental and other factors such as harvest.
- Determine the trophic impacts of horseshoe crab eggs and larvae on feeding shorebirds how this is influenced by habitat change.
- Although harvest to LAL bleeding is limited and there is no bait harvest, population trends should continue to be monitored closely.
- Avoid beach renourishment during horseshoe crab spawning season because the importance of low energy beach front as spawning and juvenile nursery habitat for horseshoe crabs.

Measures of Success

The measurement of success will be stable population trends for horseshoe crabs in South Carolina, as well as the wildlife species, particularly shorebirds, that depend upon the eggs and larvae as a food source.

Knobbed Whelk

Busycon carica

Contributor: William D. Anderson

Description

Taxonomy and Basic Description

First described by Gmelin in 1791, the knobbed whelk, *Busycon carica*, is a member of the family Melongenidae. Whelks have flourished off of South Carolina in the Atlantic for over 30 million years. Adult whelks are usually 13 to 23 cm (5 to 9 inches) in length and characterized by low knobs on the shoulder of the whorl with the aperture on the right side. Aperture coloration ranges from light orange-yellow to brick red. The knobbed whelk is the state shell of both New Jersey and Georgia.

Although the knobbed whelk is the most common whelk in South Carolina, three other species are found in state waters in the following order of abundance: channeled whelk (*Busycotypus canaliculatus*), lightning whelk (*Busycon sinistrum*) and pear whelk (*Busycotypus spiratus*). Whelks are not to be confused with filter feeding conchs, such as the queen conch (*Strombus gigas*), found in the waters of southern Florida and the Caribbean.

The structure and coloration of knobbed whelk shells vary greatly, not only over their geographical range, but also within a locality. It is not unusual to find whelks on South Carolina beaches with different knob lengths, knob directions and aperture colors. Whelks grow by extending the shell around a central axis, producing turns, or whorls, as they evolve. The final whorl, and usually the largest, is the body whorl that terminates, providing the aperture into which the snail can withdraw. Whelks also have a separate hard, horny plate, called an operculum, which acts like a trap door when the snail withdraws into the shell. Sometimes called a “shoe,” the operculum is attached to the top of the living animal’s foot and is seldom found with empty whelk shells (Magalhaes 1948; Eversole and Anderson 1985).

Knobbed whelks in South Carolina lay egg strings twice a year, usually from September through October and April through May. Egg strings start to appear at times when the water temperature approximates 20 degrees C (68 degrees F). Of the two egg-laying periods, fall appears to be the most productive. It is not known if an individual female whelk contributes to both of these egg-laying peaks or if a female lays more than one string per season. However, good estimates of the average number of eggs per capsule (34 to 35) and capsules per string (100 to 120) are available for this species. Spent egg strings often wash up on beaches and consist of a series of flattened capsules attached at one end to a tough cord or string-like structure. Some cases reach a length of over a foot and contain up to 160 capsules. In all four whelk species, eggs complete their development within the egg capsule and, after hatching, small juvenile snails emerge through a predesigned exit. The first capsules in the string usually do not contain eggs and are buried in the ocean floor as an anchor. Knobbed whelk egg capsules are coin-shaped, 20 to 30 mm (0.8 to 1.2 inches) in diameter and 3 to 6 mm (0.1 to 0.2 inches) thick with crenulations around the edges. Eggs develop slowly, hatching in about 3 to 13 months. Usually egg cases found washed up on beaches are empty with open holes that provide evidence of successful hatches. (Magalhaes 1948; Eversole and Anderson 1985).

If one finds a large knobbed whelk on the beach, chances are good it is a female. Male knobbed whelks rarely reach the large sizes of their opposite sex. Normally, female knobbed whelks

have larger shells, weigh more and possess a larger foot. Whelks are thought to be protandric hermaphrodites; this means they function first as males when young, then change into females as they grow and age. This phenomenon may lead to a preponderance of females among the older and larger-sized individuals in the population (Eversole and Anderson 1985).

Whelks are carnivorous gastropods that feed on bivalves such as hard clams (*Mercenaria mercenaria*), oysters (*Crassostrea virginica*), and incongruous arks (*Anadara brasiliiana*). Knobbed whelks use their shell's lip to chip and pry the valves of their prey apart by holding it with its foot so that the ventral edges of the prey's valves are under the outer lip of the whelk's shell. Slow chipping continues until an opening occurs to allow the whelk to wedge its shell between the clam's valves and then enter its foot to begin feeding. Since the feeding process results in damage to the shell, limited growth sometimes occurs in adults as energy is used to repair their shells (Carriker 1951; Magalhaes 1948)

Status

The knobbed whelk is a common species of the shallow shelf ecosystem and South Carolina estuaries. The prevalence of knobbed whelk in this habitat makes it an excellent indicator of the health of this ecosystem.

Many people enjoy collecting the deceased animal's shell. Aside from its recreational and ecological value, the knobbed whelk is targeted in the offshore whelk trawl fishery in South Carolina. Although this species is harvested, there is limited information about population trends or how whelk populations recover from commercial harvests.

Population Distribution and Size

Knobbed whelks are found in east coast waters from the south shore of Cape Cod to Cape Canaveral in central Florida, with the greatest numbers occurring in southern latitudes. South Carolina is well within this species' range and it can be found throughout the state's coastal waters (Abbott 1974). Although there is no estimate of the population size of knobbed whelks in South Carolina, it appears to be an abundant and stable species.

Habitat and Natural Community Requirements

The knobbed whelk lives in tidal estuarine waters and offshore in depths of up to 45.7 m (150 feet), although they are more commonly found in shallow shelf waters. In estuaries, they sometimes congregate on oyster reefs and clam beds as they feed on these and other marine bivalves. Mating and spawning occurs in estuaries and offshore where egg cases are anchored to the bottom. Because knobbed whelks feed on oysters and clams, reefs are a key habitat (Magalhaes 1948).

Results of a two-year mark and recapture study indicated that whelks are very slow growing and exhibit little long-shore movement, migrating to and from estuaries only in the immediate area of their genesis (Anderson et al. 1985). Migration to and from offshore waters usually occurs throughout the year depending on water temperatures and weather conditions. During periods of winter storms, whelks will burrow into the bottom substrate and remain dormant for extended periods (Anderson et al. 1985).

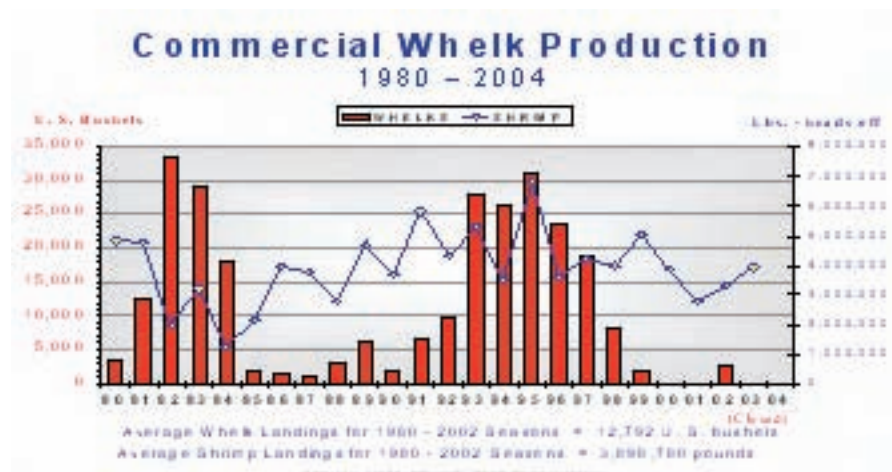
Challenges

The whelk trawl fishery off the South Carolina coast evolved during 1977 and the spring of 1978 as an alternative industry to provide cash flow during periodic closure of the shrimp season.

During the early 1980s, catches were shipped alive to whelk processing facilities in Mt. Pleasant and near Beaufort, South Carolina and cooked under pressure for approximately 20 minutes to break down the viscera attaching meats to the shell. Meats were extracted from the shell and then transported, on ice, to New England or blast frozen in Savannah, Georgia for markets in the Far East. Whelk meats that arrived in New England were usually processed as canned scungilli (Anderson et al. 1985).

To provide whelks the opportunity to reach sexual maturity and spawn before entering the fishery, SCDNR requires a minimum size of 10 cm (4 inches) in shell length (apex to end of siphonal canal) for harvest. However, as the siphonal canal frequently breaks during normal feeding, the minimum shell length may not always be indicative of sexual maturity. Trawling occurs from 0.8 to 4.8 km (0.5 to 3 miles) offshore. Peak production occurs in the spring as the water temperature approaches 14 degrees C (57 degrees F); this is when whelks begin moving on the bottom after a dormant period of burial. Knobbed whelks average approximately 90 percent of the catch with the remainder being channeled whelks. Currently, less than 35 commercial fishermen actively participate in the fishery with five or more trips each year, although as many as 100 permits have been issued. Peak whelk harvests occurred in 1982 and 1995 with landings of over 30,000 U.S. bushels. This was followed by two years of declining catches and four consecutive years (1985 to 1988) of production below 4,000 U.S. bushels as the fishery collapsed. Currently, whelk harvest in state waters is limited to a total of 13,000 U.S. bushels per year (SCDNR Office of Fisheries Management 2003).

The offshore whelk fishery will likely remain cyclical based on market demand, cost of prosecuting the fishery and the capacity of fishermen to locate aggregations of whelk populations in offshore coastal waters. South Carolina has a highly regulated, short exploitation window (usually mid-February to mid-April) that is further limited by fishing gear restrictions, weather conditions, minimum whelk harvest size and marketing opportunities.



Other anthropogenic activities that may negatively impact whelk populations include oil spills, beach renourishment, and dredging. Oil spills, depending of severity, could inhibit feeding and movement out of the affected area. Whelks can be entrained in the dredge cutter, causing mortality, during beach renourishment where sand is pumped from offshore or directly from a nearby tidal creek onto the front beach. Also, pumping substrate for projects such as maintenance dredging in South Carolina harbors or the Atlantic Intracoastal Waterway causes direct mortality in a manner similar to the one describe above (pers. obs.).

Conservation Accomplishments

Since 1983, SCDNR has had regulatory authority over commercial whelk fisheries to set lawful fishing areas, minimum size requirements, net mesh size and opening/ closing dates for the offshore whelk trawl fishery. Currently, whelk harvesting in state waters is limited to a total of 13,000 U.S. bushels/year; this amount is believed to be a sustainable harvest. The complete closure of inshore trawling areas in 1986 has conserved the resource by reducing incidental whelk bycatch during shrimp harvest. Furthermore, a management plan for South Carolina's offshore whelk trawl fishery was developed in 1999 to provide for a more balanced, less cyclical fishery. The plan specifies closing whelk season when water temperature reaches 20°C (68°F) to prevent trawling when sea turtles are present.

Conservation Recommendations

- Investigate the knobbed whelk's role in benthic communities, particularly as it pertains to oyster and clam populations.
- Develop an aging technique for knobbed whelk.
- Determine sex specific survivorship rates for knobbed whelk.
- Develop methods to examine long-term trends of knobbed whelk populations.
- Utilize and continue to update SCDNR's offshore whelk trawl fishery management plan.
- Determine effects of the fishery on whelk population in South Carolina.
- Continue to use whelk shells as cultch material to enhance and restore oyster reefs on public and state shellfish grounds.
- Continue SCDNR participation in Emergency Response training programs to ensure that 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.
- Work with appropriate agencies to develop other methods of maintaining channels that do not require the use of dredging.

Measures of Success

Developing a method to determine long-term population trends is one measure of success. Currently population data is collected from the whelk fishery and the number of individuals harvested may be more related to market demands than to actual population trends. In addition, by implementing the above mentioned actions to protect habitat, South Carolina will be able to promote healthy ecosystems and sustained yield of whelks.

Marsh Periwinkle

Littoraria irrorata

Contributors: Keith Walters and Loren Coen

Description

Taxonomy and Basic Description

The marsh periwinkle was first described in the United States by Say in 1822 from specimens collected along the Atlantic shoreline (Say 1822). This gastropod, in the order Mesogastropoda,

belongs to an important genus of common marsh snails. They can reach a size up to 30 mm (1.25 inches) in total length. Individual snails are hermaphroditic and capable of reproduction throughout the summer. In South Carolina, maximum settlement of young typically occurs in early to late spring with shell growth to maximum length taking approximately two to three years. Adult snails can range in color from dark brown to an almost bleached white.

Status

Although the marsh periwinkle is not a threatened or endangered species, it is an important component of the intertidal salt marsh community. Periwinkles may be a major participant in the decomposition of cordgrass, *Spartina alterniflora*, leaves (Bärlocher and Newell 1994; Silliman and Newell 2003) through a mutualistic association with leaf fungi (Silliman and Newell 2003). Marsh periwinkle can serve as an indicator species of the health of salt marsh habitat, a type that is critical for many species of marine invertebrates and migratory birds.

Population Distribution and Size

The marsh periwinkle is distributed from New England to the Gulf Coast of Texas. In South Carolina, it can be found within vegetated landscapes, from the low water line all the way to the terrestrial scrub community in most estuarine salt marshes. Although it is an apparently abundant and common species (pers. obs), little is known in South Carolina regarding long-term population trends and related information. Seasonal densities in the mid-marsh can range from 50 to 300 individuals per square meter, with greater densities observed during winter months (pers. obs.).

Habitat and Natural Community Requirements

The marsh periwinkle is an obligate salt marsh resident in which cordgrass may be considered a critical habitat. Individuals can be found inhabiting high-marsh areas around freshwater seeps and low-marsh stems submerged in full strength seawater (greater than 25 parts per thousand). Short-term studies (less than 2 years) indicate densities within the low marsh zone tend to be lower (less than 100 per square meter) compared to mid-marsh elevations (over 300 per square meter). Snails are also commonly found above the high water line on the stems of marsh plants; evidence suggests this climbing behavior is in response to blue crab predators (Hamilton 1976; Vaughn and Fisher 1992). Marsh periwinkles feed on microalgae and detritus; they may also garden and consume fungal decomposers found on the surface of marsh plants (Silliman and Newell 2003).

Challenges

Major Challenges to conservation of the salt marsh periwinkle include the loss of habitat and dramatic alterations to predator populations. Recently, marsh periwinkle has been implicated as a critical consumer of cordgrass and increased snail densities may responsible for observed declines in intertidal cordgrass coverage (Silliman and Bertness 2002). Increased marsh periwinkle densities are attributed to reductions in a major predator, the blue crab, *Calinectes sapidus* (Silliman and Bertness 2002). Reductions in marsh acreage or quality will also affect snail foraging and survival. Snails appear to have an obligatory relationship with cordgrass and the loss of cordgrass habitat would suggest a negative effect on snail populations. However, snails also appear to have a reciprocal negative effect on cordgrass in the absence of “natural densities” of predators. The cause of what appears to be an out of balance predator/prey dynamic between blue crabs and marsh periwinkle needs to be determined.

Conservation Accomplishments

The marsh periwinkle has received little or no attention in terms of past conservation efforts, likely in part because of the species ubiquitous distribution within coastal salt marshes.

Conservation Recommendations

- Further investigate the theory of top-down regulation of cordgrass biomass by marsh periwinkle.
- Determine whether blue crab predation is capable of regulating the distribution and abundance of periwinkles.
- Determine the preferred food(s) of marsh periwinkles.
- Determine whether recruitment is responsible for the initial distribution and abundance of marsh periwinkle in the marsh.
- Determine dispersing capabilities of marsh periwinkle.
- Determine whether cordgrass characteristics and/or environmental conditions determine snail consumption.
- Determine the fraction of the overall productivity of a marsh that is processed by snails.
- Determine the role of marsh periwinkle in observed declines of cordgrass.
- Determine factors other than predation and cordgrass quality that may account for the patchy distribution of marsh periwinkle in the field.

Measures of Success

A better understanding of the role of cordgrass/marsh periwinkle/blue crab dynamics is one measure of success. Conservation of blue crab populations would presumably restore balance to the salt marsh systems, which would be another measure of success.

Ohio Shrimp

Macrobrachium ohione

Contributor: Elizabeth Wenner

Description

Taxonomy and Basic Description

The Ohio shrimp, *Macrobrachium ohione* (Smith), is a member of the family Palaemonidae, characterized by having the first two pairs of legs chelate, the second pair larger than first, and the carpus of the second leg not subdivided. The Ohio shrimp is characterized by having a hepatic spine present and second pereopods enlarged and greatly elongated. The rostrum is curved, has up to 13 teeth but has a toothless daggerlike tip. The Ohio shrimp may grow up to 10 cm (4 inches) long. The color is pale gray flecked with small blue spots (Williams 1984).

Status

The population of Ohio shrimp in South Carolina is not listed as being threatened or endangered; however, in parts of its range, the Ohio shrimp is listed as rare and of long-term concern (Missouri Natural Heritage Program 2004). In some parts of its range, such as Louisiana, the population is abundant enough to provide a fishery.

Population Distribution and Size

This river shrimp occurs in lower salinity and tidal freshwater areas in South Carolina. Its full range extends from North Carolina into Florida. The Ohio shrimp was once common in the Mississippi river below St. Louis, where commercial fisheries for this species previously existed near Chester and Cairo, Illinois. However, Ohio shrimp have declined dramatically in the Mississippi, most likely due to channelization of the river (Barko and Hrabik 2004). The size of the population in South Carolina is unknown.

Habitat and Natural Community Requirements

Ohio shrimp apparently prefer low velocity water (Conaway and Hrabik 1997); however, open side channels, a preferred habitat of Ohio shrimp, have flow during normal river elevations (Barko and Herzog 2003). Ohio shrimp prefer borders of the main channel, especially when the borders are flooded and plant and animal material are available for foraging (Truesdale and Mermilliod 1979). Ohio Shrimp have been reported to have greater abundance in areas with suspended particulate matter, which may be a predator avoidance response. Ohio shrimp occupy low visibility physical habitats that are also occupied by predatory fishes, such as flathead catfish, a species that is not native to South Carolina (Barko and Herzog 2003). Little is known about the life history of the Ohio shrimp in South Carolina. In other areas, it has been reported to receive reproductive cues from spring floods and uses flooded terrestrial habitat for reproduction (Hobbs 2001).

According to Ortman (1902), the genus *Macrobrachium* has probably only recently evolved migratory behavior into fresh water. Biological characteristics indicative of this relatively recent adaptation include high hemolymph osmo-ionic concentrations, tolerance of high salinities, dependence on saline water for larval development with many larval stages and migratory behavior (McNamara 1987).

Challenges

Ohio Shrimp may have declined as a result of waterway channelization and habitat loss in parts of its range. Changes in river physiography that fragment main channel borders and isolate side channels during moderate to low river elevation can reduce Ohio shrimp populations (Logsdon 1993; Hobbs 2001; Barko and Herzog 2003). In parts of its range, reduced connectivity with the floodplain, because of levees, closing structures and wing dikes, has also contributed to Ohio shrimp declines.

For many years, wetlands were frequently filled, drained, polluted or used for dumping grounds. In the past two decades, 84 percent of wetlands losses have occurred in the southeastern United States (SCDHEC 1998). The losses in South Carolina do not appear to be as extensive as in other states. Officials estimate that South Carolina has lost about 27 percent of its wetlands since the mid-1700s (Dahl 1990). About 90 percent of the state's wetlands are freshwater, which is the habitat type utilized by the Ohio shrimp. Freshwater wetlands occur throughout South Carolina, but are most abundant in the central and lower areas of the state. Freshwater marshes are most prevalent along the lower portions of the Waccamaw, Pee Dee, Santee, Cooper, Edisto and Savannah rivers.

Despite recent legislation, national progress on improving protection for wetlands has not occurred as quickly as needed, and wetlands losses have continued. This is because the mitigation process does not require that the "taker" replace the lost wetland with a wetland of equal quality. This type of mitigation results in "replaced" wetlands that do not necessarily have

the same hydrologic features or wetland functions as the lost wetland. Often, a “taken” wetland will be within a system of hydrologic flow that cleanses water and supports abundant wildlife, while the replaced wetland does not perform the same ecosystem functions (E. Ciuzio, SCDNR, pers. comm. March, 2005).

Conservation Accomplishments

In recent times, Americans have become aware of the importance and value of wetland resources, which has led to legislative protection and restoration proposals across the country. The benchmark act, The North American Wetland Conservation Act of 1989 (NAWCA) established a “no net loss” policy for wetlands. That means any wetlands lost through anthropogenic activities, such as filling for development, must be matched by restoration, expansion or replacement of an equal amount of wetlands. Despite the limitations of NAWCA, this law has helped to slow the loss of wetlands in the United States, thus protecting habitat for Ohio shrimp.

Conservation Recommendations

- Examine the ecological role of Ohio shrimp in riverine systems in South Carolina.
- Establish baseline data on population size, distribution and habitat requirements of Ohio shrimp in South Carolina waters.
- Examine how anthropogenic river modifications and reduced floodplain connectivity may impact Ohio shrimp as well as other riverine species.
- Protect tidal freshwater habitats in South Carolina from development and modifications to natural freshwater flow regimes by partnering with the appropriate permitting agency to provide better technical information about the potential negative effects of development on aquatic ecosystems.
- Encourage citizens to donate wetland areas to a land trust that will protect it in perpetuity.
- Partner with the United State Army Corps of Engineers to restore natural hydrologic regimes where possible and reduce further modifications.
- Consider water flow impacts on Ohio shrimp when renewing licenses for river dams.
- Institute and implement a process of statewide or regional wetland mitigation banking with the goal of planning restoration projects such that “mitigation” wetlands function more like the ones they are meant to replace.

Measures of Success

By monitoring populations of Ohio shrimp, along with other tidal freshwater species, annual and seasonal trends in abundance can be detected. By working proactively, SCDNR will be able to manage a stable population of Ohio shrimp as well as other species that utilize the same habitat. The measurement of success will be “no net loss” of high quality wetlands.

Ribbed Mussel

Geukensia demissa

Contributors: Loren Coen and Keith Walters

Description:

Taxonomy and Basic Description

The ribbed marsh mussel (*Geukensia demissa*) was first described by Dwillyn in 1817. It belongs to the molluscan group (Bivalvia) whose members all have two valves or shells. Within that group it collectively is included in a diverse group called ‘mussels.’ This mussel was formerly placed in the genus *Modiolus*. It is relatively large, growing to nearly 10 cm (4 inches) in length. The surface is grooved with obvious ribs from which its name is derived. It has a glossy brown-black shell often with some yellow to a bleached white color outside; the inner surface is generally white. It has no external siphon; rather it draws water loosely over the gills. The ribbed mussel is distinguished from other South Carolina intertidal mussels by its oblong shape, parallel dorsal and ventral margins, very close exterior ridges and lack of teeth on the hinge. The other common mussels in South Carolina, *Brachydontes exustus* (scorched mussel) and *Ischadium recurvum* (hooked mussel) differ in several aspects; both reach sizes as adults of no more than 2.5 to 5 cm (1 to 2 inches). Further, the scorched mussel has a higher divergent angle from the umbo than the ribbed mussel, small cardinal teeth on the hinge and its shell is thicker and more stout than the ribbed mussel. Mussels are also characterized by having byssal threads, sticky filaments that are used to stabilize mussels when they attach to a substrate.

Mussels are known as filter feeders. During high tides, mussels “pump” water over their gills where particles are either selected for and passed into the digestive system or selected against and passed out as pseudofeces. Ribbed mussels are one of the few bivalves able to forage on small-sized bacterioplankton (Newell and Kambeck 1995; Kreeger et al. 1990); most bivalves only consume larger phytoplankton. As with South Carolina’s intertidal oyster, the ribbed mussel feeds only when submerged. At low tide, the shells remain closed to conserve water. Lent (1967, 1969) showed that mussels exposed at low tide are able to respire by “air-gaping.”

Ribbed mussels are aged by counting annual growth ribs on the shell (Brousseau 1982). Shell growth is greatest in late summer in the northeast. Ribbed mussels are not hermaphroditic; their sex can be determined by the color of the mantle. Females tend to be a medium brown whereas males are a yellowish-cream color. Reproduction usually occurs in spring and peaks by midsummer. Mussels are not known to spawn more than once in a season.

Status

The ribbed mussel is not a federally listed species; however, it is a very ecologically important species in marine ecosystems. Filter feeders improve water quality and affect nutrient cycling in estuarine habitats, especially with regard to the water-column microbiota community structure. Ribbed mussels are also important because they increase structural complexity of the habitat, both as living and dead animals (Kuenzler 1961; Bertness 1980; Jordan and Valiela 1982; Bertness and Grosholz 1985; Borrero 1987; Borrero and Hilbish 1988; Kemp et al. 1990; Stiven and Gardner 1992; Franz 1993, 1997).

Population Distribution and Size

The ribbed mussel can be found in coastal waters from the Gulf of St. Lawrence to Texas. In South Carolina, the ribbed mussel is found in and amongst fringing marsh grasses and intertidal oyster reefs. Although the actual population size of ribbed mussels is unknown for South Carolina, they are assumed to be very abundant and form rather dense colonies (Franz 2001); they can be found in and among intertidal oyster reef clusters in numbers over 1,500 per m² (139 per square foot) (Coen et al. 1999; Luckenbach et al. 2005). Unlike oysters, ribbed mussels have the ability to reattach if dislodged, providing this species with more opportunities to respond to disturbance. Marsh mussels do not seem to be declining in South Carolina; however, we know little about their populations here as elsewhere. As marshes and oyster reefs decline one can assume that these mussels will also decline.

Habitat and Natural Community Requirements

The ribbed mussel is a common filter feeder within South Carolina intertidal habitats including marshes, on pilings or within oyster reefs (Coen et al. 1999, 2004; Coen and Luckenbach 2000; Luckenbach et al. in press). Ribbed mussels attach by byssal threads to any hard substrate like oyster shells and cordgrass stems and protrude above the surface. Typically, one can find ribbed mussels embedded in and amongst salt marshes sediments attached by byssal threads to each other and/or to *Spartina* stalks. Ribbed mussels can be found throughout the mid- to low-intertidal elevations in most southeastern estuaries. Upper intertidal limits are determined by both exposure to high temperatures and limited food availability during the longer periods of tidal exposure. Lower intertidal limits are determined by the availability of effective refuge, mainly from crab predators. Although growth rates decline at higher shore levels, this is offset by increased survival (Bertness 1980; Bertness and Grosholz 1985; Stiven and Gardner 1992; Franz 2001).

Challenges

Habitat loss and pollution associated with coastal development is the main challenge to conserving the ribbed mussel. The ability of mussels to survive in a variety of habitats that provide both the appropriate attachment sites and refuge from predators will ameliorate, but not eliminate, the effects of habitat loss. Salt marshes and oyster reefs, sites for major mussel populations, are two habitats experiencing both quantitative and qualitative declines in many Mid-Atlantic States (Kelly 2001; Kirby 2004). Additionally, development of terrestrial-marsh ecotones will change hydrodynamics at the wetland boundary, likely altering patterns of fresh water flow in high- and mid-marsh locations (Walters et al. unpub. data). The increased survival as a result of reduced predation in higher marsh elevations may be offset by decreased survival from changes in land-based freshwater flow regimes.

Mussels have frequently been used for pollution assessment studies (O'Connor 2002; Hellou & Law 2003). "Mussel Watch" programs, in which mussels (typically *Mytilus* spp.) and oysters are used as valuable bioindicators of pollutant exposures and effects, have been used by the National Oceanic and Atmospheric Association (NOAA) in the United States and in a variety of countries throughout the world. They are regarded as especially valuable bioindicator organisms because they readily accumulate pollutants in their tissues; a number of valuable cellular biomarker approaches have been developed for characterizing adverse effects. Comparative studies with oysters have demonstrated some similarities in mussel bioaccumulation and biomarker responses, but these studies also suggest that marsh mussels may be more sensitive to pollutants. Therefore, marsh mussels may be particularly important as bioindicators of pollutants

in marsh grass habitats where oysters are less common. Moreover, since *Mytilus* spp. does not occur in the southeast, *Geukensia demissa* may be used as a valuable alternative mussel species. More recently work here in South Carolina (Ringwood 1999) and elsewhere (Ford et al. 2005) suggests that this mussel is an excellent subject to evaluate sediment contamination impacts. The results in South Carolina for the ribbed mussel were very similar to those observed previously by Ringwood et al. (1998a; 1998b; 1999a; 1999b) for *Crassostrea virginica*. Their employed cellular ‘biomarkers’ appear to be extremely useful in assessing contaminant sub lethal exposures under field and lab conditions.

Conservation Accomplishments

The South Carolina Department of Natural Resources annually samples natural and restored oyster reefs throughout the state, using quadrants, in which mussels are counted as well. Mussels seem to respond well to artificial structures such as docks, causeways and impoundments; however, the overall effect on mussel densities within the estuarine systems is unknown.

Conservation Recommendations

- Document the distribution of mussels in the near shore environment and develop models to predict future distribution.
- Evaluate reef contributions to overall mussel population by studying interactions between mussels and oyster reefs population dynamics, and the role of mussels in reef development.
- Study ribbed mussel contributions to the nutrient dynamics of salt marshes and the possible role of mussels in the restoration of marsh habitats.
- Develop ways to use mussels as a bioassay for indicating pollution and a potential indicator of the functional health of communities (oyster reefs, salt marshes) and ecosystems.
- Partner with local governments and the Department of Environmental Health and Control (DHEC) to deter development in sensitive areas or other places where development will have negative effects on oyster and mussel populations.
- Implement and improve Best Management Practices (BMPs) in future urban and commercial developments to protect water quality.
- Enhance/expand SCDNR’s oyster restoration programs.
- Continue mussel and oyster surveying.
- Develop a management plan for mussels and/or live bottom habitat in South Carolina.

Measures of Success

Because mussels are excellent bioindicators of water quality, monitoring mussel and oyster reefs will yield information about the success of efforts to improve water quality. In addition, by implementing the conservation actions listed above, SCDNR will be able to encourage stable, or even increasing, populations of ribbed mussels in South Carolina that will be documented during annual sampling of oyster reefs.

Stone Crab

Menippe mercenaria

Contributor: Elizabeth Wenner, Ph.D.

Description

Taxonomy and Basic Description

The stone crab is a true crab in the Family Xanthidae. The xanthid family of crabs is commonly called mud crabs. This is a highly diverse family characterized by having a body that is transversely oval or hexagonal and a broad front without rostrum. The last pair of legs is unmodified (Williams 1984).

The shell of the stone crab is nearly smooth to the unaided eye and transversely oval with the front broad and notched centrally. The lateral margins of the carapace are divided into four lobes. The pincers are large and heavy, unequal in size and nearly smooth. The inside of the palm has a patch of fine, oblique and parallel striations. The walking legs are stout and hairy toward the end (Williams 1984). The claws of the stone crab are asymmetrical; there is a major or crusher claw and a minor or pincer claw. Only the claw of a stone crab is harvested and a legal size claw has a propodus base measurement of more than 70 mm (2.75 inches) (SCDNR 2005). In South Carolina, only the larger of the two claws may be taken (SCDNR 2005).

The color of juveniles is generally dark purplish-blue, often with a white spot occurring on the inner carpus. Juveniles also exhibit three prominent white spots in the form of an inverted triangle on the carapace. Older individuals vary in color from brown to green on the anterior half of the carapace, with tan to cream coloration on the posterior half. The carapace is mottled with darker blotches. The fingers are dark and the walking legs are either entirely purple or brown, or with partial dark and light coloration (Caldwell 1986).

Status

The stone crab is not a state or federally listed species; however, stone crabs are dependent upon coastal nursery grounds and thus may be a potential indicator species of the health of estuarine habitat. In addition, stone crab claws are harvested in South Carolina; it is not clear what impact that activity may have on the population.

Population Distribution and Size

Stone crabs are found from North Carolina south around peninsular Florida to the Yucatan Peninsula and Belize and throughout the Bahamas and Greater Antilles (Florida Fish and Wildlife Conservation Commission 2003). In South Carolina, the stone crab is a conspicuous inhabitant of estuaries and inlets. They occur along the coast in high salinity areas, bays, sounds and along jetties (Wenner and Stokes 1984).

No long-term surveys exist to determine population size of the stone crab in South Carolina. Adequate information to determine population abundance and health is not available.

Habitat and Natural Community Requirements

Across its geographic range, stone crabs inhabit jetties, dead shell, mud and grass flats and oyster reefs (Williams 1984). Stone crabs occur in areas characterized by high salinities and live oyster beds. Although the stone crab may dwell on a variety of bottom types throughout its geographic

range, the shell substrate of oyster reefs provides reinforcement for creation of stable burrows, as well as protection from predators. Adult stone crabs live in burrows below the low tide mark around oyster bars and mud flats. The burrows provide protection for molting crabs and those females incubating eggs (Williams 1984).

In South Carolina, the American oyster is the principle food of the stone crab, which uses its major cheliped to crush the shell. Thus, stone crabs in South Carolina are generally found in proximity to intertidal oyster beds. Stone crabs may also eat other bivalves and crustaceans such as blue crab. Wenner and Stokes (1984) found that stone crabs were most abundant in areas immediately adjacent to the ocean and inlet areas with steep banks; fast current speeds yielded more stone crabs than did creek sites that had a gradual slope and slower current.

Few studies on the life history of the stone crab have been done in South Carolina. Egg bearing females occur from May to October with a peak from May to August. Females with mature ovaries occur during spring and summer. Juvenile stone crabs occurred throughout the year (Caldwell 1986). Mating is similar to that of other crabs in that the male protects the female while copulation occurs. Individual females have been reported to spawn several times during a year (Porter 1960). Once the eggs are extruded, larvae hatch as a larval form called zoea and develop through five zoeal stages, followed by a single more advanced larval stage called a megalopa before metamorphosis into the first crab stage. Juvenile crabs occur on shell bottom and consume a variety of foods including polychaete worms, small bivalves, oyster drills and occasionally other stone crabs (Bender 1971). Crabs mature at around 2 years of age.

Challenges

Stone crabs can be affected by water pollution. Urban contaminants such as heavy metals, polychlorinated biphenyls (PCBs), hydrocarbons, pesticides and herbicides entering coastal waters via runoff from farmlands and suburban yards could negatively affect stone crab populations. Stone crab productivity is considered to be dependent on the maintenance of coastal nursery grounds, especially oyster reefs. Disease and pollution that affect oyster reefs could indirectly have a negative impact on stone crab populations. C. M. Bearden observed thousands of dead stone crabs washing ashore on beaches just north of Charleston Harbor in the late 1960s, presumably because of a mass die off caused by disease (D. Whitaker, SCDNR, pers. comm., 2005).

Stone crab claws are harvested in South Carolina; however, there is no directed fishery for stone crabs (the major fishery for the stone crab is located in Florida). Stone crab claws are generally taken incidentally to the blue crab fishery in South Carolina, although there may be some individuals who directly target stone crab. The stone crab fishery depends on the ability of crabs to regenerate a lost limb. This unique fishery lands only the large, meaty claw of these crabs. One claw is removed from each trapped crab and the animal is released alive. If carefully treated, adult stone crabs can regenerate their claws several times. Most of the stone crabs sampled in South Carolina had at least one legally harvestable claw. Of those captured with both claws, most possessed unregenerated claws (Wenner and Stokes 1984). Estimates of the proportion of the harvest composed of claws regenerated after natural claw loss is around 10 percent for South Carolina. Survival depends partly upon the skill of the fisherman, who must separate the claw from the crab's body at the proper joint. If the joint is pierced or snapped quickly enough, the crabs own defense reflex contracts its muscles and sheds the claw cleanly. If a crab is de-clawed incorrectly (if, for example, part of the body is taken with the claw), the crab may bleed excessively or may be unable to regenerate a new claw, which significantly increases the

likelihood that the crab will die (Wenner and Stokes 1984).

Landings of stone crab claws in South Carolina may increase because of added interest and awareness of the potential for a fishery. However, it is unlikely that this state's stone crab population could withstand the level of fishing effort found in the Florida fishery. Wenner and Stokes (1984) found that catch per unit effort appeared to be less than six pounds of claws per trap. Until data are available on effort and yield of claws from crabbing operations in South Carolina, it will not be possible to properly assess the impact of fishing on existing stocks of stone crab. In other parts of its range, scientists and fishers believe that the population is heavily fished, although landings have remained stable (Florida Fish and Wildlife Conservation Commission 2003).

Conservation Accomplishments

At present, the minimum legal size of a harvestable claw is 70 mm (2.75 inches), which allows most females to mature and reproduce at least one season prior to attaining legal size. Although a declawed female can bear eggs and contribute to the spawning stock, mortality can result from incorrect claw removal or because the female is unable to adequately feed or protect herself. Protection of egg bearing females is a conservative measure that may be beneficial to the resource. Stone crabs have relatively high fecundity. A single female may produce four to six egg masses or "sponges" during a single mating season with an average of 4.5 spawnings per molt (U.S. Fish and Wildlife Service 1984). Each egg sponge may contain between 160,000 and 1,000,000 eggs.

Declawing crabs immediately upon their capture is also a legal stipulation that represents a good conservation measure. If crabs are held for long periods before declawing, they are subjected to air exposure and desiccation.

South Carolina is actively involved in the restoration of oyster habitat by planting shell in coastal waters, which provides a foundation for settlement of oyster larvae. Over time, these new reefs will collect oysters through natural larval settlement. Eventually, these areas should develop into natural oyster habitat. Maintenance, enhancement and restoration of oyster reefs secondarily provide excellent habitat that benefits the stone crab and other marine species that use such habitat.

Conservation Recommendations

- Determine the impact of stone crab bycatch in the blue crab fishery on reproductivity and survivorship of stone crab.
- Monitor stone crab populations, independent of fishery monitoring, in order to determine population status.
- Educate fishers about the proper method to remove a stone crab claw to achieve higher survivorship following claw harvest.
- Continue the SCDNR oyster habitat restoration project to ensure that essential habitat for stone crab populations is maintained in South Carolina waters.
- Work with municipalities to include Best Management Practices (BMPs) in development plans throughout the coastal zone. Such plans should include installation of retention ponds, modified septic systems and stream bank protection measures.

Measures of Success

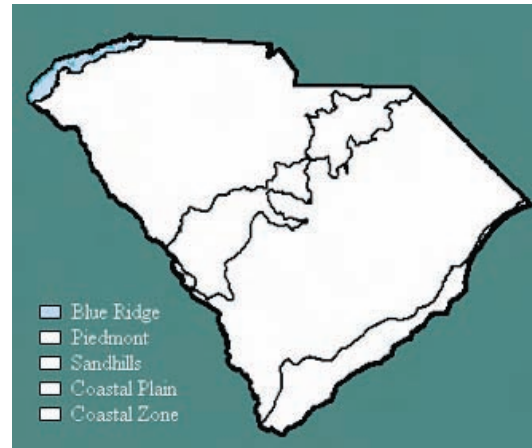
In the event that municipalities implement BMPs along coastal waterways, we should observe improved water quality in marine ecosystems. In turn, the improved water quality will benefit many sensitive marine species, including the stone crab. Continuation of the oyster bed restoration project will provide habitat for the stone crab, which will result in stable to increasing population trends.

CHAPTER 12: TERRESTRIAL HABITATS

Blue Ridge Ecoregion Terrestrial Habitats

Description and Location

South Carolina's mountains are part of a multi-state region within the Southern Appalachians known as the Southern Blue Ridge Escarpment. The escarpment forms an abrupt transition between higher mountains in adjoining states and the piedmont. High-gradient streams fed by high annual rainfalls carve the mountain landscape (Griffith et al. 2002). A portion of the region's northern boundary in South Carolina is formed by the Eastern Continental Divide, which provides resource managers with the rare opportunity of working with ecological and jurisdictional boundaries.



The present-day landscape is the remnant of an ancient mountain chain, thought to be the result of three separate episodes of mountain building (King 1959). The underlying rocks are gneisses and schists that have weathered to relatively acidic soils. Soils consist of clay loams and sandy loams that are generally thin, with well-developed organic horizons on undisturbed sites (Myers et al. 1986). In some areas, weathering of rocks with high iron and magnesium content have produced more alkaline soils that support a flora distinct from that of habitats with more acidic soils.

Although the Blue Ridge in South Carolina constitutes a small portion of the state's land area (328,500 acres or 1.69 percent of the total area), it supports the most extensive upland hardwood forest complex in the state. The region is rich in floral diversity best expressed in the mixed mesophytic forest vegetation community (Braun 1950), and described as moist broadleaved forests that can harbor over 30 different tree species and many more types of fungi and ferns. Other biological resources unique to the region include a viable black bear (*Ursus americanus*) population extending across the North Carolina, Georgia and South Carolina state lines, sustained nesting of peregrine falcons (*Falco peregrinus*) following reintroduction in the 1980's and self-sustaining populations of native brook trout (*Salvelinus fontinalis*).

Habitats and Priority Species

Overstory, understory, shrub and herbaceous plant communities of the Blue Ridge are generally related to topography, elevation, slope, and soil type of a site (Abella 2002). A few specialized habitats, such as bogs or rock faces, are present due to unique geological formations. Habitat types in the region generally blend from one to the next, rarely with abrupt transition. Because of this integration of communities, very few animal species are strictly associated with any single habitat type.

Habitat definitions primarily follow the Landscape Ecological Classification of Abella (2002), which is based on a multivariate analysis of geomorphology and vegetation on late successional sites (more than 70 years since timber harvest) in the Jocassee Gorges. To give a broader picture of habitat types across the region, the work of Patterson (1994) for the Ellicott's Rock in the

extreme Northwestern corner of the region is incorporated, as are a number of classifications based on vegetation composition and structure, notably Nelson (1986). Variation of habitat characteristics within the region has not been systematically quantified, although white pine-dominated types are more prevalent in the western portion of the region. Some qualitative differences in vegetation composition between the Elicott Rock and Jocassee Gorges areas have also been observed (Camp 2004).

Appalachian Oak & Oak-Pine Forest

General Description and Location

Oak and oak-pine forests compose the predominant vegetation type throughout the Blue Ridge Ecoregion. Vegetation composition and structure is highly variable, depending primarily on exposure and position on slope and, secondarily, on soil moisture. Ridgetops and exposed upper slopes support an open canopy forest of oak species such as scarlet, black and chestnut oak and/or mixed pines and oaks. The understory is open, and groundcover is sparse; blueberry is a characteristic groundcover. Upper portions of hill slopes and exposed nose slopes typically support a canopy dominated by chestnut oak, with numerous hardwood co-dominants, and a shrub layer dominated on some sites by dense stands of mountain laurel. More mesic lower slopes, particularly north-facing slopes at intermediate and low elevations and sites along small streams and ravines, support diverse hardwood species, typically including white oak, tulip poplar, Fraser magnolia, and red maple. Diverse shrub and herbaceous species are also present, along with widely spaced clumps of mountain laurel. Early successional sites dominated by grasses, shrubs, and seedlings or saplings of numerous tree species are included in the definition of this habitat type.

Associated Species

- | | |
|--------------------|---|
| Highest Priority: | Loggerhead Shrike, Field Sparrow, Northern Bobwhite, Wood Thrush, Eastern Wood Peewee, Kentucky Warbler, Worm-eating Warbler, Prairie Warbler, Coal Skink, Green Salamander. |
| High Priority: | Eastern small-footed Bat, Pine Snake, Timber Rattlesnake, Wood Frog, Meadow Vole, Appalachian Cottontail, Rafinesque's big-eared Bat, Hairy-tailed Mole, Red-backed Vole |
| Moderate Priority: | Scarlet Tanager, Louisiana Waterthrush, Chestnut-sided Warbler, Black-throated Blue Warbler, Slender Glass Lizard, Eastern Woodrat, Spotted Skunk, Pygmy Shrew, Woodland Jumping Mouse. |

Low Elevation Basic Mesic Forest

General Description and Location

Low elevation mesic forest occupies relatively sheltered, well-drained sites on concave landforms and lower slopes. It is a rare type within the ecoregion, occurring only on sites exhibiting unusually deep soils. It corresponds to the mixed mesophytic forest of Braun (1950), which is recognized for its rich floristic composition. Tulip poplar typically dominates the overstory, and Carolina silverbell is a characteristic in the mid-story or understory. The shrub layer is typically sparse or absent. Herb species richness and cover are highest in this type and characteristic ground flora species include bloodroot, foamflower, silverbell, partridge berry, cane and ginseng. Mixed mesophytic forests are recognized generally as habitats within the Southern Appalachians that support high densities and/or provide optimal habitat for many species of breeding birds and as have high salamander species diversity (Hunter et al. 1999).

Associated Species

- Highest Priority: Wood Thrush, Green Salamander
- High Priority: Acadian Flycatcher, Coal Skink, Seepage Salamander, Shovel-nosed Salamander, Wood Frog, Eastern small-footed Bat, Hairy-tailed Mole, Red-backed Vole, Masked Shrew
- Moderate Priority: Scarlet Tanager, Jordan's Salamander, Eastern Woodrat, Spotted Skunk, Rafinesque's big-eared Bat, Pygmy Shrew, Woodland Jumping Mouse

*Low Elevation Acidic Mesic Forest***General Description and Location**

Low elevation acidic mesic forest occurs on well-drained, relatively sheltered sites in stream bottoms, along ravines of small streams or on hill slopes. The type is more prevalent on north facing slopes or lower positions on other slopes. Eastern hemlock is the characteristic tree, occurring either as the dominant overstory or understory tree; rhododendron dominates the shrub layer, occurring in thickets or solitary clumps. Tulip poplar, white pine, hickories, sweet birch, beech and basswood are common associates. White pine becomes much more dominant along with hemlock in the Ellicott Rock /Chattooga River basin in the western portion of the Blue Ridge. The type provides key habitat for wildlife species associated with riparian habitats.

Associated Species

- Highest Priority: Swainson's Warbler, Coal Skink, Appalachian Cottontail
- High Priority: Acadian Flycatcher, Seepage Salamander, Wood Frog
- Moderate Priority: Ruffed Grouse, Red-breasted Nuthatch, Golden-crowned Kinglet, Red Crossbill, Spotted skunk, Eastern small-footed Bat, Eastern Woodrat, Rafinesque's big-eared Bat, Hairy-tailed Mole, Red-backed Vole, Pygmy Shrew, Woodland Jumping Mouse

*High-elevation Forest***General Description and Location**

In South Carolina, this type is limited to the highest peaks. Occurring at scattered sites at over 900 meters elevation, South Carolina represents the southern limit of this habitat (Braun 1950). Several canopy trees, other plant species and a few priority wildlife species, are also at their southern range limits. Canopies consist of red maple, chestnut oak, northern red oak, black oak hickory and yellow poplar. Herbaceous species diversity is high, but less than that occurring in mesic hardwood/bloodroot or cove forests. High-elevation forest is distinguished from other forests by the lack of calciphilic species and the dominance of red maple and chestnut oak. On steep to very steep upper to middle slopes with northerly aspects, vegetation is dominated by northern red oak with or without lesser amounts of chestnut oak and red maple. Rosebay rhododendron or great laurel (*Rhododendron maximum*) forms a dense continuous subcanopy and on more exposed sites, piedmont or small-leaf rhododendron (*Rhododendron minus*) becomes more dominant.

Associated Species

- Highest Priority: Field Sparrow, Northern Bobwhite, Wood Thrush, Eastern Wood-pewee, Prairie Warbler, Coal Skink

- High Priority: Black-throated Blue Warbler, Timber Rattlesnake, Wood Frog, Appalachian Cottontail, Hairy-tailed Mole, Red-backed Vole, Masked Shrew
- Moderate Priority: Scarlet Tanager, Chestnut-sided Warbler, Ruffed Grouse; Dark-eyed Junco, Common Raven, Red-breasted Nuthatch, Golden-crowned Kinglet, Red Crossbill, Eastern small-footed Bat, Rafinesque's big-eared Bat, Eastern Woodrat, Spotted Skunk, Pygmy Shrew

Riverbanks, Streambanks, and Alder Zones

General Description and Location

This habitat type forms the riparian vegetation zone on streams and rivers, typically along wadeable or navigable streams that are wide enough to prevent canopy closure, at scattered locations with a suitable substrate of seasonally flooded rocky or alluvial soils. It exhibits variation in size and persistence. At the base of the escarpment, this habitat also occupies broad floodplains, where it grades into the floodplain forest types of the upper piedmont (Barry 1980). Alder (*Alnus* spp.) is a characteristic species that occurs in relative abundance along with mixed canopy species. Common shrubs are yellow root (*Xanthorhiza simplicissima*), Virginia willow (*Itea virginica*), azalea (*Rhododendron* spp.) and occasionally black willow (*Salix nigra*) and sweet pepperbush (*Clethra alnifolia*).

Associated Species

- Highest Priority: Rusty Blackbird
- High Priority: Acadian Flycatcher, Hellbender, Mink, Eastern small-footed Bat, Star-nosed Mole, Red-backed Vole

Moist or Wet Types Due to Unique Landform

General Description and Location

Highly variable landforms within the Southern Blue Ridge Ecoregion include numerous wet places that increase local and regional habitat diversity. Open seeps of variable size occur on granitic cliffs and domes. Spray cliffs occur in spray and splash zones at the edges and bases of waterfalls. Upland bogs form in poorly drained wet seepage areas at heads of small streams, which are nearly always saturated. Upland bogs are characterized by Sphagnum (*Sphagnum* spp.) and many bog species such as orchids and sedges. Vegetation in upland bogs is apparently fire-controlled. Without burning, succession leads to a wetland community dominated by woody vegetation.

Associated Species

- Highest Priority: Bog Turtle, Coal Skink, Shovel-nosed Salamander, Green Salamander
- High Priority: Seepage Salamander, Wood Frog, Meadow Vole, Appalachian Cottontail, Star-nosed Mole, Red-backed Vole
- Moderate Priority: Woodland Jumping Mouse

Vertical or Horizontal Rock Outcrop

General Description and Location

Rock outcrops of widely varying sizes and slopes occur throughout the region. Slopes range from nearly horizontal to nearly vertical. The more extensive and exposed outcrops have their own characteristic vegetation and habitat features. Vegetation ranges from none, (bare rock) to

a mosaic of herbaceous plant, shrub and tree-dominated communities. Successional trees, such as eastern red cedar (*Juniperus virginiana*) and Virginia pine (*Pinus virginiana*) are common on these sites. Crevices and ledges can only provide habitats for larger plants once sufficient soil has built up. Vegetation communities are relatively unstable. A cliff or dome may also have a significant area of wet seepage zones.

Associated Species

High Priority: Peregrine Falcon, Pine Snake, Timber Rattlesnake

Moderate Priority: Appalachian Cottontail, Eastern small-footed Bat, Rafinesque's big-eared Bat, Dark-eyed Junco, Common Raven

General Condition of Habitats

At higher elevations, the current landscape consists of large tracts of unbroken forest. Overall condition is best described as trending toward mid-successional, relatively lacking in both the early successional stages resulting from disturbances and the late-successional or "old growth" stages characterized by canopy openings and other complexity-providing structures.

Eighteenth century European settlers cleared flatter sites at all elevations for agricultural settlements and utilized wood from surrounding forests for a variety of purposes (SCDNR, 1998). Beginning in the late nineteenth and early twentieth centuries, industrial development in the upper piedmont led to a period of extensive timber extraction. Early logging operations focused on removing oaks and yellow poplar from cove and mid-slope forests for construction timbers (SCDNR 1998; Abella 2002). Later logging operations utilized a network of temporary roads that penetrated the entire region. Therefore, between the early intensive logging at lower elevations and more recent logging roads accessing higher elevation sites, almost all sites in the region have been subjected to timber extraction in some form.



Beginning in the mid-twentieth century, a round of land consolidations began, which shifted ownership toward public and quasi-public purposes. In 1963, the Jocassee Gorges property was purchased by the Duke Power Company for hydropower development, a transfer that set the stage for the property's ultimate acquisition by the SCDNR in 1998. Other significant transfers in modern times include Sumter National Forest in Pickens and Oconee Counties; Poinsett and Table Rock Reservoirs in Greenville County; Table Rock, Jones Gap and Caesars Head State Parks; and several acquisitions by the SCDNR. Comparison of public versus private ownership in the Blue Ridge is illustrated in the adjacent map. The following table also provides a summary of the land holdings in the Blue Ridge.

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<i>Major Public Land and Protected Private Holdings in conservation status in the Blue Ridge Ecoregion (hectares)</i>	
City of Greenville, S.C.	7,614
South Carolina Department of Natural Resources	16,075

<i>Major Public Land and Protected Private Holdings in conservation status in the Blue Ridge Ecoregion (hectares)</i>	
South Carolina Department of Parks, Recreation & Tourism	5,867
The Nature Conservancy	12,690
United States Forest Service	31,032
Grand Total	73,278
Proportion of region in conservation status	53%

Forest condition and age on public lands varies with ownership. Although the Sumter National Forest is managed under a multiple-use approach, recent legal challenges have significantly curtailed forestry operations. Current composition on Sumter National Forest is primarily a mixture of mid-successional pine-hardwood stands and managed pine-dominated stands of various ages. The SCDNR-owned Jocassee Gorges tract was heavily logged before acquisition by the SCDNR and US Forest Service, while the Greenville Watershed and State Park lands have a long history of passive management.

Fire management practices also vary across the region, ranging from regular use of prescribed fire on the Sumter National Forest to total fire exclusion on Greenville Watershed and State Park lands. Current burning practices are contradictory to historic descriptions of widespread wildfires that created relatively open stands with sparse woody understory vegetation (Brose et al. 2001).

Habitats at lower elevations in the Blue Ridge are ecologically similar to those of the adjoining Piedmont Ecoregion. Settlement and land use patterns at these elevations are also similar to those of the piedmont; most land is in private ownership and, as such, land uses have become highly fragmented with agriculture, managed woodlands and residential uses separating tracts of natural forests. Further, many historic farming communities are undergoing rapid development as land values are increase rapidly. Amenities such as Highway 11, a scenic highway running along the base of the escarpment, SC PRT properties and Lakes Keowee and Jocassee contribute to the Blue Ridge region's popularity for recreation and development.

Region-wide Challenges

Most forests in the region are in mid-successional stages; therefore the forest structure is not optimal for many priority bird species (Hunter et al. 1999) and possibly species in other taxa. As forests mature, an optimal age structure is expected to develop; however, management practices that favor a faster transition or provide some of the characteristics of mature forest would benefit many priority species.

Fire exclusion that has been the practice since the early 1900's may be leading to landscape-level changes in forest. These changes include the gradual replacement of oak species by less fire-tolerant species in the overstory and increased dominance of ericaceous plants in the shrub cover (Abella 2002). At the same time, several studies indicate that early successional habitat may be lacking, which provides obligate or optimal habitat for some priority species (Abella 2002; Camp 2004).

At lower elevations and at scattered locations at higher elevations, the region is experiencing a boom in development. This activity is spurred in part by the attraction of nearby mountain scenery, which is enhanced by the large public land base protecting the views. If present trends continue, the predominant mix of agricultural lands and woodland existing at lower elevations

will continue to be supplanted by residential and recreational developments. As a consequence of this region-wide shift in land use, the suitability of private land for priority species will change. As the mountains become accessible to more people, recreation pressure is increasing, a trend that can be expected to continue. Finally, increasing human populations can be expected to lead to increasing numbers of human-wildlife conflicts.

The hemlock wooly adelgid threatens to eliminate eastern hemlock from the region's forest over time. Originally confined to the New England states (McClure 1987), this exotic insect pest first appeared in the Southern Appalachians in approximately 2002. Other potentially destructive insects, parasites and diseases that have been reported from other locations near the Blue Ridge include gypsy moth, dogwood anthracnose disease and sudden oak death.

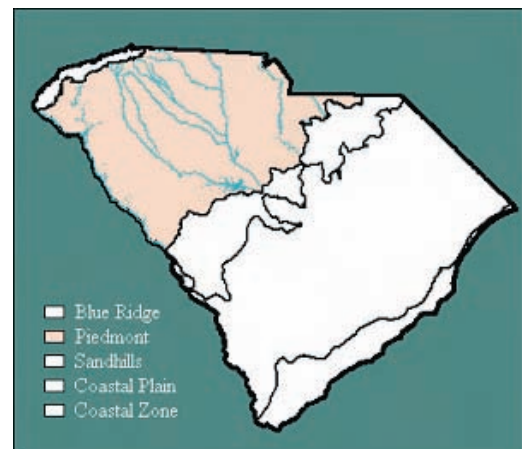
Based on data and analyses of air quality sources within the Southern Appalachian region, concentrations of potentially damaging air pollutants are relatively low along the Blue Ridge, and susceptibility of streams and vegetation to impacts from atmospheric pollution in this region is also relatively low (SAMAB 1996). However, impacts have been reported from other portions of the Southern Appalachians, so this situation should continue to be monitored.

Major recreation resources such as the Foothills Trail and popular state parks such as Table Rock, Mountain Bridge and Jones Gap, as well as the recent Jocassee Gorges acquisitions have stimulated demand for recreational access to public lands within the Blue Ridge Escarpment. Although accounts of visitation trends are currently anecdotal, visitation and demand for services is increasing dramatically. The second regional trail to traverse the escarpment, the Palmetto Trail, is also nearing completion and is expected to draw additional interest and traffic to the region. Managing agencies face competing demands for access by users whose interests are not always compatible. Impacts of recreation uses on the resource base vary by intensity and type, posing challenges to meeting resource-based management objectives.

Piedmont Ecoregion Terrestrial Habitats

Description and Location

The Piedmont Ecoregion occupies an area between the Southern Blue Ridge Escarpment and the Sandhills Ecoregion. The northwestern boundary is generally considered to be the base of the Blue Ridge Escarpment; the division between the crystalline rocks of the piedmont and the sedimentary rocks of the sandhills represents the southeastern boundary of this ecoregion. The piedmont-sandhill contact zone is marked in many river channels by shoals and rock ledges that collectively form the fall line. Gently rolling hills with many stream-cut valleys characterize the region with only a few level floodplains. In the lower piedmont, there are relatively few sharp breaks in topography except along major river valleys.



Habitats and Priority Species

The rolling uplands of the piedmont landscape are predominantly a mosaic of agricultural land and managed woodland, with a history of clearing and economic use that dates back to the

earliest times of European settlement. Hardwood-dominated forests occupy relatively narrow floodplains and scattered upland sites, while pine and pine-hardwood forests occupy the majority of forested upland sites. The resulting landscape does not constitute suitable habitat for many area-sensitive wildlife species or for species associated with either early-successional or late-successional conditions. Most of the priority species considered in the CWCS that occur in the piedmont fall into one or more of these categories.

Oak-hickory Forest

General Description and Location

Occurring throughout the state but most characteristic of rolling uplands in the piedmont, oak-hickory forest is a widely distributed community that varies from site to site. Occurring in highly fragmented stands, later successional stages tend to be made up of a diverse assemblage of hardwoods, primarily oaks and hickories, as co-dominants in combination with pines. Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species. Vegetation on most sites consists of early- to mid-successional managed stands of pine and pine-hardwood forest. The understory in pure pine stands is often open, but in mixed or older stands, it is dominated by the hardwoods characteristic of the site. Common pine species of the piedmont include shortleaf (*Pinus echinata*) and loblolly (*P. taeda*), with the former better adapted to dry, fine textured upland soils and loblolly achieving maximum growth on deep soils with good moisture and drainage.

Associated Species

Highest Priority: American Kestrel, Eastern Wood Pewee, Red-cockaded Woodpecker, Wood Thrush, Pine Snake

High Priority: Pine Woods Snake

Moderate Priority: Scarlet Tanager, Eastern Fox Squirrel

River Bottoms

General Description and Location

River bottoms, or “bottomland forests” consist of hardwood-dominated woodlands with moist soils that are usually associated with major river floodplains. Characteristic trees include sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), cherrybark oak (*Quercus pagoda*) and American holly (*Ilex opaca*). A subtype dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) occurs on lower elevation sites, but is not as prevalent as in the broader floodplains of the coastal plain. Compared to the coastal plain, the floodplains of major rivers in the piedmont are confined by topography to relatively narrow corridors.

Associated Species

Highest Priority: Black-throated Green Warbler, Kentucky Warbler, Little Blue Heron, Rusty Blackbird, Swainson’s Warbler, Yellow-crowned Night Heron, Black Bear, Northern Yellow Bat

High Priority: Acadian Flycatcher, American Alligator, Black Swamp Snake, Gulf Coast Mud Salamander, River Cooter, Spiny Softshell Turtle, Striped Mud Turtle, Mink, Rafinesque’s Big-eared Bat, Southeastern Bat, Star-nosed Mole

Moderate Priority: American Woodcock, Great Blue Heron, Great Egret, Louisiana

Waterthrush, Wood Duck, Bird-voiced Treefrog, Common Snapping Turtle, Spotted Turtle, Eastern Woodrat, Eastern Fox Squirrel

Piedmont Small Stream Forest

General Description and Location

Piedmont small stream forests are distinguished from forest communities on larger floodplains because of differences between the scales of the ecosystems. In smaller floodplains, the levees, sloughs and ridges are largely absent or poorly developed. Flooding regime is also more variable between small watersheds than larger ones. Soils are various alluvial types that are seasonally or intermittently flooded. The forest has an open to dense understory or shrub layer and a sparse to dense herb layer. The canopy has a mixture of bottomland and mesophytic trees including river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), tulip tree (*Liriodendron tulipifera*), American elm (*Ulmus americana*), hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*) and red maple (*Acer rubrum*).

Associated Species

Highest Priority: Kentucky Warbler, Little Blue Heron, Rusty Blackbird, Wood Thrush, Yellow-crowned Night Heron, Tiger Salamander

High Priority: Acadian Flycatcher, River Cooter, Spiny Softshell Turtle, Yellowbelly Turtle, Mink, Swamp Rabbit

Moderate Priority: Great Blue Heron, Great Egret, Louisiana Waterthrush

Cove Forest

General Description and Location

Cove forests are botanically diverse, well-developed hardwood forests occurring on scattered rich and generally small sites (less than 200 acre). Usually, these forests occur on protected bluffs in association with small stream forests or river bottoms. No single species tends to dominate. Shrub species are usually numerous and the herbaceous flora is fairly rich, with many spring ephemerals. Canopy and understory is composed of hardwoods including beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), black gum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), white oak (*Quercus alba*), northern red oak (*Q. rubra*), black oak (*Q. velutina*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), southern sugar maple (*A. saccharum*), basswood (*Tilia heterophylla*), ironwood (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), American holly (*Ilex opaca*), witch-hazel (*Hamamelis virginiana*) and hop-hornbeam (*Ostrya virginiana*).

Associated Species

Highest Priority: Eastern Wood Pewee, Kentucky Warbler, Wood Thrush, Webster's Salamander

High Priority: Four-toed Salamander

Moderate Priority: Scarlet Tanager

Grassland and Early Successional Habitats

General Description and Location

A variety of open habitats occupies a considerable portion of upland sites in the piedmont, including agricultural land, recently abandoned farmland, recently cleared land and a matrix of

managed open pine forest and grassland. Golf courses, urban yards and open spaces are also included in this habitat type. The vegetation on most sites is oak-hickory forest, although many sites are maintained in early successional stages.

Associated Priority Species

Highest Priority: Eastern Meadowlark, Field Sparrow, Grasshopper Sparrow, Loggerhead Shrike, Northern Bobwhite, Southern Hognose Snake

High Priority: Barn Owl, Meadow Vole

Moderate Priority: American Woodcock, Bewick's Wren

General Condition of Habitats

To a greater degree than in other regions, the vegetation in the piedmont has been altered by human activity. Cotton agriculture changed much of the original hardwood and shortleaf pine (*Pinus echinata*) forests into fields. Fields eroded, often losing all topsoil. By the 1930's various factors including the Great Depression and boll weevil outbreaks as well as severe erosion led to widespread farmland abandonment in the piedmont.

Loblolly pine (*Pinus taeda*) was introduced to the piedmont during the nineteenth century as a cash lumber crop; this pine now dominates much of the region. According to a U.S. Forest Service survey, loblolly-dominated pine forests occupy over two million acres in South Carolina's piedmont (Conner and Sheffield 2000). However, pine plantations are generally poor wildlife habitat, lacking in both food and cover needed by native wildlife.

FOREST TYPE	AREA (acres x 1000)
White-red-jack pine	9.8
Loblolly-shortleaf	2074.0
Oak-pine	668.0
Oak-hickory	1466.5
Oak-gum-cypress	63.2
Elm-ash-cottonwood	145.2
Non-stocked	2.0

Although loblolly pine plantations are found throughout the region, they are much more prevalent in some areas, in particular the southwestern piedmont. By contrast, habitat in the vicinity of York County retains substantial, if fragmented, acreage of hardwood forest. Kings Mountain State Park features a good example of piedmont upland hardwood forest.

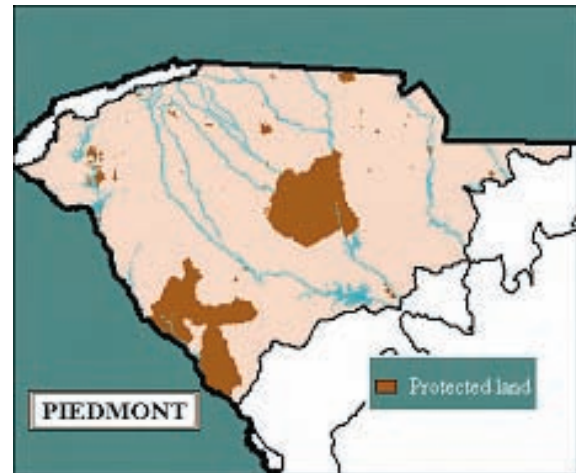
By definition, early successional habitats have a limited longevity without repeated disturbance. The habitat structure and vegetative composition changes as succession progresses; many wildlife and plant species are adapted to different stages within the early successional continuum from bare earth through mature forestland. Managing for species dependent upon early successional habitats presents several management challenges, including the need to identify which successional stage is most appropriate for the species or assemblage of interest, and the need for repeated management actions to maintain suitable habitat.

The extent and quality of early successional habitats has been greatly dependent upon human land use patterns. While there is some uncertainty as to the extent of early successional habitats prior to European settlement, it is likely that many early successional species' populations peaked in the early 1900's with extensive forest clearing and low-intensity agricultural operations. In the

second half of the 20th century, the quantity and quality of early successional habitats diminished due to fire reduction, increasing development, encroachment of exotic vegetation, changing agricultural and forestry practices and fragmentation of habitat patches into small isolated units (Cobb et al. 2002; Johnson and Igl 2001; Thompson and DeGraaf 2001; Warner 1994). Populations of many species that depend on these habitats have also declined during this time period (Hunter et al. 2001).

Historically, the piedmont in York County contained some prairie-type habitats (Barden 1997) with high plant and insect diversity. Around the time of colonization, these piedmont prairies were maintained through fire and herbivore grazing. Today, remnant tracts of prairie are found primarily along powerline right-of-ways and sites managed specifically for prairie restoration and maintenance.

A considerably smaller portion of forestland is in public ownership in the piedmont than in the Blue Ridge region. The U.S. Forest Service is the primary agent of land protection in the piedmont, with two large Ranger Districts of the Sumter National Forest, the Long Cane and the Enoree, located within the region. However, actual public ownership within the authorized National Forest boundaries is extremely fragmented. Most of the land in the piedmont is held by corporate or other private ownerships not associated with the forest product industry (Conner and Sheffield 2000).



Public holdings and private conservation lands in the Piedmont. The two large brown areas in the central and western portions of the region represent U.S. Forest Service “proclamation boundaries”, not actual Forest Service ownership.

OWNER	AREA (ha)
Clemson University	9823.94
John De La Howe School	558.15
National Park Service	2324.33
South Carolina Department of Natural Resources	3587.76
South Carolina Department of Parks, Recreation & Tourism	7517.27
South Carolina Forestry Commission	1227.21
United States Army Corps of Engineers	8142.62
United States Forest Service	114456.61
Other	3291.43
Total	150929.33

Severe soil erosion during the 19th and early 20th centuries has had lasting effects beyond the obvious changes to piedmont uplands. When large quantities of soil were carried down from cotton fields and denuded forests, a portion of the soil was deposited onto piedmont floodplains (Fox 2000). Today, there is an average of 1.2 meters of surficial sediments, not present prior to European colonization, in the floodplains of most piedmont streams. Streams typically continue to flow at the original level; therefore, many modern streams are deeply entrenched with one or both banks rising abruptly to about 1.2 meters above the streambed.

Even though agricultural land use practices improved and farming declined during the 20th century, floodplain sediments persist, overlying former piedmont wetlands. These wetlands probably featured numerous depressions of swamp tupelo (*Nyssa biflora*) and willow oak (*Quercus phellos*) that served as natural green-tree reservoirs for ducks and other wildlife (Ron Ahle, SCDNR, pers. comm.). Over time, floodplain sediments will be transported downstream as meandering streams erode and re-deposit sediments, but this is a slow process and is hampered, in some cases, by stream channelization.

Region-wide Challenges

The primary factor influencing habitat quality and quantity in the piedmont is urban sprawl. Since World War II, population growth in the piedmont has been rapid, outpacing growth in the United States as a whole. Migration from other regions of the United States as well as international immigration has fueled this growth. Both population growth and the land use patterns that have accompanied it have contributed to sprawl (Rusk 2003).

Urbanized Area	Urbanized Acreage Per New Resident
USA (396 areas)	0.18
Spartanburg	0.88
Greenville	0.93
Anderson	0.99
Rock Hill	1.01

Low-density development contributes to habitat fragmentation, which impacts many fish and wildlife species. In the piedmont, development has been particularly rapid in association with the interstate highway system. Habitat fragmentation also hinders the use of prescribed fire. Most of the priority species for this habitat decline as development encroaches. While most birds can rapidly find and colonize early successional habitat patches, some bird species (grassland birds in particular) are area sensitive and will not use small patches of habitat surrounded by forest or developed areas. The northern bobwhite may require large areas of contiguous habitat (greater than 5,000 acres) for long-term population viability (Guthery et al. 2000). The isolation of suitable early successional habitats may be most problematic for mammals, reptiles and amphibians that have limited dispersal ability and may suffer high mortality when traveling through unsuitable habitats.

The U.S. Forest Service has identified invasive species as one of the top threats to forests in the United States in the twenty-first century (Oswalt, 2004). All parts of South Carolina are affected by invasive exotics, but data from the Forest Inventory Analysis (FIA) indicates that the forests of the piedmont, where 72 percent of sampled plots contained at least one exotic plant, have been highly impacted. The South Carolina Exotic Pest Plant Council (2004) identifies the following plants as severe exotic plant pest species in the Piedmont Ecoregion:

- Shrubs: Russian Olive (*Elaeagnus angustifolia*), Thorny Olive (*Elaeagnus pungens*), Autumn Olive (*Elaeagnus umbellata*), Japanese Privet (*Ligustrum japonicum*), Multiflora Rose (*Rosa multiflora*)
- Vines: Kudzu (*Pueraria lobata*), Chinese Wisteria (*Wisteria sinensis*), Asian Wisteria (*Wisteria floribunda*),

- Herbs: Wart Removing Herb (*Murdannia keisak*),
- Grasses: Japanese stilt grass (*Microstegium vimineum*), Bahia grass (*Paspalum notatum*)

Concerns about liability, air quality, social acceptance and smoke management, as well as lack of landowners with experience and equipment to conduct prescribed burns has limited the use of fire on private lands. Similar to the coastal regions, fire once was an important natural feature of the piedmont (Frost 1998). Pre-settlement oak-hickory forests experienced surface fires that were frequent and of low intensity, sustained by fine grass, pine needles and hardwood litter. Absence of fire leads to forest stands dominated by fire-intolerant species such as maple, beech and sweet gum. The pre-settlement mean fire return interval was four to six years in many parts of the piedmont, while in certain places fires burned almost every year. Early European explorers described small, open prairies on the upper piedmont maintained by annual fall burns conducted by Native Americans.

Piedmont prairies contain highly diverse and specialized plant and insect communities and only small remnant tracts remain in South Carolina. Fire and/or other low intensity soil disturbances such as light disking at the proper time of year are necessary to maintain prairie communities. Current restoration efforts are focused on plant conservation and have been implemented on small acreages that have limited value for area-sensitive grassland species such as the grasshopper sparrow and the eastern meadowlark.

Sandhills Ecoregion Terrestrial Habitat

Description and Location

The Sandhills Ecoregion is the inland portion of the coastal plain that borders the fall line. This ecoregion is frequently recognized as a physiographic province distinct from the coastal plain, although some researchers incorporate the sandhills within a broader area known as the “inner coastal plain.” The sandhills form a discontinuous belt of varying width of deep sands across the middle of the state (Porcher and Rayner 2001).

Pliocene and Pleistocene sands deposited up to ten million years ago by strong southwest prevailing winds form the top layer of the sandhills (Murray 1995). These sands are a very pure and high quality source of silica; they are mined throughout the sandhills, especially in Lexington County (Murray 1995). These deep sands have created a xeric environment that supports a distinctive type of vegetation dominated by longleaf pines (*Pinus palustris*) and turkey oaks (*Quercus cerris*). This fire-adapted community burns with a frequency interval of 5 to 10 years and may be one of the oldest communities of this type in the southeast (Wharton 1978).

Major brownwater rivers that cut their way through the sandhills on their way from the mountains and piedmont to the sea include the Lynches, Wateree, Congaree and Savannah Rivers. The North and South Forks of the Edisto River are the only major rivers that originate in the sandhills.

Deep sand ridges ranging from 300 to over 600 feet above mean sea level are one of the most



striking and dominant features of the Sandhills. Ridge tops of pure Lakeland and Kershaw Sands, some up to 30 feet deep (Wharton 1978), support the most extreme xeric scrub communities of longleaf pine and turkey oaks. The sandy soils on the ridges, excessively drained with low available water capacity, are low in fertility due to rapid leaching and possess little to no leaf litter (Lawrence 1976). The drier sand ridges are suitable for agriculture only when managed through fertilization and irrigation. These ridges can support timber production, particularly of longleaf pine, which is well adapted to deep, dry sandy soils.

Fire is a dominant factor in the ecology of this region. Sandhills pine forests are a fire climax community; as such, these forests are dependent on frequent ground fires to reduce hardwood competition and to perpetuate pines and grasses.

Sand ridges that have more clay and silt mixed with sand support subxeric sandhill scrub vegetation and mesic pine flatwoods. Increased plant diversity is a result of the more moderate growing conditions. Due to the increase in leaf litter, fire is an important factor in the maintenance of the subxeric scrub forest and woodlands. These subxeric to mesic communities can grade into oak-hickory forests or, in the absence of fire, they may succeed to oak-hickory forests.

Rainwater rapidly percolates through the sand ridges until it reaches hardpan, at which point it moves laterally until emerging at the surface on side slopes or near the base of sand ridges. These natural seepage areas result in distinctive wetland habitats embedded within the xeric forests and woodlands. The community type that develops is determined by the amount of water, the position on the slope and, especially, by fire. In the absence of fire, this wetland habitat can be forested with longleaf or pond pines (*Pinus serotina*) growing over a dense evergreen pocosin-like shrub layer or, with frequent fire, it can be an open hillside herb bog. Seepage accumulating at the base of the sand ridges results in a saturated zone that supports a streamside pocosin forest.

Habitats and Priority Species

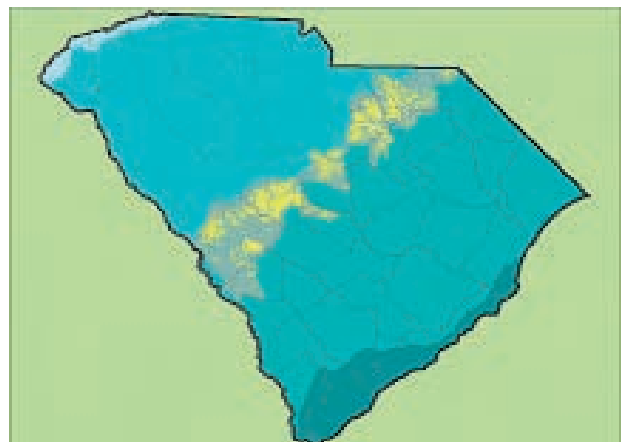
Although xeric sandy soils predominate, the rolling terrain and variations in soil and subsoil composition provide significant local variation in habitat composition. The principal habitat of the sandhills is sandhills pine woodland, with local structure and composition influenced mainly by fire history. The major sandhills habitat types are summarized below.

Sandhills Pine Woodland

General Description and Location

Pine woodland is the characteristic vegetation on the sandy soils that define the region. On deep, well-drained sands a longleaf pine (*Pinus palustris*) canopy with a subcanopy of turkey oak and other scrub oak species prevails. On lower or middle slopes, or on sites with relatively high amounts of organic matter, other pine species may share dominance with longleaf and a more diverse understory and herbaceous layer is present. On lower slopes sufficiently protected from fire, succession can proceed to oak-hickory forests similar to those of the piedmont

Several priority species favor the longleaf



pine-wiregrass community, a canopy composed of longleaf pine, an open understory and a diverse herbaceous layer with extensive wiregrass (*Aristida* sp.) cover. The longleaf pine-wiregrass subtype is dependent on fire for maintenance. Wiregrass and leaf litter generally carry fire well and longleaf pine is very fire-adapted. Where fire is excluded, turkey oak and other scrub oak species increase.

Although accurate vegetation maps for pine woodland are not available, the extent of this habitat type can be gauged from soil maps showing the distribution of the sandy soils in the region with which pine woodland is strongly associated. Potential pine woodland habitat in the South Carolina sandhills is illustrated highlighted in yellow, as predicted by soil type.

Associated Species

Highest Priority: American Kestrel, Bachman's Sparrow, Brown-headed Nuthatch, Eastern Wood Pewee, Northern Bobwhite, Red-cockaded Woodpecker, Wood Thrush, Coral Snake, Gopher Tortoise, Pine Snake, Southern Hognose Snake

High Priority: Pine Woods Snake

Moderate Priority: Eastern woodrat, Eastern Fox Squirrel

Grassland and Early Successional Habitats

General Description and Location

As in other ecoregions, a variety of grassland and early successional habitats are present, either as transitional vegetation following forest disturbances or as managed areas. Habitat characteristics and wildlife species composition do not differ from that of the coastal plain. See the Coastal Plain Ecoregion account for a full description.

Associated Species

Highest Priority: Common Ground-dove, Eastern Meadowlark, Field Sparrow, Grasshopper Sparrow, Loggerhead Shrike, Northern Bobwhite, Painted Bunting

High Priority: Barn Owl

Moderate Priority: American Woodcock, Bewick's Wren, Meadow Vole, Eastern Woodrat

Seepage Slope

General Description and Location

Seepage slopes occur on sites having a hard clay moisture-confining layer underlying the sandy soil, such as iron-bearing sandstone or kaolin deposits. Water percolating downhill is forced to the surface, which results in seasonally or permanently saturated soils. Vegetation is variable, depending on position on the slope, the amount of peat accumulation and fire history. Dense shrubland composed of several fire-tolerant species, with an open canopy of pond pine (*Pinus serotina*) is representative. The shrubland community intergrades with open grass-sedge vegetation on wetter seeps that are regularly burned or maintained in an open condition by mechanical clearing or herbicide application. Steeper slopes support a mixture of pine species, including longleaf pine and Virginia pine and a characteristic shrub layer of titi (*Cyrilla racemiflora*), sand myrtle (*Leiophyllum buxifolium*), mountain laurel (*Kalmia latifolia*) and inkberry (*Ilex glabra*).

Associated Species

Highest Priority: Chamberlain's Dwarf Salamander, Pine Barrens Treefrog

High Priority: Southern Dusky Salamander

*Ponds and Depressions***General Description and Location**

Clay lenses and other confining layers support a variety of permanently and semi-permanently flooded isolated freshwater wetlands throughout the sandhills. Landforms include natural and artificial ponds dominated by cypress and/or swamp tupelo. Varying amounts of peat accumulation and fire frequencies produce shrub-dominated pocosins or grass-sedge-herb-dominated depression meadows. Upslope from these lowland habitats, the transition to well-drained uplands supporting sandhills pine woodland is often abrupt.

Associated Species

Highest Priority: Little Blue Heron, Yellow-crowned Night Heron, Carolina Gopher Frog, Tiger Salamander

High Priority: Black Swamp Snake, Chicken Turtle, Florida Cooter, Yellowbelly Turtle, Mink, Southeastern Bat

Moderate Priority: Great Blue Heron, Great Egret, Spotted Turtle, Common Snapping Turtle

*Blackwater Stream Systems***General Description and Location**

Tributary streams rising in the sandhills and coastal plain are commonly known as "blackwater streams" for the color of tannins leaching from decaying vegetation. Forests on the narrow floodplains formed by these streams typically have a canopy dominated by swamp tupelo (*Nyssa biflora*) and red maple (*Acer rubrum*). On broader sites, bald cypress (*Taxodium distichum*) can become an important canopy species. Tulip poplar (*Liriodendron tulipifera*), sweet gum (*Liquidambar styraciflua*), pond pine (*Pinus serotina*), loblolly pine (*Pinus taeda*) and laurel oak (*Quercus laurifolia*) are important associates. The shrub layer is open in areas subjected to the most flooding, or it can be fairly dense and pocosin-like in areas subject to infrequent flooding. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets or, under suitable fire conditions, pure stands of Atlantic white cedar (*Chamaecyperus thyoides*).

Associated Species

Highest Priority: Kentucky Warbler, Eastern Wood Pewee, Rusty Blackbird, Swainson's Warbler, Wood Thrush, Yellow-crowned Night Heron

High Priority: Acadian Flycatcher, Black Swamp Snake, Spiny Softshell Turtle, Mink, Rafinesque's Big-eared Bat, Southeastern Bat

Moderate Priority: American Woodcock, Louisiana Waterthrush, Wood Duck, Spotted Turtle

*River Bottoms***General Description and Location**

The state's major rivers transect the sandhills, forming broad floodplains similar to those in the coastal plain. Steep bluffs occur where rivers have cut into sandhill formations having an erosion-resistant iron-bearing sandstone layer. Hardwood-dominated woodlands form the characteristic

vegetation. As in the coastal plain, characteristic trees include sweetgum, loblolly pine, water oak, willow oak, laurel oak, cherrybark oak and American holly. The Cypress-tupelo swamp subtype occurs on lower elevation sites as seasonally flooded swamps. Dominant trees are bald cypress and water tupelo swamp gum, water elm and red maple.

Associated Species

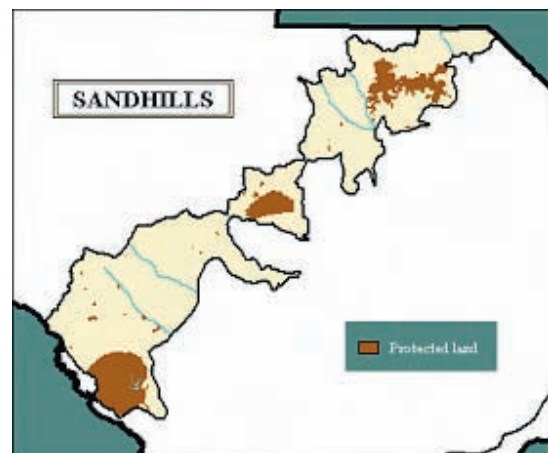
Highest Priority:	Black-throated Green Warbler, Kentucky Warbler, Little Blue Heron, Rusty Blackbird, Swainson's Warbler, Yellow-crowned Night Heron, Black Bear, Northern Yellow Bat
High Priority:	Acadian Flycatcher, American Alligator, Black Swamp Snake, Gulf Coast Mud Salamander, River Cooter, Spiny Softshell Turtle, Striped Mud Turtle, Mink, Rafinesque's Big-eared Bat, Southeastern Bat, Star-nosed Mole
Moderate Priority:	American Woodcock, Great Blue Heron, Great Egret, Louisiana Waterthrush, Wood Duck, Bird-voiced Treefrog, Common Snapping Turtle, Spotted Turtle, Eastern Woodrat, Eastern Fox Squirrel

General Condition of Habitats

Compared to the adjoining piedmont and upper coastal plain, upland forest cover in the sandhills is relatively unbroken. However, numerous cycles of pine removals and exclusion of fire have left a vast, rather monotonous forest cover on much of the landscape, consisting of small longleaf pines, turkey oak and other scrub oak species. Forest in this condition is not suitable habitat for South Carolina's priority species. Indeed, the prevalence of forest in this condition is a primary source of concern for many of these species.

Considerable effort is being made by the forestry community to encourage production of saw timber-sized longleaf pines and more liberal application of fire. Encouraged by successful efforts to restore red-cockaded woodpecker (RCW) populations on public lands and extensive enrollment of private lands in the RCW Safe Harbor program, landowner interest in longleaf pine-wiregrass forest restoration seems to be increasing. Longleaf pine seedlings and technical guidance for establishing longleaf stands are also increasingly becoming more available.

Significant public land holdings in the sandhills include the US Army base Fort Jackson and the Army National Guard Leesburg Training Site; the Sandhills National Wildlife Refuge; Sandhills State Forest; major portions of the Savannah River Site; and Hitchcock Woods (operated by a private foundation). Although the impetus for conservation-oriented management on many of these facilities stems from the listing status of the RCW, the intended future condition of many forested tracts on these lands is a longleaf pine wiregrass community, with a significant portion of longleaf pine stands attaining older age classes.



Major public land holdings and private conservation lands in the Sandhills (acres)	
Aiken County Open Land Trust	58
South Carolina Department of Natural Resources	1,873
South Carolina Department of Parks, Recreation & Tourism	4,361
Major public land holdings and private conservation lands in the Sandhills (acres)	
South Carolina Forestry Commission	18,997
The Hitchcock Foundation	791
The Nature Conservancy	141
United States Department of Energy	64,893
United States Department of the Army	21,251
United States Fish & Wildlife Service	18,118
Total	130,483

Impoundments have been constructed in sandhills streams for many centuries. In the 18th and 19th centuries they were built to provide power and water for gristmills; most of these old mill ponds are still in existence. As agriculture continued to expand in the sandhills region, farm ponds were constructed to provide irrigation for agricultural fields. The number of small impoundments in blackwater streams increased dramatically during the 1960's and 1970's (Melven pers. comm.) and this trend continued through the end of the century. There were about 1,100 farm ponds in Lexington County as of 1970 (Lawrence 1976) and there are now more than 4,000 farm ponds (Deaderick pers. comm.). In a study of the Edisto River basin, most of the wetland alterations documented in the North and South Forks of the Edisto River were found in the headwaters streams where the relatively steep and narrow valleys in the sandhills make good farm pond sites. Very few headwater streams in the Edisto Basin were found without impoundments (Marshall 1993).

Region-wide Challenges

The rate of urbanization has increased in the sandhills in the last two decades, primarily in the Aiken, Columbia, Camden and North Augusta areas. Tracts of land with existing ponds are especially sought after for residential development. Residential development is concentrated around the ponds and there is often very little buffer of natural vegetation remaining between the home sites, roads and ponds.

Although land management practices that favor restoration of the longleaf pine ecosystem are gaining wide acceptance, significant alterations continue to affect transition areas between uplands and wetlands. These alterations typically occur when access roads or firebreaks are placed at the upland-wetland boundary, which effectively excludes fire from the wetlands. The result is a closed canopy forest, rather than the complex of dense shrub (pocosin) and grass-sedge successional stages that would occur under a more natural fire regime.

The longleaf pine ecosystem, the dominant natural vegetation type in the sandhills, is one of the most imperiled in the country with only three percent of its original extent in a relatively natural condition (Frost 1993). Even in areas where longleaf pine remains, fire suppression has severely impacted the ecosystem. Fire suppression in the southeastern United States began to be institutionalized between 1910 and 1930 (Frost 1993; Ware et al. 1993). This practice severely affected the remaining patches of the longleaf pine ecosystem, resulting in a change in species composition and forest structure. In recent years, some areas have been restored or are in the process of being restored with the use of prescribed fire. This practice has been limited, however, because of the costs associated with prescribed fire and because of other risks associated with

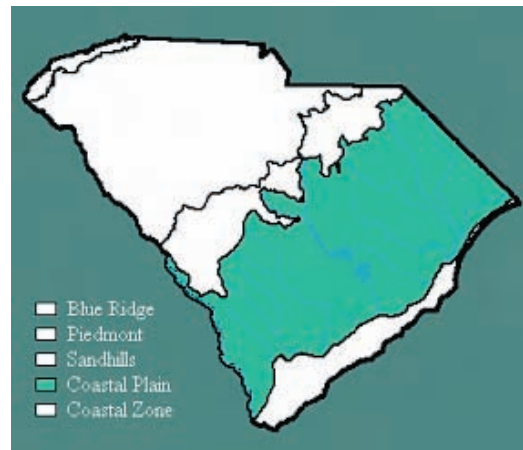
prescribed burning, including problems with smoke management.

Economic considerations have also affected timber management practices. Conversion of areas to tree species not usually associated with the sandhills have contributed to the decline of the longleaf pine ecosystem. Many land managers have planted pine species other than longleaf because they were less expensive to plant and produced a superior mid-term return on investment.

Coastal Plain Ecoregion Terrestrial Habitats

Description and Location

The coastal plain is the largest ecoregion in South Carolina. Land elevation in this ecoregion begins at 270 to 300 feet at the inland boundary with the sandhills and reaches nearly to sea level at the coastal zone boundary. Although the Sandhills Ecoregion shares some of the geological history and physical features and is included in some definitions of the coastal plain, wildlife habitats in the two regions differ in some important respects. Therefore, the coastal plain and sandhills are treated as separate ecoregions in the CWCS.



The sedimentary formations of the coastal plain consist variously of marine-deposited sand, clay, gravel, marl and limestone that lie over granite and other crystalline rocks (Murray 1995). The older inner terraces have been dissected into rolling hills separating major drainages, while the younger outer terraces are essentially flat. Outcrops throughout the region are scarce, since the formations are overlain by a thin layer of Pleistocene and recent age material (Siple 1957). However, the mineral and chemical composition of the soils that formed over the older marine sediments is influenced by the parent material.

From a land use standpoint, the coastal plain consists of two significantly different landscapes. An inner belt is predominantly composed of cropland, with forest limited to small patches and hardwood “stringers” along creeks. An outer belt, sometimes called the “flatwoods” is primarily pine-dominated forest. Bisecting both belts are major floodplains, which are largely forested.

Habitats and Priority Species

Eight major habitat types are defined for the coastal plain, of which six are either unique to the region or reach their greatest extent there. The predominant habitat types that most casual observers associate with the coastal plain are 1) grassland and early successional habitats, 2) pine woodland and 3) river bottoms. Although the remaining types are less extensive, they provide habitat diversity that is important to a number of animals, especially wetland species.

Pine Woodland

General Description and Location

This habitat is used to describe all pine-dominated forests throughout the region, including those occupying a variety of soil moisture characteristics except floodplains. The canopy is dominated

by one or several species of pine, generally loblolly (*Pinus taeda*), or longleaf (*Pinus palustris*), depending on elevation, soil type and silvicultural history. Dense shrub thickets of hollies (*Ilex* spp.) and wax myrtle (*Morella cerifera*) may be present. Higher elevation pine woodlands have abundant grasses and herbaceous cover, particularly when burning is frequent. Optimal habitat for priority species consists of open stands of longleaf pine, sparse understory and shrub layers, a ground cover of wiregrass (*Aristida* spp.) and diverse herbaceous species.

Pine savanna, an important variant of pine woodland, also known as open savanna. Wet prairie, grass-sedge bog, herb bog or pitcher plant bog, is typically found in the outer coastal plain on flat sites with high water table and soil that is saturated for at least part of the year. Vegetation consists of a thin canopy of pines, almost always longleaf (*Pinus palustris*), although loblolly (*P. taeda*) and pond pine (*P. serotina*) may also be present. The understory is essentially absent or very scattered. Herbaceous flora is quite rich, consisting of many grasses and sedges. Pine flatwoods intergrade with pine savanna; like pine savanna, it is pine woodland situated on essentially flat or rolling terrain with sandy soil and a high water table. Unlike pine savanna, pine flatwoods features a well-developed subcanopy of several tall shrub species. Pine flatwoods is the principal forest type for much of the outer coastal plain.

Associated Species

Highest Priority: American Kestrel, Bachman's Sparrow, Brown-headed Nuthatch, Henslow's Sparrow, Northern Bobwhite, Red-cockaded Woodpecker, Black Bear, Northern Yellow Bat

High Priority: Eastern Diamondback Rattlesnake, Mimic Glass Lizard, Pine Woods Snake

Moderate Priority: Slender Glass Lizard, Eastern Fox Squirrel, Eastern Woodrat

Sandhill Pine Woodland

General Description and Location

Sandhill pine woodland is a variation of pine woodland composed of species adapted to xeric, sandy soils. The type occurs principally in the sandhills but also on sand ridges in the coastal plain. Absent frequent fire, a canopy of longleaf pine and a subcanopy of turkey oak prevail, interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to development of longleaf pine-wiregrass communities

Associated Species

Highest Priority: American Kestrel, Bachman's Sparrow, Brown-headed Nuthatch, Eastern Wood Pewee, Northern Bobwhite, Red-cockaded Woodpecker, Wood Thrush, Coral Snake, Gopher Tortoise, Pine Snake, Southern Hognose Snake

High Priority: Pine Woods Snake

Moderate Priority: Eastern woodrat, Eastern Fox Squirrel

Upland Forest

General Description and Location

Vegetation composition of upland forest is similar to that of oak-hickory forest in the piedmont, where it is a major vegetation type. Upland forest is rare in the coastal plain, typically occurring on fire-suppressed upland slopes near river floodplains or between rivers and tributaries. It intergrades with river slope communities. Representative canopy trees include white oak

(*Quercus alba*), black oak (*Quercus velutina*), post oak (*Quercus stellata*), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), loblolly pine (*Pinus taeda*), flowering dogwood (*Cornus florida*) and black gum (*Nyssa sylvatica*). See the Piedmont Habitat Account for a more complete description.

Associated Species

Highest Priority: Eastern Wood Pewee, Kentucky Warbler, Rusty Blackbird, Swainson's Warbler, Swallow-tailed Kite, Wood Thrush, Worm-eating Warbler, Chamberlain's Dwarf Salamander, Black Bear, Northern Yellow Bat

High Priority: Acadian Flycatcher, Bald Eagle, Southeastern Bat, Star-nosed Mole

Moderate Priority: Louisiana Waterthrush, Eastern Woodrat, Eastern Fox Squirrel, Southern Dusky Salamander

Grassland and Early Successional Habitats

General Description and Location

A variety of open-land habitats occupy a considerable portion of upland sites in the piedmont, sandhills and coastal plain, including agricultural land, recently abandoned farmland, recently cleared land and a matrix of managed open pine forest and grassland. Golf courses, urban yards and open spaces are also included in this habitat type. Potential vegetation on most sites is pine woodland and oak-hickory forest, although many sites are maintained in early successional stages. Agricultural lands with surrounding forest edge habitat occur widely throughout the region and represent the prevailing cover type in the "agriculture belt" that composes most of the inner coastal plain.

Associated Species

Highest Priority: Common Ground-dove, Eastern Meadowlark, Field Sparrow, Grasshopper Sparrow, Loggerhead Shrike, Northern Bobwhite, Painted Bunting

High Priority: Barn Owl

Moderate Priority: American Woodcock, Bewick's Wren, Meadow Vole, Eastern Woodrat

Ponds and Depressions

General Description and Location

Topographic depressions in the coastal plain support a variety of permanently and semi-permanently flooded isolated freshwater wetlands that have open or closed canopy forest cover. Vegetation cover varies with hydrology, substrate and fire frequency. Depression meadows, pond cypress ponds, swamp tupelo ponds, pocosins and limestone sinks are also included in this habitat type. Landforms include natural and artificial ponds dominated by cypress and/or swamp tupelo, limestone sinks, and Carolina bays. Shrub-dominated pocosins or grass-sedge-herb-dominated depression meadows occur on peat- or clay-based substrates, typically in Carolina bays. Absent fire, vegetation in most of these habitats reverts to mixed floodplain hardwood and cypress-tupelo dominated forest. Upslope from these lowland habitats, the transition to well-drained uplands supporting pine woodland is often abrupt.

Associated Species

Highest Priority: Little Blue Heron, Yellow-crowned Night-Heron, Flatwoods Salamander, Tiger Salamander, Carolina Gopher Frog, Broad-striped Dwarf Siren, Chamberlain's Dwarf Salamander

- High Priority: Black Swamp Snake, Chicken Turtle, Florida Cooter, Florida Green Watersnake, Florida Softshell Turtle, Gulf Coast Mud Salamander, Yellowbelly Turtle, Upland Chorus Frog, Mink, Southeastern Bat
- Moderate Priority: Great Blue Heron, Great Egret, Common Snapping Turtle, Spotted Turtle, Southern Dusky Salamander, Northern Cricket Frog

Hardwood Slopes and Stream Bottoms

General Description and Location

A complex of hardwood and hardwood-pine communities occupy the floodplains of small streams, mesic bluffs and infrequently flooded flats in association with streams or rivers. Fire is infrequent, due either to the sheltered locations of these communities on bluffs or their isolation within a floodplain. Several mixed mesophytic subtypes characterized by the presence of American beech (*Fagus grandifolia*) occur in sheltered sites with moist soils, particularly on north-facing river bluffs and on slopes of drains and creeks. On upland flats within floodplains (hammocks), southern magnolia (*Magnolia grandiflora*) frequently shares dominance with American beech. The calcareous cliff and marl forest subtype occurs on circumneutral soils derived from limestone or unconsolidated calcareous substrates such as marl. Forest structure of all subtypes is diverse, with understory, shrub and herbaceous species varying according to soil moisture and chemistry. All subtypes intergrade with blackwater stream forest or river bottom forest on lowland sides and with upland forest on upland sides.

Associated Species

- Highest Priority: Black-throated Green Warbler, Eastern Wood Pewee, Kentucky Warbler, Rusty Blackbird, Swainson's Warbler, Swallow-tailed Kite, Wood Thrush, Worm-eating Warbler, Chamberlain's Dwarf Salamander, Black Bear, Northern Yellow Bat
- High Priority: Acadian Flycatcher, Bald Eagle, Southeastern Bat, Star-nosed Mole
- Moderate Priority: Louisiana Waterthrush, Eastern Woodrat, Eastern Fox Squirrel, Southern Dusky Salamander

Blackwater Stream Systems

General Description and Location

Tributary streams rising in the sandhills and coastal plain are commonly known as "blackwater streams" for the color of tannins leaching from decaying vegetation. Forests on the narrow floodplains formed by these streams typically have a canopy dominated by swamp tupelo (*Nyssa biflora*) and red maple (*Acer rubrum*). On broader sites, bald cypress (*Taxodium distichum*) can become an important canopy species. Tulip poplar (*Liriodendron tulipifera*), sweet gum (*Liquidambar styraciflua*), pond pine (*Pinus serotina*), loblolly pine (*Pinus taeda*) and laurel oak (*Quercus laurifolia*) are important associates. The shrub layer is open in areas subjected to the most flooding, or it can be fairly dense and pocosin-like in areas subject to infrequent flooding. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets or, under suitable fire conditions, pure stands of Atlantic white cedar (*Chamaecyperus thyooides*).

Associated Species

- Highest Priority: Kentucky Warbler, Eastern Wood Pewee, Rusty Blackbird, Swainson's Warbler, Wood Thrush, Yellow-crowned Night Heron

High Priority: Acadian Flycatcher, Black Swamp Snake, Spiny Softshell Turtle, Mink, Rafinesque's Big-eared Bat, Southeastern Bat

Moderate Priority: American Woodcock, Louisiana Waterthrush, Wood Duck, Spotted Turtle
River Bottoms

General Description and Location

River bottoms, or "bottomland forests" consist of hardwood-dominated woodlands with moist soils that are usually associated with the broad floodplains of major rivers rising in the piedmont or Blue Ridge. Locally, the floodplains of major coastal plain rivers are significant components of the landscape. Characteristic trees include sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), cherrybark oak (*Quercus pagoda*) and American holly (*Ilex opaca*).

A subtype dominated by bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*) occurs on lower elevation sites interspersed and intergrading with oak-dominated woodlands. Dominant trees are bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*), swamp gum (*Nyssa biflora*), Carolina ash (*Fraxinus caroliniana*), water elm (*Planera aquatica*) and red maple (*Acer rubrum*).

Associated Species

Highest Priority: Black-throated Green Warbler, Kentucky Warbler, Little Blue Heron, Rusty Blackbird, Swainson's Warbler, Yellow-crowned Night Heron, Black Bear, Northern Yellow Bat

High Priority: Acadian Flycatcher, American Alligator, Black Swamp Snake, Gulf Coast Mud Salamander, River Cooter, Spiny Softshell Turtle, Striped Mud Turtle, Mink, Rafinesque's Big-eared Bat, Southeastern Bat, Star-nosed Mole

Moderate Priority: American Woodcock, Great Blue Heron, Great Egret, Louisiana Waterthrush, Wood Duck, Bird-voiced Treefrog, Common Snapping Turtle, Spotted Turtle, Eastern Woodrat, Eastern Fox Squirrel

General Condition of Habitats

The coastal plain has been predominantly used for agricultural purposes since settlement by Europeans in the 18th century. Uplands and the better-drained terraces were cleared for fields at the same time that extensive longleaf pine and swamp hardwood forests on mesic and wet sites were cleared to supply timber. Several cycles of short-rotation pine forest were favored, along with agricultural practices that often provided substantial edge habitat for game species such as quail, but also deep woods or swamp habitat for deer, turkey and waterfowl. By the late 20th century, economic conditions began to favor consolidation of land into larger holdings and the practice of clean field agriculture, along with shorter rotations of both upland and lowland timber. Extensive holdings in the flatwoods belt were also used as recreational hunting reserves and managed primarily for production of game species with timber production to offset management expenses.

Several large public land holdings and privately held lands or conservation easements are distributed within the coastal plain, covering approximately 5 percent of the region's land area. By far the largest is the Francis Marion National Forest near the coast. Most public lands in the region have a strong wildlife management focus, including emphasis on threatened and endangered

species and other species of concern; for planning purposes the lands are considered protected.

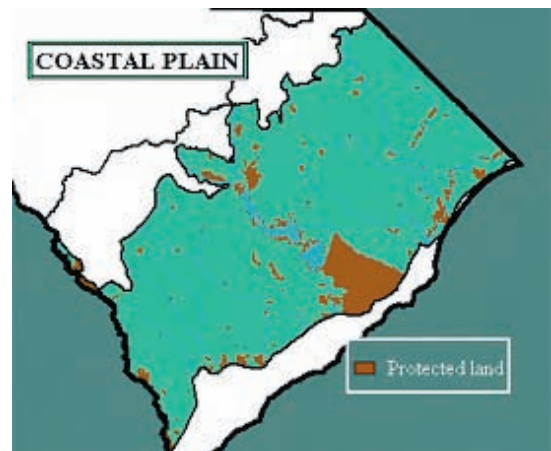
Major Public Holdings and Private Conservation Lands in the Coastal Plain (acres)	
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Brookgreen Gardens	2,700
Clemson University	1,844
National Audubon Society	4,461
National Park Service	6,038
Nemours Wildlife Foundation (easement)	983
Other Conservation easements	21,138
South Carolina Department of Natural Resources	26,685
South Carolina Department of Parks, Recreation & Tourism	5,352
South Carolina Forestry Commission	4,171
The Nature Conservancy	6,568
United States Department of Energy	15,445
United States Department of the Navy	1,582
United States Fish & Wildlife Service	16,951
United States Forest Service	97,599
Total	211,519

Region-wide Challenges

Although overall urban growth rates in the coastal plain are not as high as those in the piedmont and coastal zone, there are some local exceptions. The Myrtle Beach area at the easternmost boundary of the region is one of the fastest-growing areas in the country. Two other cities qualify as Metropolitan Statistical Areas (Florence and Sumter). Three cities in the state recently received a new designation from the Census Bureau, known as Micropolitan Statistical Areas (Bennettsville, Dillon and Walterboro).

This designation recognizes that, although these areas are small in comparison to the larger Metropolitan Statistical Areas, they still have many characteristics of larger urban areas and are experiencing typical urban growth dynamics. Rural portions of two counties (Jasper and Beaufort) are also experiencing the leading edges of expansion from rapidly growing coastal cities (Beaufort, South Carolina and Savannah, Georgia).



The South Carolina Exotic Pest Plant Council (2004) lists 13 exotic plant species as posing a “severe threat” or a “significant threat” in the coastal plain. Some species are widespread, such as privet (*Ligustrum sinense*), which is well established on many floodplains.

Pine woodland is likely the most fire-adapted forest in North America. Historically, frequent low-intensity fires were ignited by Native Americans as well as by lightning. Pre-colonial fire frequencies in the southeastern coastal plain have been estimated at 1-to-3 years. As European settlement expanded, features such as roads and plowed fields created incidental firebreaks. By the early 20th century, fire had come to be seen as an agent of destruction and was being actively

and effectively suppressed. Reduction in fire frequency to intervals greater than five years leads to elimination of the herb layer in pine woodlands (Frost 1990) and eliminates much of the habitat value of early successional stages.

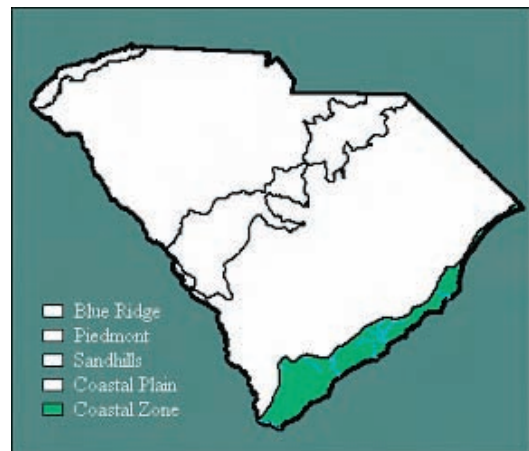
The benefits of prescribed burns, especially those conducted during spring and summer, are now better appreciated; however, burning is increasingly hampered by liability concerns. Expanding urban areas and proliferating highways mean that the smoke from a prescribed fire often creates extremely dangerous conditions. Keeping smoke away from roads is further complicated by the highly variable nature of the weather during the spring/summer season.

Few if any alternative treatments have been developed that can compete with fire from the standpoint of effectiveness and cost. Chemical applications generally cost about ten times as much per acre as prescribed fire. Mechanical treatments such as disking, chopping or raking are even more expensive.

Coastal Zone and Marine Ecoregion Terrestrial and Aquatic Habitats

Description and Location

The coastal zone is that portion of the lower coastal plain that lies seaward of US Highway 17. This region includes a small portion of the mainland but is primarily comprised of tidal marshlands and associated uplands that include large sea islands that are greater in size than 1,000 acres (404.69 hectares) and extends eastward to include barrier islands, Atlantic Ocean beaches and the Atlantic Ocean shallow continental shelf offshore to South Carolina's 4.8-kilometer (3-mile) jurisdictional boundary. The lower approximately 32 to 48 kilometers (20 to 30 miles) of all of the state's coastal rivers is included in the coastal zone.



The inland boundary of the coastal zone is somewhat arbitrary relative to mainland habitats, but is particularly relevant to riverine and alluvial habitats since Section 50-5-80 of the Code of Laws of South Carolina establishes boundaries for fresh and 'marine' waters that generally are associated with US Highway 17. These boundaries were established primarily for wildlife law enforcement concerns related to the enforcement of freshwater and marine fishery laws and regulations. The actual point at which riverine waters change from fresh (less than 0.5 parts per thousand salt) to brackish or 'marine' (greater than 0.5 parts per thousand salt) is highly variable, even daily, depending on the combined impacts of tides and river discharge as determined by rainfall or water releases from dams. During each approximately six-hour tide cycle from maximum ebb or low tide to maximum flood or high tide, the point of change from fresh to slightly brackish water may move several miles upriver, only to return downriver during the next ebb tide period.

The soils or surface sediments of the coastal zone (sands, silts and clays) are derived from the Appalachian Mountains and are organized into coastal, fluvial (riverine) and aeolian (dune) deposits. Most of these deposits were transported seaward during the Quaternary period, which began about 1.8 million years ago. Underlying the surface sediments is a bedrock stratum of

eroded sedimentary rocks dating to the Tertiary period and the Mesozoic era, between 130 and 1.8 million years ago. With the exception of manmade quarries, the bedrock stratum is only exposed within the coastal zone in banks and bottoms of rivers, in deep scoured tidal channels and on nearshore Atlantic Ocean continental shelf bottoms as “hard bottom.” The oldest sedimentary rocks are deeply buried sandstones, shales and siltstones from the Cretaceous epoch and up to 130 million years old. Limestone ranging in age from 100 to 30 to million years overlies the sedimentary rock (Matthews et al. 1980).

Habitats and Priority Species

The coastal zone contains the most diverse myriad of habitats of any of the ecoregions of the state and is treated somewhat separately from the other ecoregions because of this complexity. Many habitats within the region that are very important to wildlife species are completely dependent upon the influence of salt water and direct management action, such as coastal impoundments. In some cases it was inappropriate to classify the habitats solely based on vegetation.

Diverse forest types are distributed throughout the extreme eastern portion of the lower coastal plain mainland that is adjacent to estuaries and tidal river basins. Due to this proximity, large coastal zone islands, including barrier islands, sea islands and many hammock islands also support forested habitats very similar to those found in the lower coastal plain. Forested habitats distributed within both the coastal zone and coastal plain include the following: bottomland hardwood, pine woodland, oak-hickory or hardwood dominated, mixed mesic hardwood and bald cypress-tupelo gum swamp. Larger landmasses within the coastal zone also contain grassland and early successional habitats and wet flatwoods. Ponds and depressions, or wetlands isolated from tidal waterways, occur in the coastal zone as well, including interdune ponds that are restricted to dune systems along the Atlantic Ocean beaches.

Forest and Wetland Habitats of the Coastal Plain

General Description and Location

Typical coastal plain pine and hardwood forests extend into the coastal zone, sometimes with variations due to coastal influences or land management practices. Included are pine woodland, hardwood bottoms, upland forest and river slopes and bottoms. Cypress-tupelo hardwood bottoms within the coastal zone may be influenced more by tidal activity than by river flows, but the water is typically fresh or nearly so. Cypress-tupelo swamps may also be isolated from rivers and may be remnants of relict ricefield reserves. Several types of ponds and depressions occurring within the coastal plain ecoregion also occur within the coastal zone, including depression meadows, pond cypress ponds, swamp tupelo ponds, pocosins and limestone sinks.

Associated Species

Highest Priority:	Southern Hognose Snake, Wood Stork, Yellow-crowned Night Heron, American Eel
High Priority:	Upland Chorus Frog, Southeastern Bat, Pickerel Frog, Black Swamp Snake
Moderate Priority:	Wood Duck, Snapping Turtle, Pickerel Frog, Black Swamp Snake

*Early Successional Habitats of the Coastal Plain***General Description and Location**

Typical coastal plain upland grasslands or early successional fields extend into the coastal zone, with cover provided by grasses and/or weeds and with few, if any, trees. Also included are meadows, pastures, golf courses and expansive lawns with or without damp depressions.

Associated Species

Highest Priority: Grasshopper Sparrow, Field Sparrow, Yellow Rail, Upland Sandpiper, American Golden Plover

*Maritime Forest***General Description and Location**

Maritime forests are the typical forested plant community in the coastal zone and are found on barrier islands, salt marsh islands (hammock islands) and mainland areas that are influenced by salt spray. Maritime forests are typically dominated live oaks (*Quercus virginiana*), southern magnolia (*Magnolia grandiflora*) and one or more pine species. Typical shrubs and small trees include southern red cedar (*Juniperus silicicola*), cabbage palm (*Sabal palmetto*), American holly (*Ilex opaca*), red bay (*Persea borbonia*), wax myrtle (*Morella cerifera*) and yaupon holly (*Ilex vomitoria*). The herbaceous layer is usually fairly sparse due to the dense canopy cover.

Maritime forests exhibit much greater species and structural diversity away from the direct effects of salt spray. Deciduous trees are more common and include southern red oak (*Quercus falcata*), water oak (*Quercus nigra*), sugarberry (*Celtis laevigata*) and pignut hickory (*Carya glabra*). Dogwood (*Cornus florida*), American olive (*Osmanthus americana*) and Carolina laurel cherry (*Prunus caroliniana*) are common in the understory. Shrubs, including beauty-berry (*Callicarpa americana*) and red buckeye (*Aesculus pavia*), become more common, and saw palmetto (*Serenoa repens*) reaches its northern extent of its range on Kiawah Island in Charleston County.

A variant maritime forest resembling xeric pine woodland of the coastal plain occurs on relict dune ridges inland from the barrier island forests. This habitat has an open super-canopy of longleaf pine (*Pinus palustris*) with an understory composed of live oak (*Quercus virginiana*), laurel oak (*Quercus hemisphaerica*), sand live oak (*Quercus geminata*) and turkey oak (*Quercus laevis*). Unlike typical maritime forests, maritime sandhill forests are open and characterized by patches of bare sand and lichens such as reindeer lichens (*Cladonia* spp.).

Associated Species

Highest Priority: Painted Bunting, Southern Hognose Snake, Island Glass Lizard, Northern Yellow Bat

Moderate Priority: Northern Flicker, Eastern Woodrat

*Hammock Island***General Description and Location**

Approximately 3,500 marsh hammocks are distributed through the coastal tidelands of South Carolina. They are most abundant within the expansive estuarine and brackish marshlands and tidal waterways of Charleston, Colleton and Beaufort Counties, where nearly 90 percent of such islands occur. Hammock islands range in size from 0.04 to 404.5 hectares (0.108 to 999.9 acres) and are surrounded by tidal wetlands; hammock islands are located inland of barrier islands. Most were naturally formed while some, particularly along the Intracoastal Waterway,

were created by disposal of dredged materials or sediments excavated from post-civil war era phosphate mining. Many hammocks also occur within the delta portions of coastal river basins. As upland landforms, hammocks provide a diversity of woodland, shrub and wetland habitats.

Diversity of habitats, plant communities and associated fauna generally increases with hammock size. Islands of less than 0.4 hectares (1 acre) in size may be of uniformly low elevation and may become partially or completely inundated by salt water during extreme high tides. Such hammocks have few if any large trees and may be predominantly salt-shrub or grassland. Some very small hammocks with elevations precluding inundation except during extreme storm driven tides may have a few stunted specimens of live oak (*Quercus virginiana*) and/or cabbage palmetto (*Sabal palmetto*), but frequently have nearly pure stands of southern red cedar (*Juniperus virginiana* var. *silicicola*) with a narrow salt-shrub collar.

Most hammock islands of at least 0.4 hectares (1 acre) in size have some cover provided by live oak and cabbage palmetto and in at least these respects share characteristics with typical maritime forest. A narrow band of salt-shrub thicket encircles most hammocks at the marsh and upland interface. A broken band of southern red cedar and shrub thicket dominated by wax myrtle (*Morella cerifera*) frequently occupies the transition zone directly upland of this thicket. Seasonally flooded depressions and high marsh or salt-shrub incursions or sloughs may extend beneath cabbage palmetto dominated swales. Frequently, salt-tolerant grasses, sedges and herbs colonize these hydric soils where the shrub layer is absent or sparse. Portions of hammocks abutted by tidal waterways often have an abrupt transition from mature canopy forest to the high tide zone, with a very thin salt-shrub or high marsh collar if such occurs at all.

Associated Species

Highest Priority: Painted Bunting

High Priority: Bald Eagle, Barn Owl, Eastern Diamondback Rattlesnake, Diamondback Terrapin, Mink

Moderate Priority: “Pine Flatwood Crayfish”

Ocean Beaches and Transition Zones

General Description and Location

Ocean beaches and the associated transition zones are formed primarily from unconsolidated sand and are ubiquitous features on barrier islands or ocean strand that directly fronts the Atlantic Ocean. Dune habitat includes sand dunes and swales, flats and pools between dunes and between dunes and other features. Seaward of the dune system, sandy flats may occur in areas where dunes have been eroded. Beaches and associated habitats are influenced by windblown salt spray and sand and may be occasionally flooded, particularly during storms. Vegetated components of the beach system include:

- Maritime Grassland. That portion of the Atlantic Ocean beach dune system vegetated by grasses and herbs. This habitat includes sand dunes and swales and flats between dunes and between dunes and other features. Characteristic plants include sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), seabeach evening-primrose (*Oenothera humifusa*) and dune waterpennywort (*Hydrocotyle bonariensis*).
- Interdune Pond. Low depressions or pools within the secondary dunes that hold water either permanently or seasonally. Both vegetation and animal life in pools is largely determined by salinity. Interdune ponds, whether permanently or seasonally watered, may provide at least a

short-term supply of low salinity water in areas where it is otherwise generally absent.

- Maritime Shrub Thicket. Thickets of shrubs, vines and stunted trees often in swales within secondary dunes. Trees and shrubs must be salt tolerant and are “pruned” by windblown salt spray and sand. Typical plants are wax myrtle (*Morella cerifera*), red bay (*Persea borbonia*), groundsel tree (*Baccharis halimifolia*), saw greenbrier (*Smilax bona-nox*) and poison ivy (*Toxicodendron radicans*).

Associated Species

Highest Priority: Common Ground-dove, Wilson’s Plover, Gull-billed Tern, Painted Bunting, Island Glass Lizard, Least Tern, Piping Plover, Loggerhead Turtle

Moderate Priority: Eastern Woodrat

Unranked: Atlantic Ghost Crab, Sheepshead Minnow

Isolated Nonforested uplands

General Description and Location

Numerous small emergent landforms occur within inlets, sounds, bays and river deltas. They are generally sparsely vegetated and are constantly reshaped by the dynamic forces of currents, waves and wind. Such islands lying entirely within sounds and inlets and surrounded by expanses of open, relatively deep water are generally devoid of terrestrial predators, particularly raccoons. Lower-lying islands are vulnerable to over washing by storm-induced high tides and to salt spray from strong winds. In more sheltered situations, even though high-profile dunes are absent, vegetation develops to salt tolerant grasses and low shrubs. Sandy beach, intertidal beach and surf zone habitats may also be present. The extent and type of vegetation likely determines the utilization of such sites by nesting and resting seabirds, shorebirds and wading birds.

Emergent landforms influenced by human activity consist of diked spoil islands and shall rakes. Diked spoil islands are created from disposal of dredged materials in previously open tidal marshlands or on previously existing uplands. Both dikes and interior areas above normal spoil pooling are usually colonized by early successional grasses, such as broom sedges (*Andropogon* spp.) and shrubs and trees including groundsel tree (*Baccharis halimifolia*), tallowtree (*Triadica sebiferum*) and sugarberry (*Celtis laevigata*). Vegetation cover becomes more dense when spoil deposition is discontinued. Although the value of these sites to wildlife is highly variable, spoil islands receiving sediments consisting primarily of sand with a low organic content can be manipulated to maintain an unvegetated condition to facilitate use by sea and shorebirds.

Shell rakes are deposits of oyster and other mollusk shell produced by wave action from wind and/or boat wakes, occurring along exposed marsh borders of inlets, sounds, bays and other large waterways. These sites are partially abundant adjacent to the Intracoastal Waterway where wave action from boat wakes can deposit shell, but can also overwash them. Shell rakes are highly valuable as nesting and roosting sites for American oystercatcher (*Haematopus palliatus*) and as shorebird roost sites. High wakes are especially problematic during summer when overwashing can destroy oystercatcher nests (T. Murphy, SCDNR, pers. comm. 2004).

Associated Species

Highest Priority: Wilson’s Plover, Sandwich Tern, White Ibis, Least Sandpiper, Painted Bunting, Black Skimmer, Eastern Brown Pelican, Royal Tern, American Oystercatcher

High Priority: Black-bellied Plover, Diamondback Terrapin, Mink

Ponds and Depressions

General Description and Location

Ponds and depressions, including pools and isolated wetlands, occur throughout the coastal zone and may be embedded within larger habitats. These include forested habitats, early successional habitats, hammock islands, maritime forest and diked spoil islands. Such sites are not generally identified on soil maps. In addition to the isolated wetland subtypes occurring throughout the coastal plain, the following subtypes are unique to the coastal zone:

- Manmade ponds, constructed for recreational, water supply or stormwater retention, are highly variable with regard to physical features, water chemistry and connection to open tidal systems. These factors, as well as land use and other human activities near such wetlands, primarily control both floral and faunal features. Though such habitats are not generally considered high quality wildlife habitat, some provide suitable habitat for priority species as foraging, nesting, roosting and resting habitat for wading birds.
- Vernal pools, small, seasonally flooded depressions with gradually sloping margins, occur in sandy uplands on barrier islands and other landforms of recent origin. They may be embedded in non-alluvial swamp forests or other forest types within the interior of uplands or may lie near the perimeter of uplands and receive occasional input of water of varying salinity on exceptionally high tides. Except where soils are highly saline, many of these habitats have been colonized by the invasive, non-native tallowtree (*Triadica sebiferum*). Vernal pools may be a primary source of low salinity water for birds and mammals and as breeding and/or resident habitat for turtles, amphibians and crayfish. Since these pools are only seasonally flooded, large predatory fishes are absent. Smaller vernal pools may afford the only wetland habitats on smaller islands.
- Small depression ponds may intergrade with vernal pools but are permanently flooded, except possibly during severe droughts. Obligate aquatic plants like fragrant waterlily (*Nymphaea odorata*) or yellow pondlily (*Nuphar lutea*) may inhabit submerged areas and a variety of emergent and wetland species, including sedges and grasses, generally colonize shallows and intermittently exposed borders. Small depression ponds generally are not affected by tidal activities.
- Interdune ponds are depressions located in swales between beach dunes or ridges that contain permanent or vernal pools.

Associated Species

Highest Priority: White Ibis, Wilson's Snipe, Flatwoods Salamander, Broad-striped Dwarf Siren

High Priority: Chicken Turtle

Moderate Priority: Greater Yellowlegs

Unranked: Marsh Killifish, Sailfin Molly

Managed Impoundments

General Description and Location

The coastal wetland impoundments of South Carolina are managed and formerly managed

tidal wetlands. Impoundments generally occur from Georgetown County southward, coincident with the state's most extensive tidal marshlands. Salinity regimes range from fresh to brackish, depending on water sources and management practices.

A diverse assemblage of rooted floating aquatics, such as white waterlily, American lotus, and pondweeds occupies managed freshwater impoundments. Emergent plants such as cattails, southern wild rice and pickerel weed are common. Submerged and free-floating aquatic plant species also occur and include duckweed, bladderwort, waterfern and fernwort. Managed brackish and intermediate emergent wetlands principally contain widgeongrass, saltmarsh bulrush and dwarf spikerush.

Emergent tidal marshes are common along the banks of canals of abandoned rice fields and modern-day waterfowl impoundments. Dominant species can include cutgrass (*Zizaniopsis miliacea*) or Jamaica swamp sawgrass (*Cladium jamaicense*). Intermixed among these grasses are various herbaceous plants such as pickerelweed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.) and alligatorweed (*Alternanthera philoxeroides*). Shrubs and trees are present in the more elevated areas of the tidal marsh community. Bald cypress-tupelo swamp communities occur on abandoned rice fields and swales inland of modern-day impoundments.

Associated Species

Highest Priority: Glossy Ibis, Black Rail, Northern Pintail

High Priority: Pee Dee Lotic Crayfish

Moderate Priority: Black-necked Stilt, Tundra Swan

Tidal Fresh and Brackish Systems

General Description and Location

Tidal fresh and brackish systems consist of a complex of marshlands, sandbars, mud flats, sand flats and waterways that are subject to mixing of salt and freshwater flows, usually in association with a freshwater source, such as a river delta. Substrates and vegetation communities include intertidal marsh, intertidal flat, intertidal sandbar, channels, Creeks, subtidal/submerged flat and emergent marsh. Vegetation is predominantly grasses, sedges and herbs with few trees; species makeup depends on salinity. Submerged vegetation may occur as well.

Associated Species

Highest Priority: Spotted Sandpiper, Black Skimmer, Lesser Scaup, Least Tern, Hickory Shad, Black Skimmer

High Priority: Forster's Tern, Spiny Softshell Turtle, Florida Green Water Snake,

Moderate Priority: Banded Killifish, Bluefin Killifish

Unranked: Ohio Shrimp

Estuarine Systems

General Description and Location

Estuaries form one of the predominant landscapes of the coastal zone. They consist of interconnected networks of intertidal marshland with tidal channels of various sizes branching throughout, generally interfacing with marine or Atlantic Ocean waters via deep channels through sounds and bays or through smaller inlets. Following are the generally recognized vegetative and geophysical components of estuaries and their interrelationships:

- Salt Marsh. Intertidal marshlands in estuarine (salinity ranges 15 to ~40 ppt) areas that are variously flooded and dewatered by tidal forces, with influence from lunar cycles, wind, rainfall and river discharge, particularly within or near river deltas. Smooth cordgrass (*Spartina alterniflora*) is the dominant plant.
- Black Needlerush Marsh. The portion of highest elevation salt marsh dominated by black needlerush (*Juncus roemerianus*), which often occurs in dense stands. This habitat is usually near uplands.
- Salt Flat. Sparsely vegetated, hypersaline (greater than 40 ppt salinity) and exposed flats of sand and/or mud. Typical plants include glassworts (*Salicornia* spp.) and saltwort (*Batis maritima*).
- Salt-Shrub Thicket. Bands or patches of usually low, dense shrubs that typically interface high salt marsh and uplands. Characteristic plants include sea ox-eye (*Borrichia frutescens*), marsh elder (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*).
- High Marsh Pool. Poorly drained pools in high salt marsh, often near uplands. Salinity is highly variable depending on frequency and timing of tidal input and rainfall. Both soils and water may become hypersaline (greater than 40 ppt salinity).
- Estuarine Intertidal Flat. Mud and sand flats in estuarine systems that have little or no vegetation and are dewatered on ebb tide and submerged during high tides. Mud and sand flats may occur between marshlands and channels and creeks or may be interspersed within marshlands.
- Estuarine Intertidal Sandbar. Sandbars in estuarine systems that are partially exposed during part of most tide cycles and river stages but are typically submerged during high tide.
- Estuarine Tidal Channels and Creeks. Tidal estuarine waterways of variable depth and with currents generated by riverine and/or tidal flows.
- Estuarine Subtidal/Submerged Flat. Mud and sand flats with little or no vegetation that are inundated during all or part of each tidal cycle. Submerged flats include sand and/or mud bottom areas outside of channels and creeks and usually lie between channel habitats and tidal marshlands.
- Oyster Reef. Bars or reefs primarily composed of live and dead eastern oyster (*Crassostrea virginica*). Oyster reefs can be either intertidal or subtidal and are usually in flats between tidal channels and salt marsh. Reefs may occur in flats within expanses of salt marsh.

Associated Species

Highest Priority:	Louisiana (Tri-colored) Heron, Black Rail, Black Skimmer
High Priority:	Mink, Diamondback Terrapin, Black-bellied Plover, Bottlenose Dolphin
Moderate Priority:	Greater Scaup
Unranked:	Ribbed Mussel, Sheepshead Minnow, Mud Fiddler Crab, Cobia, Atlantic Brief Squid, Colorful Sea Whip, Southern Flounder, Finetooth Shark, Horseshoe Crab, Knobbed Whelk

Marine Ecosystem

General Description and Location

The Coastal Marine Ecosystem occurs along all 291.5 km (181 mi) of South Carolina's Atlantic

Ocean coastline and extends offshore to the state 4.8-kilometer (3-mile) jurisdictional boundary, incorporating a surface area of nearly 140,000 hectares (~346,000 acres). The following habitats are generally recognized:

- **Intertidal Beach.** The front ocean beach region that is typically inundated on flood tides and dewatered on ebb tides. Invertebrate fauna in the intertidal beach zone such as the coquina clam (*Donax variabilis*) and the mole crab (*Emerita talpoida*) are an integral part of the food supply for shorebirds and seabirds (piping plover (*Charadrius melodus*), willet (*Catoptrophorus semipalmatus*), sanderling (*Calidris alba*) and red knot (*Calidris canutus*) that forage at the intertidal beach and surf interface.
- **Surf Zone.** The submerged portion of the beach area and extending offshore to a depth of 6 feet at any tidal stage. Marine aquatic species in this zone are heavily influenced by turbulence from wave action. Ninety-eight fish and 317 macro-invertebrate species are recognized as at least occasional inhabitants.
- **Shallow Shelf.** The portion of the Atlantic Ocean submerged continental shelf offshore to the 3-mile state territorial limit. Shallow shelf habitats can be further divided into three important types, *soft bottom*, *hard bottom* and *pelagic zone*. Soft bottom is composed of unconsolidated sediments that supply sand to the continental shelf, barrier islands, and beaches; store nutrients in the sediment; and are critical nursery and feeding habitat for fish. Hard bottom supports a wide variety of invertebrate and fish species, including many species popular with recreational fishers. Hard bottom habitats are continually being discovered and mapped. The pelagic zone supports many year-round nekton (water-column) species, but also is an important migration route or temporary home for numerous transitory species.

Associated Species

High Priority: Bottlenose Dolphin, Black Scoter

Moderate Priority: Common Loon

Unranked: Hardhead Catfish, Southern Kingfish, Surf Scoter, Sheepshead, Atlantic Spadefish, Cannonball Jellyfish, Coquina Clam

Man-made Structures

General Description and Location

Engineered structures are estimated to cover over 25 percent of South Carolina's nearly 90 miles of developed coastline (SCDHEC 2005). Some of the most familiar structures include piers, boardwalks, housing and commercial development, jetties and groins. Manmade structures can provide hard surfaces and relief (vertical extension) of substrate into the water column that promote the attachment of many aquatic species, including algae and mosses in low salinity waters and algae and sedentary invertebrates (hydroids, bryozoans, sponges, barnacles, oysters and mussels) in estuarine and near-shore marine waters.

Rock seawalls and jetties provide hardened substrate for attachment of organisms in intertidal and subtidal zones and exposed rock may be used by resting and foraging shore and seabirds, most notably the purple sandpiper (*Calidris maritima*), which prefers rocky coast habitats that are rare in the southeast. Submerged rock also provides cover for many fishes and invertebrates.

However, hardened structures designed for shoreline and channel protection also disrupt natural processes of sand movement along beaches and can contribute significantly to beach

erosion. Seawalls and bulkheads in inland waterways can protect the immediate shoreline while potentially exacerbating erosion of the nearby, unprotected shoreline. Such structures also interfere with the nesting of sea turtles either by totally displacing nesting sites or by rendering them more susceptible to flooding.

Associated Species

Moderate Priority: Purple Sandpiper

Unranked: Gag, Lined Seahorse, Florida Stone Crab

General Condition of Habitats

Much of the South Carolina coastal zone has been adversely affected by human population growth and associated development. By the early 1990's, about 50 percent of the total United States' human population lived in coastal areas (Moore et al. 1995), and the trend of concentrated growth along coasts is expected to continue into the next century (Cullitan et al. 1990). About 88 miles (48.6 percent) of South Carolina's beachfront is currently affected by development (Kana 1988). The high concentration of human population growth and development in the coastal zone has fragmented forests and reduced other valuable habitats, such as shrub thickets and isolated wetlands. The vast majority of protected coastal zone holdings are in two regions, the ACE Basin and the Cape Romain- McClellanville area.

Region-wide Challenges

Non-native plants colonize both terrestrial and wetland habitats. Such species can dominate or displace native vegetation and can occur in nearly single-species colonies or stands that present a lowered structural diversity and poor wildlife habitat. Both tidal low-salinity marshes and wetlands and littoral (shallow water) areas in ponds and impoundments can be densely covered

Major Public land holdings and private lands in conservation status in the Coastal Zone (acres)

Belle W Baruch Foundation	6,815
Brookgreen Gardens	632
Lowcountry Open Land Trust	733
Nemours Wildlife Foundation	2,906
Public Service Authority	606
South Carolina Department of Natural Resources	35,585
South Carolina Department of Parks, Recreation & Tourism	2,798
The Nature Conservancy	3,952
United States Department of the Navy	1,056
United States Fish & Wildlife Service	29,297
United States Forest Service	4,732
United States Marine Corps	5,875
University of South Carolina	568
Total	95,556

in waterthyme (*Hydrilla verticillata*) or common reed (*Phragmites communis*). Dense colonies of these plants may restrict flows and capture sediment, thereby increasing the rate of eutrophication and contributing to low dissolved oxygen (DO) (McCann et al. 1996; Aulbach-Smith and deKozlowski 1996). Forested wetlands and coastal forests with damp (hydric or mesic) soils may be heavily populated with tallowtree (*Triadica sebiferum*), which quickly becomes established

and out-competes more desirable native plants (J.W. McCord, SCDNR, pers. obs.). Feral non-native mammals like goats (*Capra hircus*) and pigs (*Sus scrofa*), inhabit coastal zone islands and marshlands. Goats can heavily browse vegetation, thereby reducing plant diversity, cover and soil stability; feral pigs can damage soils, marshes and impoundment dikes (J.W. McCord, SCDNR, pers. obs.). Non-native fishes like the common carp (*Cyprinus carpio*), the flathead catfish (*Pylodictis olivaris*), and the blue catfish (*Ictalurus furcatus*), may not directly impact habitats, but can alter ecosystem health through predation on or competition with native species.

Coastal development along the Grand Strand and barrier island beaches has reduced unique coastal zone habitats. A high percentage of the state's maritime forests, maritime grasslands, maritime shrub thickets, beach flats and intertidal beaches have been negatively affected. Terrestrial habitats are physically removed to accommodate housing and other structures and natural and dynamic beach processes of erosion and accretion of sands have been altered to protect human structures and recreational interests. Hardened structures such as rocks, groins and jetties prevent natural sand movements. Beach renourishment from sand pumped from offshore or estuarine sites is frequently used to restore dune systems and beach flats.

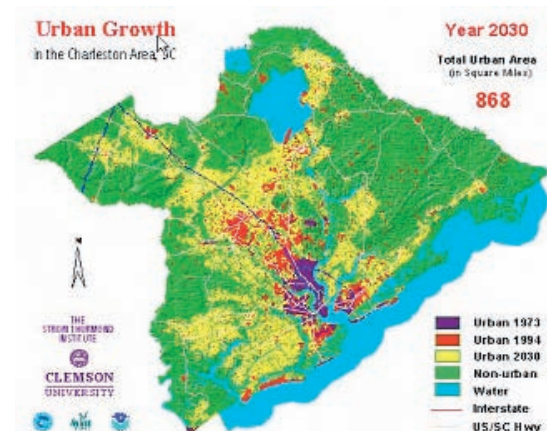
Beachfront habitats in South Carolina have likely been more negatively affected by anthropogenic activities than any other ecosystem. Further, many priority species either presently rely, or once relied, upon such habitats. Human population growth and associated anthropogenic impacts are greater in or near the coastal zone than in any other ecoregion in the state.

According to the U. S. Census Bureau, the human population within the seven counties (Horry, Georgetown, Charleston, Berkeley, Colleton, Beaufort and Jasper) that include or border portions of the coastal zone increased by 41.1 percent from 1980 to 2000. Furthermore, this area is predicted to undergo an additional 28.1 percent growth in human population from 2000 to 2020. Over the past decade, there has been a substantial increase in the proportion of the population that lives within watersheds that drain into South Carolina estuaries (Cofer-Shabica et al. 1999).

Projected urban land area changes for the Charleston area to the year 2030. Source: Allen & Lu (2000).

The urbanized area of Charleston increased by more than 400 percent from 1973 to 1994 and is expected to increase at a similar rate for the next several decades (Allen and Lu 2000). Obvious impacts have been, and will continue to be, increased deforestation and forest fragmentation caused by increased residential, commercial and industrial development, and expanded highway and other transportation corridors to support the increased population.

Both point source and nonpoint source pollution also increase with population growth. Consumptive pressures relative to recreational uses of fishery resources will accompany population growth as well, as will nonpoint source pollution from watercraft and disturbance of wildlife from increased human activity. The ultimate result is increased stress on natural habitats and natural resources within the coastal zone, as well as increased vulnerability of habitats, fish and wildlife populations, and people to catastrophic events such as major hurricanes.



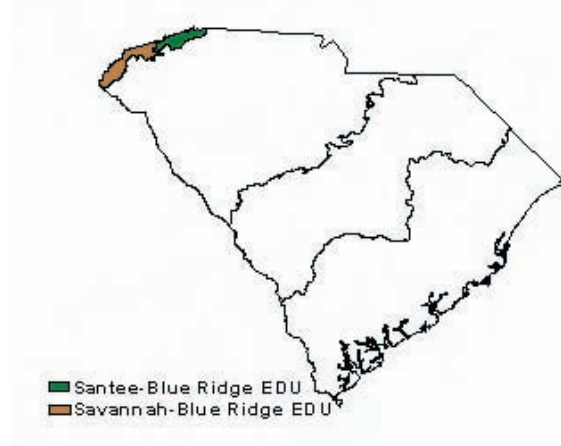
Such predicted human population growth, and the associated impacts on wildlife and habitat, is added incentive to proactively plan for wildlife habitat conservation in the state's coastal zone.

CHAPTER 13: AQUATIC HABITATS

Blue Ridge Ecoregion Aquatic Habitats

Description and Location

The Blue Ridge ecoregion is located in the northwest corner of the state in Oconee, Pickens and Greenville Counties. Although the Blue Ridge is the smallest ecoregion in South Carolina, encompassing only 465 square miles, it harbors a diverse and unique aquatic community. The Blue Ridge Ecoregion cuts across the top of two major South Carolina drainages, the Savannah and the Santee, forming two ecobasins: the Savannah-Blue Ridge and the Santee-Blue Ridge.



Santee-Blue Ridge Ecobasin

The Blue Ridge portion of the Santee drainage originates in South Carolina as the headwaters of the Saluda River, which flows southeast and is a major tributary to the Santee River. The ecobasin encompasses approximately 175 square miles. Most of the land is privately owned; however, a significant portion (63 square miles) is protected by state, municipal and private entities. Significant protected areas include two Greenville Watershed properties managed by the City of Greenville (under conservation easement to the Nature Conservancy), the Mountain Bridge Wilderness Area and Jocassee Gorges Recreation Area managed by the South Carolina Department of Natural Resources (SCDNR) and Table Rock State Park. The ecobasin encompasses approximately 245 miles of lotic habitat. The largest two impoundments, North Saluda Reservoir and Table Rock Reservoir, total only 1,519 acres.

Savannah-Blue Ridge Ecobasin

The Blue Ridge portion of the Savannah drainage originates in the mountains of South Carolina, North Carolina and Georgia. Major tributaries in the ecobasin include the Chauga, Chattooga and Toxaway rivers. The ecobasin encompasses approximately 283 square miles. Most of the land is publicly owned (143 square miles), with a significant portion protected by federal and state entities: Sumter National Forest (88 square miles) and Jocassee Gorges Recreation Area (27 square miles). Other protected areas include the Sumter National Forest Wild and Scenic River Corridor along the Chattooga River and Oconee State Park. The ecobasin encompasses approximately 372 miles of lotic habitat and 8,298 acres of impoundments. Most of the impounded area is a result of Lake Jocassee (7,362 acres) and the headwaters of Lake Keowee (547 acres).

General Condition

The Blue Ridge Ecoregion is the least developed ecoregion in the state and is primarily forested. Nearly 50 percent of the land in the Blue Ridge is protected to some degree. Three large tracts account for most of the protected land. These are the Sumter National Forest, the Jocassee Gorges Recreation Area and the Greenville Watershed Easement.

	Agriculture	Barren	Developed	Forest	Scrub	Water	Total area	Protected
Santee	1,466 1.3%	99 0.1%	478 0.4%	107,116 95.0%	1,636 1.5%	1,997 1.8%	112,793	35.9%
Savannah	7,909 4.4%	131 0.1%	1,169 0.6%	154,219 85.0%	7,776 4.3%	10,193 5.6%	181,400	50.5%
Total area	9,375 3.2%	230 0.1%	1,647 0.6%	261,336 88.8%	9,412 3.2%	12,190 4.1%	294,193	44.9%

Overall water quality in the Blue Ridge Ecoregion is good. In the Savannah-Blue Ridge Ecobasin 5 of 27 sites (19 percent) sampled by the South Carolina Department of Health and Environmental Control were designated as impaired, primarily due to mercury or total phosphorous contamination (SCDHEC 2003). Fish consumption advisories have been issued for Lake Jocassee and the Seneca River arm of Lake Hartwell (SCDHEC 2003). In the Saluda-Blue Ridge Ecobasin only 1 of 13 sites (8 percent) sampled by SCDHEC (1998) was designated as impaired; that impairment was based on absence of aquatic fauna.

Major Classifications

Wadeable Streams

Wadeable streams are the dominant aquatic classification in the Blue Ridge Ecoregion. There are 254 miles of wadeable streams in the Santee-Blue Ridge Ecobasin and 364 miles in the Savannah-Blue Ridge Ecobasin. Wadeable streams are defined as streams with Strahler stream orders of 0 to 3, generally streams that can be waded comfortably throughout most of the year. Wadeable streams in the Blue Ridge are typically high gradient with clear water and a mixture of bedrock, gravel, cobble and sand substrates. These streams contain a variety of habitats including riffles, runs, pools, glides and cascades. At higher elevations, many of these streams contain cascades and waterfalls.

Navigable Streams

Navigable streams are less common in the Blue Ridge ecoregion with only about 20 miles of free-flowing stream within South Carolina. These streams are generally defined as being large enough to operate watercraft, if only a canoe, and are generally too deep to be waded throughout most of the year. The Chauga and Chattooga Rivers are examples of navigable streams in the Blue Ridge. Navigable streams in the Blue Ridge contain a myriad of aquatic habitats including riffles, shoals, pools, runs and glides in various combinations. These streams are somewhat more productive than the wadeable streams, despite being generally swift flowing and clear. Substrate in these habitats is primarily bedrock, gravel, cobble and sand.

Priority Species Associations

There are 23 fish species on South Carolina's Priority Species List within the Blue Ridge ecoregions; of these, six species occur in both ecobasins, eight species are restricted to the Savannah drainage and nine species are restricted to the Santee drainage. Two priority mussel species occur in the Blue Ridge ecoregion, both in the Santee drainage. However, very few surveys have been conducted in this area for mussels. The paucity of documented priority mussel species found in this ecoregion may be due to lack of information rather than absence of sensitive mussels. Two priority crayfish species and one priority snail species occur in the Blue Ridge and are found in the Savannah drainage, while one priority crayfish species found in the Blue Ridge is in the Santee drainage. Habitat preferences of these species can be found in the species accounts chapters of this Supplemental Volume.

Region-wide Challenges

Challenges to conservation of aquatic fauna in these two ecobasins are similar to other ecobasins in the state and primarily include impacts associated with impoundments, nonpoint source pollution and introduction of non-native species. Point source pollution is not a significant problem in the Blue Ridge Ecoregion at this time.

Impoundments in the Savannah-Blue Ridge ecobasin have negatively affected a significant portion of habitat for native aquatic species. Nearly 40 miles of historically free-flowing streams within the ecobasin have been impounded; most of the stream habitat lost (25 miles) was due to the impoundment of the Toxaway River to form Lake Jocassee. In the Santee-Blue Ridge Ecobasin, 12.5 miles of stream habitat have been lost to impoundments, including North Saluda Reservoir and Table Rock Reservoir. Impoundments affect native aquatic fauna through direct loss of habitat as lotic habitat is converted to lentic habitat, which favors competitive and often predacious species such as largemouth bass and other centrarchids. In addition, impoundments

Common Name	Scientific Name	Ecobasin	
		Blue Ridge - Santee	Blue Ridge - Savannah
Highest Priority			
Fishes			
Redeye bass	<i>Micropterus coosae</i>	X	X
Christmas darter	<i>Etheostoma hopkinsi</i>		X
Crayfish			
Oconee stream crayfish	<i>Cambarus chaugaensis</i>		X
A crayfish	<i>Cambarus</i> sp. nov. “B”		X
Red Burrowing crayfish	<i>Cambarus carolinus</i>	X	
Snails			
A pebblesnail	<i>Somatogyrus tenax/virginicus</i> (identity uncertain)		X
High Priority			
Fishes			
Santee chub	<i>Hybopsis zanema</i>	X	
“Smoky sculpin”	<i>Cottus bairdii complex</i>		X
Fantail darter	<i>Etheostoma flabellare</i>	X	X
Turquoise darter	<i>Etheostoma inscriptum</i>		X
Seagreen darter	<i>Etheostoma thalassinum</i>	X	
Piedmont darter	<i>Percina crassa</i>	X	
Moderate Priority			
Fishes			
Central stoneroller	<i>Campostoma anomalum</i>	X	X
Greenfin shiner	<i>Cyprinella chloristia</i>	X	
Whitetail shiner	<i>Cyprinella galactura</i>		X
Fieryblack shiner	<i>Cyprinella pyrrhomelas</i>	X	
Highback chub	<i>Hybopsis hypsinotus</i>	X	
Thicklip chub	<i>Hybopsis labrosa</i>	X	

Common Name	Scientific Name	Ecobasin	
		Blue Ridge - Santee	Blue Ridge - Savannah
Fishes Continued			
Rosyface chub	<i>Hybopsis rubrifrons</i>	X	X
Warpaint shiner	<i>Luxilus coccogenis</i>		X
Tennessee shiner	<i>Notropis leuciodus</i>		X
Mirror shiner	<i>Notropis spectrunculus</i>		X
Longnose dace	<i>Rhinichthys cataractae</i>		X
Blacknose dace	<i>Rhnicthys atratulus</i>	X	X
V-lip redhorse	<i>Moxostoma pappillosum</i>	X	
Snail bullhead	<i>Ameiurus brunneus</i>		X
White catfish	<i>Ameiurus catus</i>	X	
Brook trout	<i>Salvelinus fontinalis</i>	X	X
Mussels			
Carolina lance	<i>Elliptio congarea</i>	X	
Variable spike	<i>Elliptio icterina</i>	X	

often negatively impact unimpounded stream reaches downstream due to altered hydrologic and thermal regimes (Cushman 1985), modified stream channel morphology and increased erosion and sedimentation (Waters 1995), ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004).

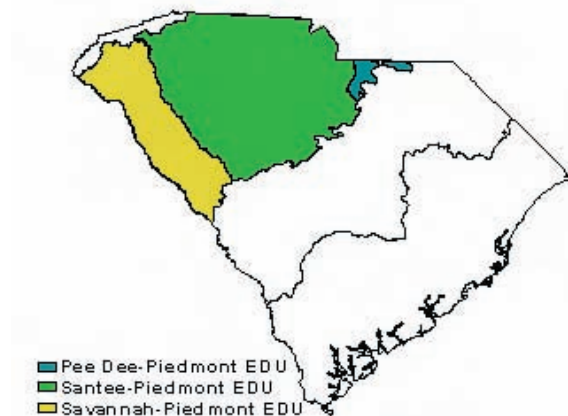
Sedimentation is the primary form of nonpoint source pollution in the Blue Ridge Ecoregion as it is throughout the state. Erosion from residential and commercial development and transportation and utility construction projects is the primary source of sedimentation in streams. Poor agricultural and silvicultural practices also contribute significantly to stream sedimentation.

Introductions of non-native species also threaten native fauna in the Blue Ridge Ecoregion. Introduced rainbow trout and brown trout displace the native brook trout and may prey on native nongame fishes as well. Introductions of spotted bass to Lakes Jocassee and Keowee have displaced the native redeye bass and further threaten the fish through hybridization.

Piedmont Ecoregion Aquatic Habitats

Description and Location

The piedmont ecoregion extends south of Blue Ridge to the fall line near Columbia, South Carolina and from the Savannah River east to the Pee Dee River. Encompassing 24 counties and 10,788 square miles, the piedmont is the largest physiographic province in South Carolina. The piedmont is an area with gently rolling hills dissected by narrow stream and river valleys. Forests, farms and orchards dominate most of the land. Elevations range from 375 to 1,000 feet. The Piedmont Ecoregion



cuts across the top of three major South Carolina drainages, the Savannah, the Santee and the Pee Dee, forming three ecobasins: the Savannah-Piedmont, Santee-Piedmont and Pee Dee-Piedmont.

Savannah-Piedmont Ecobasin

The Savannah River drainage originates in the mountains of North Carolina and Georgia. The Savannah River flows southeast along the border of South Carolina and Georgia through the piedmont for approximately 131 miles on its way to the Atlantic Ocean. Major tributaries to the Savannah River in the South Carolina portion of this ecobasin include the Tugaloo River, Seneca River, Chauga River, Rocky River, Little River and Stevens Creek.

The ecobasin encompasses 36 watersheds and approximately 2,879 square miles. The vast majority of the land is privately owned with only 239 square miles protected by federal, state and private entities. Most of the protected land (192 square miles) occurs in Sumter National Forest. The ecobasin contains 3,328 miles of lotic habitat with 143 square miles of impoundments. Most of the impounded water occurs in four large reservoirs, Lake Keowee (17,010 acres), and the South Carolina portions of Lake Hartwell (35,187 acres), Lake Russell (15,207 acres) and Thurmond Reservoir (21,297 acres).

Primary conservation targets within the ecobasin include the Stevens Creek watershed in Greenwood and McCormick Counties, the Turkey Creek watershed in Edgefield County and the mainstem Savannah River in Edgefield and Aiken Counties (Smith et al. 2000). The Stevens Creek and Turkey Creek watersheds are home to several mussels on South Carolina's Priority Species List including the brook floater, yellow lampmussel, creeper and the federally endangered Carolina heelsplitter. At least 13 priority fish species are also found in this ecobasin, including the Christmas darter, redeye bass, Savannah darter and turquoise darter. The mainstem of the Savannah River in Edgefield and Aiken Counties is home to the robust redhorse and federally endangered shortnose sturgeon as well as several other priority fish species. Several priority mussel species (barrel floater, pod lance, Roanoke slabshell, yellow lampmussel, reyed pink fatmucket and Savannah lilliput) are also found in the mainstem Savannah River.

Santee-Piedmont Ecobasin

The upper Santee River drainage originates mostly in the south central piedmont of North Carolina, but receives some input from the mountains of South Carolina and North Carolina through the Saluda and Catawba River systems, respectively. The Broad River and Catawba-Wateree Rivers are the dominant rivers in this ecobasin. The Broad River flows nearly directly south from North Carolina to Columbia, South Carolina where it merges with the Saluda River at the fall line to form the Congaree River. As the Broad River flows south, it picks up inputs from the Pacolet River, Tyger River and Enoree River along the western portion of the drainage and Kings Creek, Turkey Creek, Sandy River and Cedar Creek from the eastern portion of the drainage. The Catawba River originates on the eastern slope of the Blue Ridge in North Carolina and flows through the inner piedmont and Charlotte, North Carolina before entering South Carolina. The Catawba flows south through South Carolina until it is impounded to form Lake Wateree and thereafter is known as the Wateree River. The Wateree River continues to flow south through the southeastern plains until it merges with the Congaree River to form the Santee River.

The Santee-Piedmont Ecobasin is the largest in the state, containing part or all of 84 watersheds and encompassing 7,604 square miles. The ecobasin contains approximately 7,161 miles of stream habitat and nearly 160 square miles of impoundments. Most of the impounded area (127 square miles) is the result of five large reservoirs, including Lake Greenwood (9,957 acres) and Lake

Murray (48,417 acres) on the Saluda River, Monticello Reservoir (6,644 acres) on the Broad River, and Lake Wylie (5,067 acres) and Wateree Lake (11,386 acres) on the Catawba-Wateree River.

Most land in the ecobasin is privately owned with only 298 square miles protected by state, federal and private entities. Most of the protected land (251 square miles) occurs in the Sumter National Forest. Other significant protected areas include the Croft State Natural Area (10.7 square miles), Kings Mountain State Park (9.6 square miles) and the Kings Mountain National Military Park (6.0 square miles).

The Santee-Piedmont Ecobasin contains several areas of conservation priority (Smith et al. 2000). Conservation targets that contain rare, threatened and endemic species include: the Saluda River headwaters, which encompass the North Saluda River, South Saluda River and Oolenoy River watersheds located in the inner piedmont of Greenville and Pickens Counties; the Clouds Creek watershed in the Slate Belt ecoregion in Saluda County; the mainstem of the Broad River from the North Carolina line to Parr Shoals Reservoir in South Carolina; the Kings Creek watershed and the Clarks Fork system in the Bullocks Creek watershed located primarily in the Kings Mountain ecoregion in Cherokee and York Counties; the Sixmile Creek and Waxhaw Creek systems in the Twelvemile Creek watershed in Lancaster County; the Gills Creek system in the Camp Creek watershed in Lancaster County; and the Wateree Creek watershed in Richland County. The Saluda River headwaters contain populations of at least 13 priority fish species including redeye bass, turquoise darter and fantail darter. The Clouds Creek watershed contains populations of at least five priority fish species including the Saluda darter as well as at least one priority mussel species (Savannah lilliput). The mainstem of the Broad River contains at least 17 priority fish species including several catostomids (notchlip redhorse, V-lip redhorse, quillback and highfin carpsucker) and percids (seagreen darter, fantail darter and Piedmont darter). The Kings Creek watershed and Clarks Fork system contain at least nine priority fish species including the fantail darter, the seagreen darter and the piedmont darter. The Sixmile Creek and Waxhaw Creek systems contain several priority mussel species including the notched rainbow, Carolina creekshell and the federally endangered Carolina heelsplitter. The Gills Creek system also contains Carolina creekshell and Carolina heelsplitter. The Wateree Creek watershed contains several priority fish species including the Carolina darter, the Piedmont darter and the seagreen darter.

Pee Dee-Piedmont Ecobasin

The South Carolina piedmont portion of the Pee Dee drainage originates just across the state line in North Carolina. The Pee Dee–Piedmont Ecobasin is the second smallest ecobasin in the state, encompassing only 276 square miles. Tributaries to the Pee Dee River included in the ecobasin are Lynches River and Thompson Creek. There are approximately 468 miles of stream habitat within the ecobasin and only 337 acres of impounded water. The only two protected areas are Forty Acre Rock Heritage Preserve (1,584 acres) and the Hanging Rock Battleground property (251 acres).

The majority of the ecobasin is a primary conservation target, including the Lynches River, Flat Creek and Little Lynches River systems in the upper Lynches River basin located in Lancaster and Chesterfield Counties as well as the Thompson Creek system in the upper Pee Dee basin in Chesterfield County. Several priority fish species occur in the upper Lynches River basin, including the “thinlip” chub, Sandhills chub, and “broadtail” madtom. In addition to those fish species several priority mussel species populate the basin including, the brook floater, creeper, notched rainbow and federally endangered Carolina heelsplitter. The Thompson Creek system contains several priority fish species (“thinlip” chub, Sandhills chub, fantail darter and Piedmont

darther) as well as several species whose populations in South Carolina are entirely restricted to that system, including the satinfin shiner, redlip shiner and comely shiner.

General Condition

As of 1990, forests and farms dominated the land cover in the Piedmont Ecoregion. However, the vast majority of piedmont forests were cleared at some point during the last two centuries to develop crop and pasture lands. Most piedmont streams are now heavily silted due to the agricultural development of the piedmont's modest slopes and highly erodible soils.

	Agriculture	Barren	Developed	Forest	Forested Wetland	Scrub	Water	Protected
Savannah	477.76 16.59%	24.33 0.85%	112.52 3.91%	1,693.92 58.83%	1.30 0.05%	421.86 14.65%	147.43 5.12%	8.31%
Santee	1,060.22 13.92%	39.25 0.52%	543.93 7.14%	5,133.38 67.41%	6.00 0.08%	641.15 8.42%	191.19 2.51%	3.91%
Pee Dee	69.77 25.30%	2.12 0.77%	2.40 0.87%	184.05 66.73%	1.64 0.59%	15.05 5.46%	0.77 0.28%	1.1%
Total area	1,607.75 14.93%	65.70 0.61%	658.85 6.12%	7,011.35 65.10%	8.94 0.08%	1,078.06 10.01%	339.39 3.15%	5.01%

Savannah-Piedmont Ecobasin

Water quality in this ecobasin was designated as impaired at 65 of 138 sites (47 percent) sampled by SCDHEC (SCDHEC 2003). Recreational uses were not supported at 30 sites due to the presence of fecal coliform bacteria. Aquatic life uses were not supported at 28 sites due to copper contamination, paucity of aquatic fauna, low dissolved oxygen concentrations or abnormal pH values. Fish consumption advisories have been listed for seven sites including, Lake Hartwell, Lake Jocassee, Lake Russell and the Chauga River (SCDHEC 2003). Fish consumption advisories are due to mercury and PCB contamination.

Santee-Piedmont Ecobasin

Water quality was impaired at 279 of 468 locations (59 percent) sampled by SCDHEC (SCDHEC 1998; SCDHEC 1999; SCDHEC 2001). Recreational uses were not supported at 151 sites due to the presence of high concentrations of fecal coliform bacteria. Aquatic life uses were not supported at 125 sites primarily due to lack of invertebrate fauna, low pH, low dissolved oxygen concentrations or copper contamination. Fish consumption advisories due to mercury contamination have been issued for the Wateree River below Wateree Dam to its confluence with the Congaree River and the Saluda River from Pelzer to the Congaree River in Columbia. Very few river miles (approximately 11) have been designated as Outstanding Resource Waters by SCDHEC.

Pee Dee-Piedmont ecobasin

Water quality was impaired at 15 of 25 sites (60 percent) sampled by the South Carolina Department of Health and Environmental Control (SCDHEC 2000), representing one of the highest ratios of impairment within the state. Recreational uses were not supported at six sites due to the presence of high concentrations of fecal coliform bacteria. Aquatic life uses were not

supported at nine additional sites due to lack of aquatic invertebrate diversity, low dissolved oxygen, copper contamination or high turbidity (SCDHEC 2000).

Major Classifications

Wadeable Streams

Wadeable streams are the dominant habitat in the piedmont and are defined as those with Strahler stream orders of 0 to 3; they are generally streams that can be waded comfortably throughout most of the year. Wadeable streams in the piedmont possess different characteristics based chiefly on their gradient. Streams in the inner piedmont (just below the Blue Ridge) typically have moderate gradients with clear to moderately turbid water. Substrates in those streams are generally sand, gravel and cobble, with boulders and exposed bedrock occurring less frequently. These streams contain a variety of habitats including frequent long stretches of riffles and runs separated by short sections of pools and glides. As one moves south and east through the outer piedmont toward the fall line, wadeable streams have less gradient; runs and riffles become less frequent and shorter in length, while slow flowing pools comprise the majority of habitat. Outer piedmont streams are generally turbid, carrying a heavy sediment load from both historic and current conversion of forested land to agriculture and silviculture. These streams have substrates of mostly sand, silt, clay and detritus.

Navigable Streams

Navigable streams are common in the Piedmont ecoregion and include large rivers like the Savannah River, Saluda River, Broad River and Catawba River, as well as smaller rivers like the Reedy River, Enoree River and Fishing Creek. These streams are generally defined as being large enough to operate watercraft, if only a canoe, and are generally too deep to be waded throughout most of the year. These larger streams are more productive than their smaller counterparts and typically carry a heavy sediment burden. Substrates are typically sand, clay, and detritus, although the high gradient areas produce shoals and riffles that contain gravel, cobble and, occasionally, exposed bedrock and boulders. All of the large rivers (Savannah, Saluda, Broad and Catawba) and many of the smaller rivers (Reedy, Enoree and Tyger) have been impounded somewhere along their course. These impoundments have forever altered the natural hydrographs of these rivers and the habitats they contain.

Priority Species Associations

The Piedmont Ecoregion is home to 79 aquatic priority species including 42 fish, 22 mussels, 14 crayfish and one snail. Of those species, 25 have been identified as being of the highest conservation concern.

Common Name	Scientific Name	Piedmont Ecobasin		
		Savannah	Santee	Pee Dee
Highest Priority				
Fishes				
“Thinlip” chub	<i>Cyprinella spp. (c.f. zanema)</i>			X
Sandhills chub	<i>Semotilus lumbee</i>		X	X
Highfin carpsucker	<i>Carpionodes sp.</i>		X	X
Redeye bass	<i>Micropterus coosae</i>	X	X	
“broadtail” madtom	<i>Noturus spp. (c.f. insignis)</i>			X

Common Name	Scientific Name	Piedmont Ecobasin		
		Savannah	Santee	Pee Dee
Fishes Continued				
Savannah darter	<i>Etheostoma fricksium</i>	X		
Christmas darter	<i>Etheostoma hopkinsi</i>	X		
Saluda darter	<i>Etheostoma saludae</i>		X	
Mussels				
Carolina heelsplitter	<i>Lasmigona decorata</i>	X	X	X
Creeper	<i>Strophitus undulatus</i>	X	X	X
Yellow lampmussel	<i>Lampsilis cariosa</i>	X	X	
Brother spike	<i>Elliptio fraterna</i>	X		
Triangle floater	<i>Alasmidonta undulata</i>	X		
Brook floater	<i>Alasmidonta varicosa</i>	X		X
Notched rainbow	<i>Villosa constricta</i>		X	X
Carolina creekshell	<i>Villosa vaughniana</i>		X	
Southern rainbow	<i>Villosa vibex</i>	X		
Savannah lilliput	<i>Toxolasma pullus</i>		X	
Crayfish				
A crayfish	<i>Cambarus</i> sp. “B”	X		
Red burrowing crayfish	<i>Cambarus carolinus</i> ^b		X	
Mimic crayfish	<i>Distocambarus carlsoni</i> ^b		X	
A crayfish	<i>Distocambarus hunteri</i> ^b		X	
A crayfish	<i>Distocambarus youngineri</i> ^b		X	
Oconee stream crayfish	<i>Cambarus chaugaensis</i> *		X	
Snails				
Savannah pebblesnail	<i>Somatogyrus tenax</i> or <i>S. virginicus</i> ^a	X	X	
High Priority				
Fishes				
Santee chub	<i>Hybopsis zanema</i>		X	
Greenhead shiner	<i>Notropis chlorocephalus</i>		X	X
Quillback	<i>Carpionodes cyprinus</i>	X	X	
“Smoky sculpin”	<i>Cottus bairdii complex</i>	X		
Blackbanded sunfish	<i>Enneacanthus chaetodon</i>			X
Carolina darter	<i>Etheostoma collis</i>		X	
Fantail darter	<i>Etheostoma flabellare</i>		X	X
Turquoise darter	<i>Etheostoma inscriptum</i>	X	X	
Seagreen darter	<i>Etheostoma thalassinum</i>		X	
Piedmont darter	<i>Percina crassa</i>		X	X
Mussels				
Roanoke slabshell	<i>Elliptio roanokensis</i>		X	
Rayed pink fatmucket/ Eastern lampmussel ^c	<i>Lampsilis splendida/radiata</i>		X	
Eastern pond mussel	<i>Ligumia nasuta</i>		X	
Pod lance	<i>Elliptio folliculata</i>		X	

Common Name	Scientific Name	Piedmont Ecobasin		
		Savannah	Santee	Pee Dee
Crayfish				
A crayfish	<i>Distocambarus crockeri</i>		X	
Broad River spiny crayfish	<i>Cambarus spicatus</i>		X	
Moderate Priority				
Fishes				
Central stoneroller	<i>Campostoma anomalum</i>	X	X	
Satinfin shiner	<i>Cyprinella analostana</i>			X
Greenfin shiner	<i>Cyprinella chloristia</i>		X	X
Whitetail shiner	<i>Cyprinella galactura</i>	X		
Fieryblack shiner	<i>Cyprinella pyrrhomelas</i>		X	X
Highback chub	<i>Hybopsis hypsinotus</i>		X	X
Thicklip chub	<i>Hybopsis labrosa</i>		X	
Rosyface chub	<i>Hybopsis rubrifrons</i>	X	X	
Warpaint shiner	<i>Luxilus coccogenis</i>	X		
River chub	<i>Nocomis micropogon</i>	X		
Comely shiner	<i>Notropis amoenus</i>			X
Whitemouth shiner	<i>Notropis alborus</i>			X
Redlip shiner	<i>Notropis chiliticus</i>			X
Sailfin shiner	<i>Notropis hypselopterus</i>	X	X	
Tennessee shiner	<i>Notropis leuciodus</i>	X		
Mirror shiner	<i>Notropis spectrunculus</i>	X		
Blacknose dace	<i>Rhynchichthys atratulus</i>	X	X	
Notchlip redhorse	<i>Moxostoma collapsum</i>	X	X	X
V-lip redhorse	<i>Moxostoma pappillosum</i>		X	
Snail bullhead	<i>Ameiurus brunneus</i>	X	X	X
White catfish	<i>Ameiurus catus</i>	X	X	X
Flat bullhead	<i>Ameiurus platycephalus</i>	X	X	X
Brook trout	<i>Salvelinus fontinalis</i>	X	X	
Banded darter	<i>Etheostoma zonale</i>	X		
Mussels				
Carolina lance	<i>Elliptio angustata</i>		X	X
Eastern elliptio	<i>Elliptio complanata</i> complex	X	X	X
Variable spike	<i>Elliptio icterina</i> complex	X	X	
Carolina slabshell*	<i>Elliptio congarea</i>	X	X	
Pod lance*	<i>Elliptio folliculata</i>	X		
Atlantic spike	<i>Elliptio producta</i>	X		
Eastern creekshell	<i>Villosa delumbis</i>	X	X	X
Crayfish				
Ditch fencing crayfish	<i>Faxonella clypeata</i>	X		
Pee Dee Crayfish	<i>Procambarus blaningii</i> ^a			
A crayfish	<i>Procambarus pubescens</i>	X		
Rocky river crayfish	<i>Cambarus hobbsorum</i>		X	
Ditch fencing crayfish	<i>Faxonella clypeata</i>		X	

* needs confirmation

^b Primary burrowing crayfish, which spend most of their lives in burrows beneath the ground. They are included here, because they may depend upon soils with a high water table, and hydrologic modifications may affect their survival. However, very little is known about the habitat requirements of these species.

^a Identity uncertain

^c taxonomic uncertainty in distinguishing species.

Region-wide Challenges

Challenges to conservation of aquatic fauna in these two ecobasins are similar to other ecobasins in the state and primarily include impacts associated with impoundments, nonpoint source pollution, point source pollution, poorly planned development and introductions of non-native species.

Impacts from hydropower development have substantially altered and degraded a significant portion of habitat for most native aquatic species. Nearly 970 miles of streams within the ecoregion have been impounded. Roughly 57 dams have been constructed on navigable streams during the last two centuries and more than 900 smaller impoundments, including farm ponds, pepper the landscape, disrupting and fragmenting smaller streams. Dams result in a loss of connectivity and negatively affect aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004) through direct loss of habitat as lotic habitat is converted to lentic habitat, which favors competitive and often predacious species including largemouth bass and other centrarchids. In addition to direct loss of habitat, impoundments often impact the unimpounded stream reaches downstream through altered hydrologic and thermal regimes (Cushman 1985), modified stream channel morphology and increased erosion and sedimentation (Watters 1996); all of which ultimately reduce suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Impoundments on the Savannah River, Saluda River, Broad River and Catawba-Wateree River have disrupted the historic migrations of anadromous species (American shad and striped bass) that once represented culturally and economically important fisheries. Fish passage is also critical in allowing the dispersal of mussels, since larval mussels are parasitic on the gills of host fishes and are dispersed by the fish prior to settlement.

Although a large portion of the ecoregion is currently forested, most of the forests were cleared at some point during the last two centuries to develop crop and pasture lands. Forest and tilling of the Piedmont's highly erodible soils has resulted in streams that are still heavily silted. Modern soil conservation practices have reduced those impacts, but sedimentation from nonpoint and point sources remains a significant detriment to piedmont streams today. Farmers that have neglected to implement soil conservation practices further compound sedimentation problems in piedmont streams. Ground disturbance from development activities, agriculture and silviculture are primary sources of erosion that lead to sedimentation in piedmont streams. Corporate and private timber managers that fail to follow best management practices (BMPs) further contribute significant siltation and other nonpoint source pollution within the ecoregion. Streambank erosion due to loss of riparian areas, livestock grazing and altered hydrology also contribute to sedimentation in piedmont streams.

Excessive nutrients and other chemical contamination also negatively affect water quality in the ecoregion. Point source discharges from industrial, municipal and community sources add nutrients and other pollutants to the receiving streams, rivers and lakes. In addition to those

sources of pollution, agricultural operations also impact water quality. Nationwide, pollution from agricultural sources is the greatest impairment to streams and lakes (SCDHEC 2003). The piedmont has the highest density of permitted discharges within the state and the second highest density of concentrated animal feeding operations (CAFOs) with nearly five agricultural operations per 100 square miles. Water quality in the piedmont was impaired at 57 percent of the sites sampled by the SCDHEC, which is the second highest impairment rate among the four aquatic ecoregions in the state. Recreational uses were impaired at nearly 30 percent of the sites sampled due to the presence of high concentrations of fecal coliform bacteria. Fecal coliform bacteria are present in the digestive tract of warm-blooded animals; although fecal coliform bacteria are not generally harmful to humans they do indicate that surface waters may contain disease-causing pathogens (SCDHEC). More than one quarter of the streams sampled by SCDHEC within the ecoregion did not support aquatic life uses. Those stream sites do not possess sufficient water quality to maintain a balanced aquatic community of plants and animals.

Introductions of non-native fish species may threaten native aquatic fauna in the piedmont. Smallmouth bass, spotted bass, muskellunge, flathead catfish and blue catfish are established in portions of the ecoregion. The effects of these introduced species on native game and nongame species is not currently well known. Flathead catfish introductions into the Savannah River, Saluda River and Catawba River basins as well as blue catfish introductions into the Savannah River, Broad River and Catawba River basins likely pose the greatest risks to native fauna. Flathead catfish have been shown to prey on bullheads, darters, shad, suckers and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of flathead catfish (Guire et al. 1984; Jenkins and Burkhead 1994; Bart et al. 1994). The introduced spotted bass and smallmouth bass in the Savannah River and its tributaries threaten the native redeye bass through competition and hybridization.

Introduction of nonnative invertebrates also pose a threat to the native fauna. The Asian clam, *Corbicula fluminea*, has been introduced and has spread throughout the United States, including South Carolina. The effects of *Corbicula* on native species are not well understood. A review of the literature on the interactions between *Corbicula* and native mussels (Dillon 2000) indicated that most field studies failed to find any significant negative effects on native species, although a few detected reductions in growth of mussels. The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the coastal plain, but has yet to be identified in the piedmont; however, there have been very few crayfish inventories conducted, none of which have been initiated on a statewide basis. In North Carolina, the red swamp crayfish has become established in all drainages of the coastal plain and eastern piedmont plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are believed to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b), and the risk to our native species is great if further introductions or if extensive spread of nonnative crayfish occurs.

Rapid development in the piedmont, especially in the upstate, has included substantial highway construction. The requirement for sand in road construction has resulted in sand mining operations in the mainstem or riparian areas of many piedmont rivers and streams. Sand mining not only causes bank stability problems and loss of riparian areas at the mining site, but instream impacts as well. Mining operations affect physical and chemical habitat and can negatively affect biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate

type and stability and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by decreasing reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and distribution and composition of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Savannah–Piedmont Ecobasin

Approximately 457 miles of streams within the Savannah-Piedmont Ecobasin have been impounded. Seven dams have been erected on navigable streams to form large impoundments and 210 smaller dams have impounded smaller streams (small reservoirs and farm ponds). Approximately 110 miles of the 131 miles of the Savannah River that occur within the ecobasin have been impounded by mainstem reservoirs including Lake Hartwell, Lake Russell and Thurmond Reservoir. The Stevens Creek hydroelectric dam on the Savannah River represents an impediment to diadromous fish movement within the basin. Notable species affected include striped bass, American shad, blueback herring and American eels. Passage is needed to accommodate both upstream migration of adults and outmigration of adult and juvenile fishes. Priority mussel species will also benefit from fish passage, as fish are a dispersal mechanism for mussels.

Excessive inputs of nutrients and other chemicals also degrade water quality. There are 128 active discharges permitted by SCDHEC within the ecobasin (SCDHEC 2003). Of those, the majority (70 discharges) are industrial, while the remainder are from municipal (31 discharges) and community sources (27 discharges). CAFOs also add nonpoint source pollution. There are 120 agricultural facilities permitted by SCDHEC within the ecobasin, the majority of which are poultry operations (eight small farms, 54 medium farms, and 27 large farms). The remaining facilities include dairy farms (16 small and one medium operation), and eight small swine farms. On a statewide basis the amount of agricultural activity within the ecobasin is moderate (just over four agricultural operations per 100 square miles) which probably doesn't significantly threaten water quality throughout the ecobasin. However, within the Tugaloo River/Lake Hartwell watershed there are many agricultural facilities (55, or approximately 41 per 100 square miles). These are primarily poultry operations that may significantly impact water quality within the watershed. Other agricultural operations such as row crops (corn and wheat) and pastureland also contribute to nonpoint source pollution of sediments and nutrients.

Poorly planned industrial, residential and commercial development has resulted in significant negative impacts to aquatic resources within the ecobasin. Overall, a moderate amount of industrial, residential and commercial growth can be expected for the ecobasin (SCDHEC 2003). Moderate to high levels of growth are expected in the upper third of the ecobasin along the I-85 corridor. Areas likely to experience high growth include Clemson, Easley and Anderson. Growth in the lower portion of the ecobasin will be slower because the Sumter National Forest encompasses much of the land, limiting development opportunities.

The Stevens Creek watershed in Edgefield, McCormick and Greenwood Counties is known to be a unique aquatic resource. Priority fish species such as the Christmas darter and imperiled mussels such as the Carolina heelsplitter reside in streams of this watershed. Tributaries such as Hard Labor Creek drain the region around metropolitan Greenwood, South Carolina. This is an area of rapid urban growth and increased human population. Impacts to the watershed from point and nonpoint sources can have a degrading effect on the aquatic community downstream.

Santee–Piedmont Ecobasin

Nearly 500 miles of streams within this ecobasin have been impounded. Roughly 50 dams have been constructed on navigable streams during the last two centuries and nearly 700 smaller impoundments (small reservoirs and farm ponds) pepper the landscape, disrupting and fragmenting smaller streams. The Lake Murray Dam, which impounds the Saluda River to form Lake Murray has degraded aquatic habitat in the Saluda River below the dam.

Excessive nutrient and other chemical inputs also degrade water quality within the ecobasin. There are 454 point source contributors permitted by SCDHEC within the ecobasin (SCDHEC 1998; SCDHEC 1999; SCDHEC 2001). Of those, 261 are associated with industry, 119 are associated with municipalities and the remainder are associated with community discharges. Saluda River studies conducted by Hayes and Penny (2002) implicated the Ware Shoals Waste Treatment Plant (WTP) as having a depressing effect on the downstream fish community. The study indicated that species richness and abundance were reduced in the stretch of river between Ware Shoals and Lake Greenwood. CAFOs are abundant in the ecobasin as well, with 245 facilities permitted by SCDHEC (SCDHEC 1998; SCDHEC 1999; SCDHEC 2001). Agricultural facilities throughout the ecobasin are relatively sparse in most areas and on a statewide basis there is only a moderate amount of agricultural activity with approximately three facilities per 100 square miles. However, in the upper Lake Murray area, including the Clouds Creek, Little Saluda River and Bush River watersheds, there is significant agricultural activity (86 sites) with nearly 14 agricultural facilities per 100 square miles.

The Saluda River basin drains much of the Greenville-Spartanburg metropolitan area. The rapidly increasing population and accompanying development have led to significant urban sprawl and resulted in associated aquatic impacts such as stormwater runoff, nonpoint source chemical inputs and stream channel alterations. Although improvements in municipal waste treatment have occurred in this area, point source pollutants add unnatural coloration and increase nutrient levels that sometime lead to noxious algal blooms downstream in Lake Greenwood (SCDNR, unpublished data).

The I-85 corridor from Anderson, South Carolina to Charlotte, North Carolina is one of the most rapidly developing areas of the state. Impacts of road construction, residential and commercial development and general urban sprawl have been felt in most of the major river systems (Saluda, Reed, Pacolet, Enoree, Tyger and Broad Rivers) in this area. Water quality degradation and stream channel alteration are probably the most obvious impacts to these aquatic systems.

Pee Dee–Piedmont Ecobasin

Impoundments do not currently pose a great threat to aquatic fauna in the Pee Dee-Piedmont ecobasin. There are only 15 dams permitted by SCDHEC within the ecobasin and only six miles of impounded streams, none of which are navigable.

As with most ecobasins, especially in the Piedmont Ecoregion, erosion and sedimentation have substantially degraded aquatic habitat. Ground disturbance from development activities, agriculture and silviculture are primary sources of erosion that lead to sedimentation in piedmont streams. In the Pee Dee-Piedmont ecobasin more than 25 percent of the land within the ecobasin is agricultural, which may contribute significantly to stream sedimentation.

Excessive nutrient and other chemical inputs may degrade water quality within the ecobasin. There are nine active point source discharges permitted by SCDHEC (2000) within the ecoregion

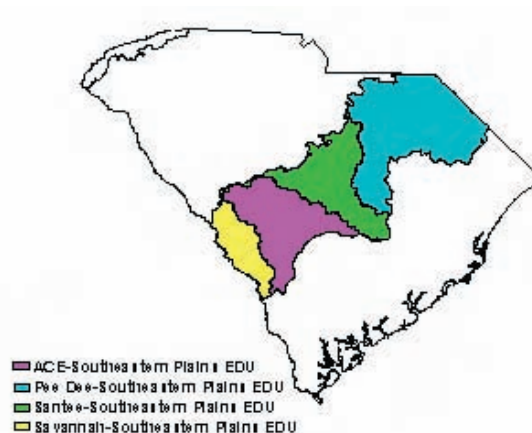
including, two industrial and four municipal (e.g. waste water treatment plant) discharges. With 35 CAFOs, the ecobasin has the highest density of CAFOs in the state, nearly 13 per 100 square miles. Most of the CAFOs are turkey (22) and poultry (12) farms. In addition to the CAFOs, other agricultural operations (row crops and pastureland) may significantly impact water quality within the ecobasin.

There is low to moderate potential for growth within the ecobasin (SCDHEC 2000). The greatest potential for development occurs in the northwestern portion of the ecobasin, which is part of the Charlotte Metroplex. Future development will pose new threats to aquatic habitats and biota, particularly if those developments are not carefully planned.

Southeastern Plains Ecoregion Aquatic Habitats

Description and Location

The Southeastern Plains Ecoregion is sandwiched between the piedmont to the north and the coastal plain to the south. It extends northwest from the Savannah River to the Pee Dee River. The southeastern plains encompass portions of 24 counties and 9,106 square miles. Just below the fall line, the ecoregion is dominated by sandy soils with scrub vegetation on moderate sloping lands. This area is known as the sandhills and varies in elevation from 250 to 450 feet above mean sea level. Moving toward the coast, the topography is reduced to gentle sloping to nearly level lands with elevations of 25 to 450 feet.



Savannah–Southeastern Plains Ecobasin

The Savannah–Southeastern Plains Ecobasin extends from the southern portions of Edgefield County south to the southern portion of Allendale County. It includes about 85 miles of the Savannah River as it meanders toward the coastal plain and ultimately the Atlantic Ocean. Major South Carolina tributaries to the Savannah River in the ecobasin include Horse Creek, Hollow Creek, Upper Three Runs Creek and Lower Three Runs Creek. The ecobasin encompasses most of six watersheds and parts of ten others in its 980 square miles. A large portion (31 percent) of the ecobasin is protected by federal, private and state entities. Most of this protected land (303 square miles) is included in the Savannah River Site. Other significant protected areas include the Hitchcock Woods Conservation Easement (1,955 acres), the Henderson Heritage Preserve (441 acres) and the Redcliffe State Historic Site (340 acres). Two other Heritage Preserves (Bear Branch and Gopher Branch) encompass 186 acres. The ecobasin contains 979 miles of lotic habitat and 6,425 acres of lentic habitat, primarily impoundments. A small portion of the lentic habitat is comprised of Carolina bays. The largest impoundment in the ecobasin is Par Pond (2,953 acres) on the Savannah River Site property. The next largest reservoir is Langley Pond (301 acres) near Langley, South Carolina. Other impoundments in the ecobasin are less than 150 acres.

Primary conservation targets in the ecobasin include the mainstem Savannah River in Aiken and Allendale Counties, Upper Three Runs Creek and its tributaries in Aiken and Barnwell Counties, and Brier Creek system in Allendale County (Smith et al. 2000). The mainstem of the Savannah River within the ecobasin contains several aquatic animals on South Carolina's Priority Species List including shortnose sturgeon and robust redhorse, as well as several mussel species (pod lance and Savannah lilliput). Priority fish species in Upper Three Runs Creek and its tributaries include the Savannah darter and turquoise darter. The Savannah darter and bluebarred pygmy sunfish inhabit the Brier Creek system.

ACE–Southeastern Plains Ecobasin

The ACE–Southeastern Plains Ecobasin is the only ecobasin in the state to originate entirely in the Southeastern Plains Ecoregion. The headwaters of the North and South Forks of the Edisto River originate in the extreme southern portion of Edgefield and Lexington Counties. The headwaters of the Salkehatchie River originate in Barnwell County. Major tributaries to the North Fork Edisto River in the ecobasin include Black Creek, Bull Swamp Creek and Caw Caw Swamp. Major tributaries to the South Fork Edisto River include Shaw Creek, Dean Swamp Creek, Little River and Roberts Swamp. The ecobasin includes portions of 27 watersheds and covers 2,219 square miles. Very little (0.7 percent) of the land is protected by federal, state and private entities. The largest area of protected land (3,455 acres) occurs on the Savannah River Site. Other significant protected areas include Clemson University's Edisto Research and Education Facility (2,300 acres), the Aiken Gopher Tortoise Heritage Preserve (1,391 acres) and the Aiken State Natural Area (1,153 acres). The ecobasin contains approximately 2,117 miles of lotic habitat and 9,047 acres of lentic habitats. There are no major reservoirs within in the ecobasin and largest lentic areas (more than 75 acres) are primarily Carolina bays.

Primary conservation targets in the ecobasin include the upper portion of the South Fork Edisto River in Aiken, Barnwell and Orangeburg Counties, the mainstem of the lower North Fork Edisto River in Orangeburg County and Black Creek, a tributary to the North Fork Edisto River in Lexington County (Smith et al. 2000). Priority fish species in the upper South Fork Edisto River include the "broadtail" madtom, Savannah darter, turquoise darter and blackbanded sunfish. The lower North Fork Edisto River and its tributaries provide habitat for the "broadtail" madtom, bluebarred pygmy sunfish and Savannah darter as well as the federally endangered shortnose sturgeon.

Santee–Southeastern Plains Ecobasin

The upper extent of the Santee–Southeastern Plains Ecobasin is the fall line, which runs through central Lexington, Richland and Kershaw Counties. The ecobasin extends southeasterly to the upper portion of Berkeley County and includes three major rivers. The Congaree and Wateree merge to form the Santee River southeast of Columbia. Major tributaries to the Congaree River include Congaree Creek, Gills Creek and Cedar Creek. Major tributaries to the Wateree River include Five and Twenty Mile Creek, Big Pine Tree Creek, Colonel's Creek and Beech Creek. The ecobasin contains all of 17 watersheds and portions of 30 others, and covers 2,064 square miles. Approximately 162 square miles of land within the ecobasin are protected by federal and state entities. The largest protected areas include Fort Jackson (82 square miles), Congaree Swamp National Park (23 square miles) and Santee National Wildlife Refuge (20 square miles). Other significant protected areas include Manchester State Forest (8 square miles) and Santee State Park (4 square miles). The ecobasin contains approximately 2,230 miles of lotic habitat

and 146 square miles of lentic habitat, most of which is contained in Lake Marion (136 square miles). Big Pine Tree Creek near Camden South Carolina is a primary conservation target in the ecobasin as it holds one of very few known Carolina pygmy sunfish populations.

Pee Dee–Southeastern Plains Ecobasin

The Pee Dee-Southeastern Plains Ecobasin is located in the northeast corner of the state, originating in Chesterfield, Marlboro, and Dillon Counties and flowing through parts or all of Kershaw, Darlington, Florence, Lee, Marion, Sumter and Clarendon Counties. The ecobasin contains three major rivers including the Lynches, Pee Dee and Little Pee Dee as well as the headwaters of the Black River. The Lynches River originates just north of South Carolina in the piedmont of North Carolina. It flows about 21 miles through the South Carolina piedmont before entering the Pee Dee-Southeastern Plains Ecobasin, then flows another 71 miles until it enters the coastal plain, picking up inputs from two major tributaries, Buffalo Creek and the Little Lynches River, along the way. The Pee Dee River originates in the southern portion of the North Carolina piedmont and southeastern plains. Within the Pee Dee-Southeastern Plains Ecobasin, the Pee Dee River flows about 92 miles before entering the coastal plain. Major tributaries to the Pee Dee River include Thompson Creek, Crooked Creek, Black Creek and Jefferies Creek. The Little Pee Dee River originates in the southeastern plains of North Carolina and flows approximately 74 miles through the Pee Dee-Southeastern Plains Ecobasin before entering the coastal plain of South Carolina. The primary tributary is Buck Swamp. Pocatigo River and Black River Swamp are the main tributaries of the Black River. Both originate within the ecobasin and flow southeast before entering the coastal plain and merging to form the Black River. The ecobasin contains all of 11 watersheds and parts of 46 others, and covers 3,830 square miles. There are approximately 194 square miles of land within the ecobasin protected by federal, state and private entities. The South Carolina Forestry Commission manages the largest amount of protected land (about 78 square miles) within the ecobasin, including Sandhills State Forest (73 square miles) and Manchester State Forest (5 square miles). The next largest protected area includes nearly 70 square miles of Carolina Sandhills National Wildlife Refuge. Other significant protected areas include Cheraw State Recreation Area (12 square miles), Great Pee Dee Heritage Preserve (4.5 square miles) and Lee State Natural Area (4.4 square miles). There are about 4,591 miles of lotic habitat and 37 square miles of lentic habitat. There are no major reservoirs within the ecobasin. The largest lentic areas are Big Bay (2,476 acres), a Carolina bay, and Lake Robinson (2,058 acres), an impoundment on Black Creek.

Areas of primary conservation concern include the upper Lynches River and its sandhills tributaries in Chesterfield, Kershaw, Lee and Darlington Counties; upper Pee Dee River between Marlboro and Chesterfield Counties; and sandhills tributaries to the Little Pee Dee River along the border of South Carolina and North Carolina in Marlboro and Dillon Counties (Smith et al. 2000). The upper Lynches River is home to several aquatic priority species including fish (sandhills chub, “thinlip” chub and “broadtail” madtom) and mussels (brook floater, creeper, notched rainbow and the federally endangered Carolina heelsplitter). The mainstem of the upper Pee Dee River contains several fish (“Carolina” redhorse, robust redhorse and the federally endangered shortnose sturgeon) and mussel (yellow lampmussel and Roanoke slabshell) priority species. Sandhills tributaries to the Little Pee Dee River contain sandhills chub and once harbored populations of pinewoods darter that may now be extirpated from the state.

General Condition

Savannah–Southeastern Plains Ecobasin

Water quality was impaired at 17 of 40 sites (43 percent) sampled by the South Carolina Department of Health and Environmental Control (SCDHEC 2003). Aquatic life uses were not supported at two sites due to a lack of invertebrate diversity or abnormal pH. Recreational uses were not supported at eight sites due to the presence of high fecal coliform bacteria concentration. Fish consumption advisories were listed for several areas due to mercury contamination, including Flat Rock Pond, Langley Pond, Vaucluse Pond and the Savannah River. No streams within the ecobasin are considered outstanding resource waters by SCDHEC.

ACE–Southeastern Plains Ecobasin

Water quality was impaired at 33 of 77 sites (33 percent) sampled by SCDHEC (SCDHEC 1998, SCDHEC 2003). Aquatic life uses were not supported at 13 sites due to lack of invertebrate diversity (seven sites), low dissolved oxygen concentrations (four sites) and abnormal pH values (two sites). Recreational uses were not supported at 15 sites due the presence of high fecal coliform bacteria concentrations. Fish consumption advisories were listed for the Salkehatchie River below US 301, South Fork Edisto River below Aiken State Park and the Orangeburg County portion of the North Fork Edisto River. No streams within the ecobasin are considered outstanding resource waters by the SCDHEC.

Santee–Southeastern Plains Ecobasin

Water quality was impaired at 50 of 127 sites (39 percent) sampled by SCDHEC (SCDHEC 1998; SCDHEC 1999^a; SCDHEC 1999^b). Aquatic life uses were not supported at 14 sites primarily due to a lack of invertebrate diversity (four sites) and low dissolved oxygen (five sites). One site was contaminated with tin. Recreational uses were not supported at 24 sites due the presence of high concentrations of fecal coliform bacteria. Fish consumptions advisories were listed for 12 sites, primarily due to the presence of mercury (11 sites). Fish consumption advisories have been listed for the Congaree River from Columbia to the Santee River, the Wateree River along its entire length within the ecobasin, Lake Marion, Cary's Lake, Windsor Lake and Sesquicentennial State Park.

Pee Dee–Southeastern Plains Ecobasin

Water quality was impaired at 57 of 134 sites (43 percent) sampled by SCDHEC (SCDHEC 2000). Aquatic life uses were not supported at 28 sites due to low dissolved oxygen concentrations (17 sites), copper contamination (four sites), abnormal pH values (four sites), and lack of invertebrate diversity (three sites). Recreational uses were not supported at 19 sites due to the presence of high concentrations of fecal coliform bacteria. Fish consumption advisories were listed for 10 sites due to mercury contamination including every major river within the ecobasin (Pocotaligo River, Lynches River, Great Pee Dee River and Little Pee Dee River) and two small impoundments: Louthers Lake and Lake Robinson.

Major Classifications

Wadeable Streams

Wadeable streams are the dominant aquatic habitat in the Southeastern Plains Ecoregion and provide most of the habitat for aquatic animals on South Carolina's Priority Species List. Wadeable streams those with Strahler stream orders of 0 to 3; generally, streams that can be

waded comfortably throughout most of the year. These streams are often bordered with pond-like backwaters and swamps. Wadeable streams in the southeastern plains are mostly low gradient, although some near the fall line have swifter flows. In moderate flowing areas, the substrate is chiefly clean shifting sand; with the absence of rocks in most streams, logs and debris jams provide habitat for aquatic fauna. In slow flowing areas, substrate is comprised of finer materials such as mud, clay, silt and fine detritus. Most southeastern plains streams that receive ample sunlight are well vegetated with aquatic macrophytes. The streams that flow through the ecoregion are often termed “blackwater” due to their tannin-stained waters.

Navigable Streams

Navigable streams are less common in the southeastern plains, but provide habitat for many priority species. These streams are generally defined as large enough to operate watercraft, if only a canoe and are usually too deep to be waded throughout most of the year. The Pee Dee River, Lynches River and Edisto River are examples of navigable streams in the southeastern plains. These lazy meandering streams have substrates of mostly shifting sand in the flowing areas while finer materials (silt, clay and detritus) are deposited in the pools. As with the smaller streams in the ecobasin the navigable streams are also “blackwater,” stained by the decomposition of organic materials.

Carolina Bays

The lower portion of the southeastern plains, known as the Atlantic Southern Loam Plains, contains the highest concentration of Carolina bays in the state. Carolina Bays are shallow elliptical depressions of unknown origin, many of which contain water throughout the year. The waters in Carolina bays are highly acidic, which limits the number of fish species. However, some sunfish and minnow species populate these depressions. Carolina bays may be important habitat for some rare crayfish species, as several have been observed in these formations. However, data on the crayfishes associated with Carolina bays is particularly lacking; more surveys are needed in order to determine the importance of these depressions as crayfish habitat.

Priority Species Associations

The Southeastern Plains Ecoregion contains the greatest number of imperiled fish species in the state. There are 32 priority fish species within the ecoregion including 11 of the highest conservation need; this represents 92 percent of the fish species of highest conservation need in South Carolina. There are 15 priority mussel species (or species complexes), 11 priority crayfish species, and 2 priority snail species in the ecoregion.

Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Highest Priority					
Fishes					
“Thinlip” chub	<i>Cyprinella sp. (c.f. zanema)</i>		X		
Bridle shiner	<i>Notropis bifrenatus</i>			X	
Sandhills chub	<i>Semotilus lumbee</i>		X	X	
Highfin carpsucker	<i>Carpionodes sp.</i>			X	X
Robust redborse	<i>Moxostoma robustum</i>		X		X
Carolina pygmy sunfish	<i>Elassoma boehlkei</i>		X	X	
Bluebarred pygmy sunfish	<i>Elassoma okatie</i>				X

Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Fishes Continued					
Savannah darter	<i>Etheostoma fricksium</i>	X			X
Christmas darter	<i>Etheostoma hopkinsi</i>				X
Saluda darter	<i>Etheostoma saludae</i>			X	
“Broadtail” madtom	<i>Noturus spp. (c.f. insignis)</i>	X	X		
Mussels					
Southern rainbow	<i>Villosa vibex</i>	X			
Yellow lampmussel	<i>Lampsilis cariosa</i>		X	X	X
Savannah lilliput	<i>Toxolasma pullus</i>			X	X
Brook floater	<i>Alasmidonta varicosa</i>		X		
Barrel floater	<i>Anodonta couperiana</i>	X	X		X
Crayfish					
A crayfish	<i>Procambarus echinatus</i>	X			
A crayfish	<i>Cambarus reflexus</i>				X
Snails					
Ridged lioplax	<i>Lioplax subcarinata</i>		X		
High Priority					
Fishes					
Bannerfin shiner	<i>Notropis leedsi</i>	X			X
Quillback	<i>Carpionodes cyprinus</i>			X	X
Blackbanded sunfish	<i>Enneacanthus chaetodon</i>	X	X	X	X
Turquoise darter	<i>Etheostoma inscriptum</i>	X			X
Pinewoods darter	<i>Etheostoma mariae</i>		X		
Seagreen darter	<i>Etheostoma thalassinum</i>			X	
Piedmont darter	<i>Percina crassa</i>		X	X	
Mussels					
Roanoke slabshell	<i>Elliptio roanokensis</i>		X	X	X
Rayed pink fatmucket/ Eastern lampmussel	<i>Lampsilis splendida/radiata</i>			X	X
Eastern pondmussel	<i>Ligumia nasuta</i>			X	
Crayfish					
Sandhills crayfish	<i>Procambarus pearsei</i>		X		
Pee Dee lotic crayfish	<i>Procambarus lepidodactylus</i>	X	X	X	
Snails					
Moderate Priority					
Fishes					
Satinfish shiner	<i>Cyprinella analostana</i>		X		
Greenfin shiner	<i>Cyprinella chloristia</i>		X	X	
Fieryblack shiner	<i>Cyprinella pyrrhomelas</i>		X	X	
Highback chub	<i>Hybopsis hypsinotus</i>		X	X	
Comely shiner	<i>Notropis amoenus</i>		X		

Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Fishes Contined					
Redlip shiner	<i>Notropis chiliticus</i>		X		
Lowland shiner	<i>Pteronotropis stonei</i>	X	X	X	X
Notchlip redhorse	<i>Moxostoma collapsum</i>		X	X	
Snail bullhead	<i>Ameiurus abrunneus</i>	X	X	X	X
White catfish	<i>Ameiurus catus</i>	X	X	X	X
Flat bullhead	<i>Ameiurus platycephalus</i>	X	X	X	X
Striped bass	<i>Morone saxatilis</i>		X	X	
Pugnose minnow	<i>Opsopoeodus emiliae</i>	X			X
Mud sunfish	<i>Acantharchus pomotis</i>	X	X	X	X
Mussels					
Carolina lance	<i>Elliptio angustata</i>	X	X	X	
Carolina slabshell	<i>Elliptio congarea</i>	X	X	X	X
Eastern elliptio	<i>Elliptio complanata</i> complex		X	X	
Variable spike	<i>Elliptio icterina</i> complex	X	X	X	
Pod lance	<i>Elliptio folliculata</i>		X		
Atlantic spike	<i>Elliptio producta</i>	X	X		
Eastern creekshell	<i>Villosa delumbis</i>	X	X		X
Crayfish					
Ditch fencing crayfish	<i>Faxonella clypeata</i>				
Edisto crayfish	<i>Procambarus ancylus</i>	X	X	X	
Santee crayfish	<i>Procambarus blandingii</i>		X	X	
A crayfish	<i>Procambarus chacei</i> *	X		X	X
A crayfish	<i>Procambarus enoplosternum</i> *			X	X
A crayfish	<i>Procambarus hirsutus</i> *		X	?	X
A crayfish	<i>Procambarus pubescens</i> *				X
*because of difficulty in obtaining information on these species, the level of priority is undetermined					
Snails					
A snail	<i>Physa</i> sp. "A"				X

Region-wide Challenges

Challenges to conservation of aquatic fauna in the Southeastern Plains Ecoregion are similar to other ecobasins in the state and primarily include impacts associated with impoundments, nonpoint source pollution, point source pollution, poorly planned development and introduction of non-native species.

There is only one major impoundment (Lake Marion) in the southeastern plains; however, dams still have a significant impact on aquatic resources within the ecoregion. With more than 1,000 dams impounding 550 miles of streams, there are more dams in the Southeastern Plains Ecoregion than any other; the density of dams within the ecoregion is second only to the Blue Ridge. Dams result in a loss of connectivity and negatively affect aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004). Impoundments affect native aquatic fauna through direct loss of habitat as lotic habitat

is converted to lentic habitat; the latter favors competitive and often predacious species like largemouth bass and other centrarchids. In addition, impoundments often negatively affect unimpounded downstream reaches by altering hydrologic and thermal regimes (Cushman 1985), modifying stream channel morphology, increasing erosion and sedimentation (Waters 1995) and ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Dams also prevent migrations of native anadromous fish (shad species, striped bass and sturgeon) to their historic spawning grounds.

Forest clearing, soil tilling and channelization in the vicinity of southeastern plains streams have resulted in streams that are heavily silted. Modern soil conservation practices and lower potential for channelization have reduced those impacts, but sedimentation from nonpoint and point sources remains a significant detriment to streams. Development activities, agriculture and silviculture are primary sources of erosion that lead to sedimentation in streams. Corporate and private timber managers that fail to follow best management practices (BMPs) contribute to siltation and other nonpoint source pollution within the ecoregion. Stream bank erosion due to loss of riparian areas, livestock grazing and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the southeastern plains were channelized to improve drainage of croplands. Channelized streams lead to increased erosion of cropland and increased sedimentation of the receiving streams (Etnier and Starnes 1993). The result of channelization was changing many streams into straight shallow ditches with severely depressed populations of aquatic fauna.

Excessive contamination by nutrients and other chemicals also negatively affect water quality within the ecoregion. Point source discharges from industrial, municipal and commercial sources add a variety of chemical pollutants to the receiving streams, rivers and lakes. In addition, nonpoint sources discharges from agricultural operations negatively affect water quality. Nationwide, pollution from agricultural sources is the greatest cause of impairment to streams and lakes (SCDHEC 2003). The southeastern plains has the second highest density of permitted discharges within the state and the highest density of Concentrated Animal Feeding Operations (CAFOs) with approximately 6.5 operations per 100 square miles.

Water quantity is also a problem in southeastern plain streams. Water withdrawal for irrigation is a common practice in the ecoregion. During summer months, some streams are completely dewatered due to uncontrolled irrigation of croplands. Furthermore, many pond-owners will close their drain structures during dry periods in an attempt to maintain esthetic water levels, thereby dewatering the stream below.

Introductions of non-native species have had a significant impact on native aquatic fauna in the Southeastern Plains Ecoregion. Buffalo (fish), common carp, flathead catfish and blue catfish are established in several drainages. Flathead catfish and blue catfish introductions probably pose the greatest direct risks to native fauna. Flathead catfish have been shown to prey on bullheads, darters, shad, suckers and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of flathead catfish (Guire et al. 1984; Jenkins and Burkhead 1994; Bart et al. 1994). It is not well known what effects buffalo have on the native community, but it has been suggested that they may be a factor in the decline of some catostomids in the Pee Dee River (Wayne Starnes, pers. comm.). Common carp occur in every South Carolina drainage and are considered a pest; however, their impact on native fauna is not well known. Common carp disrupt aquatic habitats by rooting around in the substrate where they uproot aquatic plants and increase turbidity and siltation. Common carp have also been shown to prey on the eggs of other fish species.

The Asian clam, *Corbicula fluminea*, has been introduced and has widely spread throughout the United States, including South Carolina. The effects of *Corbicula* on native species are not particularly well understood. According to a review of the literature on interactions between *Corbicula* and native mussels (Dillon 2000), most field studies failed to find any significant negative effects on native mussels, although a few detected reductions in growth. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica*) are present in Lakes Marion and Lake Moultrie but their impact on native fauna is not known.

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from one of the native species have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the coastal plain and eastern piedmont plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b); the risk to our native species is great if further introductions or extensive spread of the red swamp crayfish occur.

Sand mining operations have been initiated or are ongoing in the mainstem or riparian areas of many southeastern plains rivers. Instream sand mining is a significant threat to aquatic resources within the ecoregion. Sand mining not only causes bank stability problems and loss of riparian areas at the mining site; within the stream, this activity adversely affects physical and chemical habitat and can negatively affect biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate type and stability and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by decreasing reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and distribution, composition and reproduction of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Savannah–Southeastern Plains Ecobasin

Approximately 54 miles of streams have been impounded in the ecobasin. Nearly 90 dams are present in the ecobasin, ten of which impound navigable streams, forming small reservoirs. Most of the dams occur in the Horse Creek (34 dams) and Hollow Creek (26) watersheds.

There is comparatively little agricultural activity within the ecobasin, with only six active permitted agricultural operations. However, point source discharges are abundant. The ecobasin has the highest density of point source discharges in the state with more than six per 100 square miles. Most of those discharges (5.5 per 100 square miles) are from industrial sources, giving the ecobasin the highest density of industrial discharges in the state.

There is moderate growth potential in the ecobasin. Residential and commercial growth in the vicinity of North Augusta and Aiken is expected and will have negative affects on aquatic environments if those developments are not carefully planned.

ACE–Southeastern Plains Ecobasin

Three hundred and sixty-eight dams impound approximately 109 miles streams within the ecobasin, but none of them impound navigable streams.

On a statewide basis, the ecobasin contains a moderate number of point source discharges.

There are 57 active discharges permitted by SCDHEC within the ecobasin, 28 of which are from industrial sources, 19 from municipal sources and 10 from community sources. The ecobasin has the second highest density of agricultural operations in the state with nearly 11 operations per 100 square miles. There are 244 permitted active agricultural operations within the ecobasin, most of which are poultry farms (42 large, 129 medium, and 32 small). Other significant agricultural operations include swine farms (17), dairy farms (13) and peach orchards (6). The highest concentration of agricultural operations occurs in the upper portion of the North Fork Edisto River drainage, where 113 permitted farms are located in the Chinquapin Creek/

Lightwood Knot Creek and Black Creek watersheds.

Development throughout most of the ecobasin is not a major concern. There is low potential for growth in most areas. The Caw Caw Swamp watershed and North Fork Edisto River watershed may be negatively affected by development in the vicinity of Orangeburg. There is high potential for commercial development in the Shaw Creek watershed northeast of Aiken, near the intersection of I-20 and US 1.

Santee–Southeastern Plains Ecobasin

There are 235 miles of impounded streams in the ecobasin, most of which (148 miles) results from the impoundment of Santee River to form Lake Marion. There are 295 dams permitted by SCDHEC within the ecobasin. Hydroelectric peaking operations on rivers (Saluda, Broad and Wateree) located in the piedmont have had significant negative impacts on the integrity of the Congaree and Wateree rivers in the southeastern plains. Rapidly fluctuating flows associated with hydroelectric peaking have lead to decreased bank stability, allowing the banks to slough-off into the rivers, increasing sedimentation.

Excessive nutrients and other chemical inputs from both point and nonpoint sources are a serious threat to water quality within the ecobasin. The ecobasin has the second highest density of active discharges permitted by SCDHEC with more than six discharges per 100 square miles. There are 128 active discharges permitted by SCDHEC within the ecobasin; 80 of which are from industrial sources, 33 from community sources and 14 from municipal sources. There are 114 active agricultural operations within the ecobasin; most are poultry and turkey farms (14 large, 45 medium and 4 small). Other significant agricultural operations include 33 manure brokers and nine swine farms (two medium-sized and seven small).

Residential, industrial and commercial development in the northern portion of the ecobasin poses a significant threat to aquatic habitats. Significant growth is occurring in the West Columbia, Columbia and northeast Columbia areas, threatening water quality and aquatic habitats in the Congaree River, Congaree Creek and Gills Creek watersheds. Development pressure is also great in the Wateree River watersheds near Camden and Lugoff. The Spears Creek watershed can also expect moderate to high residential, commercial and industrial growth.

Pee Dee–Southeastern Plains Ecobasin

The 291 dams located in the ecobasin impound 150 miles of streams. Sixteen of those dams impound navigable streams.

There are 128 active discharges permitted by SCDHEC within the ecobasin, including 76 industrial discharges, 40 municipal discharges and 12 community discharges. The highest concentration of those discharges (28) occurs in the Pocatoligo River watershed near Shaw Air Force Base and the town of Sumter. There are 226 agricultural facilities permitted by SCDHEC

within the ecobasin, primarily poultry and turkey farms (15 small, 126 medium, and 18 large) and swine farms (22 small, 19 medium and 19 large).

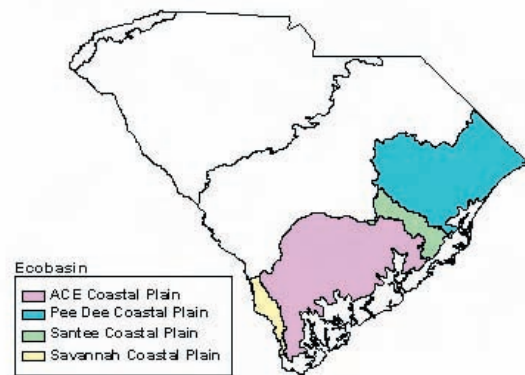
The construction of a proposed new interstate highway (I-73) running from Michigan to Myrtle Beach has the potential to result in significant impacts to the aquatic resources of this ecobasin. The final route for the highway has not been established so it is unknown which resources will be impacted.

Development pressure is expected to be high in the Black Creek and Jeffries Creek watersheds. Those watersheds encompass Hartsville, Darlington and Florence. Major industrial expansion is expected beyond the several large industrial parks that are already located along the western side of Florence. Increased water withdrawals and point source discharges that accompany development could potentially have severe impacts on aquatic habitats in the mainstem of the Pee Dee River.

Coastal Plain Ecoregion Aquatic Habitats

Description and Location

The Coastal Plain is situated directly below the Southeastern Plains ecoregion and terminates at the Coastal Marsh. In South Carolina it extends northwest from the Savannah River to the North Carolina state line. The Coastal Plain intersects 19 counties and covers approximately 8,555 square miles. The Coastal Plain is nearly level with elevations ranging from 25 to 125 feet. The major aquatic habitats within the ecoregion include lazy meandering streams, swamps, marshes, and estuaries. Pocosins and Carolina Bays are abundant in some areas.



Savannah–Coastal Plain Ecobasin

The Savannah-Coastal Plain Ecobasin is located in the extreme southwest corner of the state extending from southern Allendale County through Hampton and Jasper Counties before terminating at the coastal zone marsh. The ecobasin includes 45 miles of the Savannah River as it meanders toward the coast. Primary tributaries to the Savannah River in this ecobasin include Brier Creek and Boggy Branch. The ecobasin intersects 10 watersheds and covers 350 square miles. Approximately 26 square miles of land are protected by federal and state entities within the ecobasin. The largest protected areas are the Palachucola Wildlife Management Area (11.1 square miles) and the James W. Webb Wildlife Center (8.6 square miles), both managed by the South Carolina Department of Natural Resources. Other protected areas include a small portion of the Savannah National Wildlife Refuge (5.3 square miles) and the Tillman Sand Ridge Heritage preserve (1.3 square miles). The ecobasin contains approximately 277 miles of lotic habitat and 620 acres of lentic habitat. There are no major reservoirs within the ecobasin; the largest lentic habitat is only 62 acres.

Primary conservation targets within the ecobasin include the mainstem of the Savannah River throughout the ecobasin and the Brier Creek/Boggy Gut Creek system in Allendale County

(Smith et al. 2000). The mainstem of the Savannah River contains several aquatic animals that are on South Carolina's Priority Species List including fish (shortnose sturgeon and robust redhorse) and mussels (pod lance and Savannah lilliput). The Brier Creek/Boggy Gut Creek system is home to one of the few known populations of bluebarred pygmy sunfish.

ACE–Coastal Plain Ecobasin

The northern extreme of the ACE-Coastal Plain Ecobasin is situated in central Bamberg and Orangeburg Counties. The ecobasin encompasses parts of Allendale, Hampton, Colleton, Dorchester, Jasper, Beaufort, Berkeley and Charleston Counties before terminating at the coastal zone marsh. Coastal rivers in the ecobasin include the Coosawhatchie, Salkehatchie, Combahee, Ashepoo, Ashley, Edisto and Cooper. The Coosawhatchie River originates just north (6 miles) of the coastal plain in the southeastern plains and flows for about 47 miles through the coastal plain before merging with Tulifiny River to form the Broad River, which ultimately is deposited into the Atlantic Ocean at Port Royal Sound. The Salkehatchie River originates in the southeastern plains and flows for about 27 miles through the coastal plain before merging with the Little Salkehatchie River to form the Combahee River, which flows for 51 miles through the coastal plain before terminating in the Atlantic Ocean at St. Helena Sound. The Ashepoo River originates in the coastal plain and flows for about 57 miles, picking up inputs from Horseshoe Creek and Deer Creek before terminating at the Atlantic Ocean in St. Helena Sound. The Edisto River is formed at the confluence of the North Fork Edisto River and South Fork Edisto River. Each fork originates in the southeastern plains and flows for about 19 miles through the coastal plain before merging and forming the Edisto River. The Edisto River flows for about 122 miles through the coastal plain before entering St. Helena Sound and the Atlantic Ocean. As the Edisto flows through the coastal plain, it picks up inputs from Field Swamp, Four Hole Swamp and Penny Creek. The Ashley River originates entirely in the coastal plain. Its headwater, Great Cypress Swamp, flows for about 25 miles until it merges with Captains Creek to form the Ashley River. The Ashley River flows for about 40 miles through the coastal plain until terminating at Charleston Harbor and the Atlantic Ocean. The Cooper River is formed at the confluence of the East Branch and West Branch Cooper River. Once a self-contained drainage, the Cooper River now receives inputs from the Santee River via a diversion canal that diverts water from Lake Marion to Lake Moultrie. The West Branch Cooper River originates at the tailrace of Lake Moultrie and flows through the coastal plain for about 18 miles before merging with the East Branch Cooper River to form the Cooper River. The Cooper River flows through the coastal plain for about 30 miles, picking up inputs from the Back River, Goose Creek and Filbin Creek along its western shore and Flag Creek and Yellow House Creek along the eastern shore before being deposited in Charleston Harbor and the Atlantic Ocean.

The ecobasin intersects 72 watersheds and encompasses 4,093 square miles. There are 277 square miles of land protected by state, federal and private entities within the ecobasin. The largest tracts of protected land include the Francis Marion National Forest (198 square miles) and the Francis Beidler Forest (17 square miles), an Audubon Society Preserve. Other significant protected lands include the Nemours Plantation (7.7 square miles), the Medway Plantation (7.1 square miles), the Santee National Wildlife Refuge (6.9 square miles) and the Donnelley Wildlife Management Area (6.2 square miles). There are approximately 3,678 miles of lotic habitat and 108 square miles of lentic habitat within the ecobasin. The majority (89 square miles) of lentic habitat is represented by Lake Moultrie, the only major reservoir in the coastal plain.

Primary areas of conservation concern in the ACE-Coastal Plain Ecobasin include the Jasper County wetlands in Jasper County; the Cypress/Beaver Dam Creek systems in Jasper and Hampton Counties; the Sandy Run system in Colleton County; the lower North Fork Edisto and mainstem Edisto Rivers throughout the ecobasin; and the Cooper River in Berkeley and Charleston Counties. The Jasper County wetlands, Cypress/Beaver Dam Creek and the Sandy Run systems all contain populations of bluebarred pygmy sunfish and other fishes that are on South Carolina's Priority Species List. The North Fork and mainstem Edisto River contain several fish species on the priority species list ("broadtail" madtom, shortnose sturgeon, bannerfin shiner and striped bass). The Cooper River and its backwaters contain populations of bluefin killifish, striped bass and the federally endangered shortnose sturgeon.

Santee–Coastal Plain Ecobasin

The Santee-Coastal Plain Ecobasin originates in southeastern Clarendon County and encompasses portions of Williamsburg, Berkeley, Georgetown and Charleston Counties before terminating at the coast. The only major river within the ecobasin is the Santee River. The headwaters of the Santee originate in the Blue Ridge and Piedmont Ecoregions. The Santee River flows for approximately 81 miles through the coastal plain, receiving inputs from Echaw Creek and Wambaw Creek, until terminating at the Atlantic Ocean.

The ecobasin intersects 19 watersheds and encompasses 620 square miles. A large portion (169 square miles, 27 percent) of the land is protected by federal, state and private entities. The largest areas (147 square miles) of protected land are the Francis Marion National Forest and the Francis Marion National Forest Wilderness Area (18 square miles). Other significant protected areas include the Francis Marion National Forest Botanical and Zoological Area (1.5 square miles) and the Bennett's Bay Heritage Preserve (1 square mile). There are 572 miles of lotic habitat and 4.4 square miles of lentic habitats. There are no large impoundments within the ecobasin.

Pee Dee–Coastal Plain Ecobasin

The Pee Dee-Coastal Plain ecobasin is located in the northeast corner of the state and encompasses portions of Dillon, Lee, Horry, Florence, Marion, Sumter, Clarendon, Williamsburg, and Georgetown Counties. Several coastal rivers are located within the ecobasin, including the Black River, Lynches River, Pee Dee River, Little Pee Dee River, and Waccamaw River. The headwaters of the Black River originate in the southeastern plains. The Black River flows unimpounded through approximately 123 miles of the coastal plain before merging with the Pee Dee River at the coast. As the Black River flows through the coastal plain it picks up inputs from several major tributaries including Black Mingo Creek, Peters Creek, Cottage Creek, Lanes Creek and Six-mile Creek. The headwaters of the Lynches River originate in the piedmont of South Carolina and North Carolina. The Lynches flows unimpounded through approximately 77 miles of the coastal plain before merging with the Pee Dee River near Gilbert Crossroads, South Carolina. Major tributaries to the Lynches River in the coastal plain include Sparrow Swamp and Lake Swamp. The Pee Dee River originates in the southern portion of the North Carolina piedmont and southeastern plains and flows through about 89 miles of South Carolina's coastal plain before terminating at Winyah Bay. As the Pee Dee flows through the coastal plain, it picks up inputs from several significant tributaries, including Catfish Creek, Lynches River, Little Pee Dee River, Conch Creek and the Black River. The Little Pee Dee River originates in the southeastern plains of North Carolina and flows through approximately 74 miles of the South Carolina's southeastern plains before entering the coastal plain. Within the coastal plain,

the Little Pee Dee River flows for about 65 miles, receiving input from the Lumber River before merging with the Pee Dee River. The Waccamaw River originates in the coastal plain of North Carolina and flows through approximately 104 miles of South Carolina's coastal plain before terminating at Winyah Bay. Within the ecobasin, the Waccamaw River picks up significant inputs from Buck Creek, Simpson Creek and Kingston Swamp.

The ecobasin intersects 50 watersheds and encompasses 3,492 square miles. Approximately 2.7 percent (95 square miles) of the ecobasin is protected by state, federal and private entities. A large portion (42.4 square miles) of this land is protected by the state and managed by the SCDNR as Natural Heritage Preserves. The preserves include the Little Pee Dee River Heritage Preserve (15.9 square miles), the Lewis Ocean Bay Heritage Preserve (14.4 square miles) and the Waccamaw River Heritage Preserve (8.7 square miles) as well as five smaller heritage preserves encompassing 3.3 square miles. Other significant protected areas include the Sandy Island Mitigation Site (12.3 square miles) and the Bucksport and Oliver Mitigation Site (11.5 square miles), managed by the South Carolina Department of Transportation as State Wildlife Reserves, and the Waccamaw National Wildlife Refuge (10.3 square miles) managed by the US Fish and Wildlife Service. Within the ecobasin, there are approximately 3,745 miles of lotic habitat and 18.3 square miles of lentic habitats. There are no major impoundments within the ecobasin.

Areas of primary conservation concern in the Pee Dee-Coastal Plain Ecobasin include the Lynches River and its tributaries in Lee, Florence and Sumter Counties; the Pee Dee River from its confluence with the Lynches River to Winyah Bay; and the upper Waccamaw River in Horry County. The Lynches River contains populations of "broadtail" madtom as well as several mussel species on South Carolina's Priority Species List (brook floater, creeper and notched rainbow). The Pee Dee River and its backwaters contain several fishes on the priority list including the "broadtail" madtom, robust redhorse, Carolina pygmy sunfish and federally endangered shortnose sturgeon. Several mussel species on the priority list are in the Pee Dee River, including the Waccamaw spike, yellow lampmussel, Roanoke slabshell and rayed pink fatmucket. The upper Waccamaw contains populations of Carolina pygmy sunfish and "broadtail" madtom and mussel species (Waccamaw spike and yellow lampmussel).

General Condition

Savannah–Coastal Plain Ecobasin

Water quality was impaired at seven of ten sites sampled by the SCDHEC. Aquatic life uses were not supported at two sites due to a lack of invertebrate diversity and low dissolved oxygen levels. Fish consumption advisories were listed for five sites due to mercury contamination. Fish consumption advisories have been issued for the Savannah River and Cypress Creek. None of the streams within the ecobasin is considered an outstanding resource water by SCDHEC.

ACE–Coastal Plain Ecobasin

Water quality was impaired at 72 of 115 sites (62 percent) sampled by SCDHEC. Aquatic life uses were not supported at 30 sites due to a lack of invertebrate diversity (13 sites), low dissolved oxygen concentrations (7 sites), zinc excursions (5 sites), abnormal pH values (3 sites), high turbidity (1 site) and chromium excursions (1 site). Recreational uses were not supported at 23 sites primarily due to high concentrations of fecal coliform bacteria. Mercury excursions were found in the tissue of fish at 19 sites. Fish consumption advisories have been issued for nearly

every major water body in the ecobasin including the North Fork Edisto River, South Fork Edisto River, mainstem Edisto River, Cooper River, East Fork Cooper River, Ashepoo River, Salkehatchie River, Little Salkehatchie River, Combahee River, Coosawhatchie River, New River, Black River, Ashley River, Four Hole Swamp, Wadboo Creek, Chessie Creek, Horseshoe Creek, Lake Moultrie and Goose Creek Reservoir.

Santee–Coastal Plain Ecobasin

Ten of 16 sites (62.5 percent) sampled by SCDHEC within the ecobasin were impaired. Aquatic life uses were not supported at two sites due to a lack of invertebrate diversity. Recreational uses were impaired at two sites due to the presence of high fecal coliform concentrations. Fish consumption advisories due to mercury contamination have been issued for the Diversion and Rediversion Canals, Santee River, South Santee River, North Santee River, Wambaw Creek and Wadmacon Creek.

Pee Dee–Coastal Plain Ecobasin

Water quality was impaired at 70 of 110 sites (64 percent) sampled by SCDHEC. Aquatic life uses were not supported at 23 sites due to low dissolved oxygen levels (11 sites), abnormal pH values (5 sites), copper contamination (3 sites), lack of invertebrate diversity (3 sites) and zinc contamination (1 site). Recreational uses were not supported at three sites due to the presence of high concentrations of fecal coliform bacteria. Due to high levels of mercury in fish tissue, SCDHEC has issued a fish consumption advisory for the entire length of every major river (Pocotaligo River, Black River, Black Mingo Creek, Lynches River, Pee Dee River, Little Pee Dee River, Lumber River, Waccamaw River) in the ecobasin.

Major Classifications

Wadeable Streams

Wadeable streams, as with the other ecoregions, are the dominant aquatic habitat in the coastal plain and provide a large portion of the habitat for aquatic animals on the priority species list. Wadeable streams are those with Strahler stream orders of 0 to 3; these are generally streams that can be waded comfortably throughout most of the year. These streams are often bordered with pond-like backwaters and swamps. Wadeable streams in the coastal plain are low gradient with sluggish flows. Although some of the larger streams may have moderate currents, they lack whitewater. In the moderate flowing areas, the substrate is chiefly clean shifting sand. With the absence of rocks in most streams, logs and debris jams provide habitat for aquatic fauna. In slow-flowing areas substrate is comprised of finer materials such as mud, clay, silt and fine detritus. Most coastal plain streams that receive ample sunlight are well vegetated with aquatic macrophytes. Coastal plain streams can contain turbid or clear water (whether stained or not). Generally those streams that originate in the piedmont and flow through the coastal plain are turbid due to the heavy sediment load they carry and are termed “brownwater.” Streams that originate in the southeastern plains and/or coastal plain and are not turbid as a result of anthropogenic impacts are termed “blackwater” due to their tannin-stained waters.

Navigable Streams

Navigable streams are less common in the coastal plain, but provide habitat for many species on the priority list. These streams are generally defined as large enough to operate watercraft, if only a canoe and are usually too deep to be waded throughout most of the year. The Pee Dee River, Lynches River and Edisto River are examples of navigable streams in the coastal plain. These

lazy meandering streams have substrates of mostly shifting sand in the flowing areas while finer materials (silt, clay and detritus) are deposited in the pools. As with the smaller streams in the ecobasin, the navigable streams that originate in the southeastern plains and/or coastal plain are also “blackwater,” stained by the decomposition of organic materials.

Carolina Bays

Carolina bays are common in the coastal plain. These shallow elliptical depressions of unknown origin, many of which contain water throughout the year. The waters contained in Carolina bays are highly acidic which limits the number of fish species. However, some sunfish, minnow, killifish and livebearer species may populate Carolina bays. These depressions may be important habitat for some rare crayfish species, as several have been observed in these formations.

However, data on the crayfishes of Carolina bays is particularly lacking and more surveys are needed in order to determine the importance of these depressions as crayfish habitat.

Priority Species Associations

Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Highest Priority					
Fishes					
Robust redhorse	<i>Moxostoma robustum</i>		X		X
Carolina pygmy sunfish	<i>Elassoma boehlkei</i>		X	X	
Bluebarred pygmy sunfish	<i>Elassoma okatie</i>				X
Savannah darter	<i>Etheostoma fricksium</i>	X			
Broadtail” madtom	<i>Noturus spp. (c.f. insignis)</i>	X	X		
Mussels					
Barrel floater	<i>Anodonta couperiana</i>	X			X
Waccamaw spike	<i>Elliptio waccamawensis</i>		X		
Yellow lampmussel	<i>Lampsilis cariosa</i>	X	X		X
Southern rainbow	<i>Villosa vibex</i>	X	X		
Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Crayfish					
A crayfish	<i>Procambarus echinatus</i>	X			
A crayfish	<i>Procambarus reflexus</i>		X		
High Priority					
Fishes					
Bannerfin shiner	<i>Notropis leedsii</i>	X			X
Blackbanded sunfish	<i>Enneacanthus chaetodon</i>	X	X	X	X
Mussels					
Rayed pink fatmucket/ Eastern lampmussel	<i>Lampsilis splendida/radiata</i>	X	X		X
Roanoke slabshell	<i>Elliptio roanokensis</i>		X		
Eastern pondmussel	<i>Ligumia nasuta</i>		X		

Common Name	Scientific Name	Ecobasin			
		ACE	Pee Dee	Santee	Savannah
Mussels Continued					
Tidewater mucket	<i>Leptodea ochracea</i>		X		
Crayfish					
Waccamaw crayfish	<i>Procambarus braswelli</i>		X		
Pee Dee Lotic crayfish	<i>Procambarus lepidodactylus</i>	X	X	X	
Sandhills crayfish	<i>Procambarus pearsei</i>		X		
Snails					
Ridged lioplax	<i>Lioplax subcarinata</i>		X		
Buffalo pebblesnail	<i>Gillia altilis</i>		X		
Moderate Priority					
Fishes					
Florida gar	<i>Lepisosteus platyrhinchus</i>				X
Lowland shiner	<i>Pteronotropis stonei</i>	X	X	X	X
White catfish	<i>Ameiurus catus</i>	X	X	X	X
Flat bullhead	<i>Ameiurus platycephalus</i>	X	X	X	X
Bluefin killifish	<i>Lucania goodei</i>			X	
Banded killifish	<i>Fundulus diaphanus</i>		X		
Striped bass	<i>Morone saxatilis</i>	X	X	X	X
Pugnose minnow	<i>Opsopoeodus emiliae</i>	X			X
Mud sunfish	<i>Acantharchus pomotis</i>	X	X	X	X
Mussels					
Eastern creekshell	<i>Villosa delumbis</i>	X	X		X
Carolina lance	<i>Elliptio angustata</i>	X	X		
Eastern elliptio	<i>Elliptio complanata</i>	X	X		X
Carolina slabshell	<i>Elliptio congraea</i>	X	X		X
Variable spike	<i>Elliptio icterinacomplex</i>	X	X		X
Pod lance	<i>Elliptio folliculata</i>		X		
Atlantic spike	<i>Elliptio producta</i>		X		
Crayfish					
Edisto crayfish	<i>Procambarus ancylus</i>	X	X	X	
A crayfish	<i>Procambarus barbatus</i>				X
Santee crayfish	<i>Procambarus blandingii</i>		X	X	
A crayfish	<i>Procambarus lunzi</i>			X	X
A crayfish	<i>Procambarus chacei</i>	X		X	X
A crayfish	<i>Procambarus enoplosternum</i>			X	X
A crayfish	<i>Procambarus hirsutus</i>	X			X
A crayfish	<i>Procambarus pubescens</i>				X
Snails					
An undescribed snail	<i>Physa</i> spp. "A"	X		X	

Region-wide Challenges

Challenges to conservation of aquatic fauna in the Coastal Plain Ecoregion are similar to other ecoregions in the state and primarily include impacts associated with impoundments, nonpoint source pollution, point source pollution, poorly planned development and introductions of non-native species. Increased population growth and the accompanying uncontrolled residential, commercial and industrial growth may be the greatest challenge to species and their habitats in this ecoregion, especially near the coast.

There is only one major impoundment (Lake Moultrie) in the coastal plain; however, dams still have a significant impact on aquatic resources within the ecoregion. There are roughly 176 dams permitted by SCDHEC, although numerous other unpermitted dams, such as those associated with farm ponds, also exist, impounding 152 miles of stream. The presence of dams results in a loss of connectivity and negatively affects aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004). Impoundments negatively affect native aquatic fauna by direct loss of habitat through the conversion of lotic habitat to lentic habitat, which favors competitive and often predacious species like largemouth bass and other centrarchids. In addition, impoundments often negatively impact unimpounded reaches downstream by altering hydrologic and thermal regimes (Cushman 1985), modifying stream channel morphology, increasing erosion and sedimentation (Waters 1995), ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Dams in the coastal plain like Pinopolis Dam also hinder the migrations of native anadromous fish including shad, striped bass and sturgeon to their historic spawning grounds in the piedmont.

Siltation resulting from clearing forests, tilling soils and channelization of coastal plain streams has altered stream morphology. Modern soil conservation practices and reduced channelization have reduced those impacts, but sedimentation from nonpoint and point sources remains a significant detriment to streams today. Ground disturbance from development, agriculture and silviculture are primary sources of erosion that lead to sedimentation in streams. When timber managers fail to follow best management practices (BMPs), significant siltation occurs. Stream bank erosion due to loss of riparian areas, livestock grazing and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the coastal plain were channelized to improve drainage of croplands. Channelized streams lead to increased erosion of cropland and increased sedimentation of the receiving streams (Etnier and Starnes 1993). The result of channelization changed many streams into straight shallow ditches with severely depressed populations of aquatic fauna.

Clearing hardwoods from bottomland and cypress swamps also threatens aquatic habitat in the coastal plain. In addition to increasing sedimentation and erosion, the loss of canopy results in increased water temperatures that will limit the amount of available habitat for some species like striped bass. Timber companies, which have been proven to be good stewards of the land, are selling off large tracts of land, making floodplain timber more vulnerable to harvest by other owners.

Excessive contamination from nutrients and chemicals also negatively affect water quality within the ecoregion. Point source discharges from industrial, municipal and commercial sources add a variety of pollutants to receiving streams, rivers and lakes. In addition, contamination from nonpoint sources also negatively impacts water quality. Nationwide, pollution from agricultural sources is the greatest cause of impairment to streams and lakes (SCDHEC 2003). Statewide,

the coastal plain has a modest amount of permitted discharges and concentrated animal feeding operations (CAFOs), 2.3 and 1.9 per 100 square miles respectively. However, those discharges and CAFOs are a significant threat to aquatic habitats. Water quality in the coastal plain was impaired at 63 percent of the sites sampled by the SCDHEC, which is the highest impairment rate of the four ecoregions in the state. Recreational uses were impaired at nearly 11 percent of the sites sampled due to the presence of high concentrations of fecal coliform bacteria. Fecal coliform bacteria are present in the digestive tract of warm-blooded animals. Although the bacteria themselves are not generally harmful to humans, they do indicate that surface waters may contain disease-causing pathogens (SCDHEC). Twenty-three percent of streams sampled by SCDHEC within the ecoregion did not support aquatic life uses, indicating the streams do not possess sufficient water quality to maintain a balanced aquatic community of plants and animals. Mercury contamination is abundant in the coastal plain; this contamination indicates a serious threat not only to aquatic fauna but also to human health and recreational uses. Fish consumption advisories have been issued for nearly every major water body in the Coastal Plain. Nearly 30 percent of the sites sampled by SCDHEC were impaired due to mercury contamination in fish tissue, which is the highest impairment rate in the state.

Water quantity is also a problem in coastal plain streams. Water withdrawal for irrigation is a common practice in the ecoregion. During summer months, some streams are completely dewatered due to uncontrolled irrigation of croplands. Furthermore, many pond owners will close their drain structures during dry periods in an attempt to maintain esthetic water levels, thereby dewatering the stream below. With the rapidly increasing populations along the coast, demand for freshwater will increase dramatically and water withdrawal from streams and rivers as well as interbasin water transfers will be a serious threat to aquatic habitats and their natural communities.

Introductions of non-native species have had a significant impact on native aquatic fauna in the Coastal Plain Ecoregion. Buffalo (fish), common carp, flathead catfish and blue catfish are established in several drainages. Flathead catfish and blue catfish introductions probably pose the greatest direct risks to native fauna. Flathead catfish have been shown to prey on bullheads, darters, shad, suckers and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of flathead catfish (Guire et al. 1984; Jenkins and Burkhead 1994; Bart et al. 1994). It is not well known what effects buffalo have on the native community, but it has been suggested that they may be a factor in the decline of some catostomids in the Pee Dee River (Wayne Starnes, pers. comm.). Common carp occur in every South Carolina drainage and are considered a pest, but their impact on native fauna is not well known. Common carp disrupt aquatic habitats by rooting around in the substrate, which uproots aquatic plants and increases turbidity and siltation. Common carp have also been shown to prey on the eggs of other fish species.

The Asian clam, *Corbicula fluminea*, has been introduced and has widely spread throughout the United States, including South Carolina. The effects of *Corbicula* on native species are not particularly well understood. According to a review of the literature on interactions between *Corbicula* and native mussels (Dillon 2000), most field studies failed to find any significant negative effects on native mussels, although a few detected reductions in growth. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica*) are present in Lakes Marion and Lake Moultrie; however, their impact on native fauna is not known.

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from a native catfish have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the coastal plain and eastern piedmont plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b) and the risk to our native species is great if further introductions or extensive spread on non-indigenous crayfish occurs.

Sand mining operations have been initiated or are ongoing in the mainstem or riparian areas of many coastal plain rivers. Instream sand mining is a significant threat to aquatic resources within the ecoregion. Sand mining not only causes bank stability problems and loss of riparian habitat at the mining site but instream impacts as well by changing the physical and chemical habitat. Such impacts can negatively affect biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate type and stability and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by impacting the reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and the distribution, composition and reproduction of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Savannah–Coastal Plain Ecobasin

Approximately 36 miles of stream within the ecobasin have been impounded. There are 15 dams permitted by SCDHEC within the ecobasin, none of which impound navigable streams. Numerous other dams not permitted by SCDHEC also occur in the ecobasin.

Point source pollution from within the ecobasin is not currently a large threat as there are only two active discharges permitted by SCDHEC: one municipal and one industrial. There are no active agricultural operations permitted by SCDHEC within the ecobasin.

There is little expected growth throughout the majority of the ecobasin. One area that may experience moderate growth is the area near the town of Hardeeville.

ACE–Coastal Plain Ecobasin

Approximately 73 miles of stream in the ecobasin have been impounded. There are 77 dams permitted by SCDHEC within the ecobasin. The majority of the impounded area is a result of Pinopolis Dam on the Cooper River that forms Lake Moultrie. The Pinopolis Dam has had a significant negative impact on the Cooper River below the dam. Currently, there is no continuous minimum flow for the Pinopolis Dam tailrace and aquatic habitats are frequently dewatered during low flows.

There is a moderate amount of industrial and agricultural activity within this ecobasin. There are 98 active discharges permitted by SCDHEC; of those active discharges 60 are industrial discharges, 26 are municipal discharges and 12 are community discharges. There are 87 CAFOs permitted by SCDHEC; the majority of those facilities are poultry farms (17 small, 21 medium and 10 large). Swine farms also contribute significantly to the total number of agricultural facilities with 21 facilities (11 small, 9 medium and 1 large). CAFOs are not a large threat to aquatic habitats overall, but may pose a significant threat to portions of the ecobasin. The vast

majority (70 operations) of the agricultural facilities are located in the north-central portion of the ecobasin in the Edisto River basin, primarily in the Cattle Creek, Indian Field Swamp and Cowcastle Creek watersheds; CAFOs likely pose a significant threat in those watersheds.

There is little expected commercial, residential or industrial development throughout most of the northern portion of the ecobasin, although, a moderate amount of commercial and residential growth can be expected along the I-95 corridor and Lake Moultrie. In the middle and southern portion of this ecobasin, uncontrolled residential, commercial and (potentially) industrial growth is a serious threat to aquatic habitats. Many areas are experiencing high levels of commercial and residential development as spillover from Charleston. The area between Cottageville and Charleston along the US 17 corridor is one of the fastest growing areas in the state. Other areas where large-scale residential and commercial development is expected include the towns of Ridgeland and Bluffton.

Water quantity will likely be a future challenge to the aquatic habitats of the ACE-Coastal Plain Ecobasin. Currently an interbasin water transfer exists on the Edisto River, where water is removed to support the town of Hannah WTP and the large industries along the Cooper River. Increased industrial growth along the Cooper River and the expected large scale residential growth in the town of Hannah and of North Charleston will exacerbate water quantity issues.

Santee–Coastal Plain Ecobasin

There are no large impoundments in this ecobasin; roughly 6.8 miles of stream are impounded. There are 11 dams permitted by SCDHEC within the ecobasin, although numerous unpermitted dams also occur in the ecobasin. Aquatic habitat in the Santee River is negatively influenced by the operation of the Santee Dam upstream.

There are 19 active discharges permitted by SCDHEC within this ecobasin. Of those active discharges, 16 are from industrial sources and three are from municipal sources. There is only one active agricultural operation (medium sized poultry farm) within the ecobasin.

Development in this ecobasin is not a major concern, but moderate growth is expected on the south side of Lake Marion and in the vicinity of the town of St. Stephen.

While much of the Santee River flood plain is public land, a substantial amount is privately held; removal of tree canopy poses a threat to aquatic habitats. The increasing trend towards conversion of upland agrarian land use to smaller home sites has the potential to negatively change hydrology, nutrient loading and sedimentation. A growing beaver population is also likely to affect streams in this ecobasin, changing habitat that favors warm lentic adapted species over those that favor cooler lotic habitats.

Pee Dee–Coastal Plain Ecobasin

Approximately 36.5 miles of streams are impounded within this ecobasin. There are 73 dams permitted by SCDHEC, most of which occur on small tributary streams.

There are a moderate number of point source discharges within the ecobasin with 76 active discharges permitted by SCDHEC. Of those active discharges, 38 are from municipal sources, 31 are from industrial sources and seven are from community sources. There are 71 active agricultural facilities within the ecobasin, the majority (48) of which are swine farms (27 small farms, 14 medium farms and 7 large farms). Poultry and turkey farms are also prevalent within the ecobasin, accounting for 20 operations (2 small farms, 15 medium farms and 3 large farms).

Increased population growth accompanied by unplanned and uncontrolled industrial, residential and commercial development is a serious threat to aquatic resources in the Pee Dee-Coastal Plain Ecobasin. The majority of the growth and the greatest threat to aquatic resources is expected to occur along the eastern portion of the ecobasin near the coast. Increased commercial and residential growth is expected along several highway corridors: US 52 connecting Florence to Charleston and US 378 and US Hwy 501 connecting I-95 to Myrtle Beach. The construction of a proposed new interstate highway (I-73) running from Michigan to Myrtle Beach, South Carolina has the potential significantly impact the aquatic resources of this ecobasin. The final route for I-73 has not been established; therefore, the exact location for impacts is unknown. Residential and resort communities along the “Grand Strand” will strain the already significantly degraded aquatic habitats. When developed, the largest tract of currently undeveloped land (Buist Tract) in Horry County is expected to accommodate 10,000 new residents and 11 new golf courses.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE Basin	Ashepoo, Combahee and Edisto Rivers
ACGRP	Appalachian Cooperative Grouse Research Project
ACOE	Army Corps of Engineers
ALWTRT	Atlantic Large Whale Take Reduction Team
APHA	American Public Health Association
ASMFC	Atlantic States Marine Fisheries Commission
AVM	Avian Vacuolar Myelinopathy
BBS	Breeding Bird Survey
BCR	Bird Conservation Region
BDTRP	Bottlenose Dolphin Take Reduction Plan
BDTRT	Bottlenose Dolphin Take Reduction Team
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BRD	Bycatch Reduction Device
CCEHBR	Center for Coastal Environmental Health and Biomolecular Research
CITES	Convention on International Trade in Endangered Species (of Wild Fauna & Flora)
COASTSPAN	Cooperative Atlantic States Shark Pupping and Nursery Survey
CPUE	Catch Per Unit of Effort
CRBO	Cape Romain Bird Observatory
CRNWR	Cape Romain National Wildlife Refuge
CWS	Canadian Wildlife Service
DBH	Diameter Breast Height
DHEC	Department of Health and Environmental Control
DOE	Department of Energy
DPS	Distinct Population Segment
DTWG	Diamondback Terrapin Working Group
EDC	Endocrine Disrupting Chemical
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
EPT	Ephemeroptera, the mayflies; Plecoptera, the stoneflies; and Trichoptera, the caddis flies
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FLMNH	Florida Museum of Natural History
FMNF	Francis Marion National Forest
FMP	Fishery Management Plan
FSA	Farm Service Agency
GADNR	Georgia Department of Natural Resources
GIS	Geographic Information System
HABs	Harmful Algal Blooms

HAPC	Habitat Areas of Particular Concern
HIP	Harvest Information Program
IFMP	Interstate Fisheries Management Plan
ISS	International Shorebird Surveys
ITIS	Integrated Taxonomic Information System
IUCN	International Union for the Conservation of Nature and Natural Resources
LAL	Limulus Amoebocyte Lysate
LIP	Landowner Incentive Program
MARMAP	Marine Resources Monitoring, Assessment and Prediction
MARPOL	International Convention for the Prevention of Pollution from Ships
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MRFSS	Marine Recreational Fisheries Statistics Survey
MRRI	Marine Resources Research Institute
mtDNA	mitochondrial Deoxyribonucleic acid
MWS	Midwinter Waterfowl Survey
NABCI	North American Bird Conservation Initiative
NAWCA	North American Wetland Conservation Act (of 1989)
NAWMP	North American Waterfowl Management Plan
NCDENR	North Carolina Department of Environment and Natural Resources
NCSU	North Carolina State University
NCWRC	North Carolina Wildlife Resources Commission
NGO	Non-Governmental Organization
NGS	National Geographic Society
NMFS	National Marine Fisheries Service
NMFS FRP	National Marine Fisheries Service, Final Recovery Plan
NMP	Nutrient Management Plan
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Services
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
NWCO's	Pest Control and Wildlife Control Operators
NWR	National Wildlife Refuge
OCP	Outer Coastal Plain
OCRM	Ocean and Coastal Resource Management
ODMDS	Ocean Dredged Material Disposal Site
OFM	Office of Fisheries Management
OSP	Optimum Sustainable Population
PAH	Polycyclic Aromatic Hydrocarbon
PARC SE HMG	Partners in Amphibians and Reptile Conservation South Eastern Habitat Management Guidelines
PBR	Potential Biological Removal
PCB	Polychlorinated Biphenyl
PHEREC	Public Health Entomology Research & Education Center
PIF	Partners in Flight

PPT	Parts Per Thousand
QPX	Quahog Pathogen Unknown
RRCC	Robust Redhorse Conservation Committee
SAFMC	South Atlantic Fishery Management Council
SAMBI	South Atlantic Migratory Bird Initiative
SAV	Submerged Aquatic Vegetation
SC SRFSS	State Recreational Fisheries Statistics Survey
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCDOT	SC Dept of Transportation
SCECAP	South Carolina Estuarine and Coastal Assessment Program
SCR	Santee Coastal Reserve
SEAMAP	Southeast Area Monitoring and Assessment Program
SEAMAP-SA	Southeast Area Monitoring and Assessment Program – South Atlantic (Shallow Water Trawl Survey)
SEIT	Southeastern Right Whale Recovery Plan Implementation Team
SFA	Sustainable Fisheries Act
SHNWR	Carolina Sandhills National Wildlife Refuge
SMZ	Streamside Management Zones
SOD	Sudden Oak Death
SREL	Savannah River Ecological Laboratory
SRFAC	State Recreational Fisheries Advisory Committee
SRS	Savannah River Site
SRS-DOE	Savannah River Site – Dept of Energy
SR-USFS	Savannah River-U.S. Forest Service
TED	Turtle Excluder Device
TL	Total Length
TSRHP	Tillman Sand Ridge Heritage Preserve
UGA	The University of Georgia
UME	Unusual Mortality Event
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USSCP	U.S. Shorebird Conservation Plan
WCRP	World Climate Research Program
WHSRN	Western Hemisphere Shorebird Reserve Network
WMA	Wildlife Management Area
WNV	West Nile Virus
WRP	Wetlands Reserve Program
YONAH	Years of the North Atlantic Humpback
ZMRG	zero mortality rate goal

Glossary of Terms

A

accreted - To make larger or greater, as by increased growth.

acumen - A tapering point.

adipose fin - A soft boneless fin.

agouti (grizzled) - The alternation of light and dark bands of color in the fur of various animals, producing a grizzled appearance.

alates - Bearing wings.

allele - One member of a pair or series of genes that occupy a specific position on a specific chromosome.

allopatry - Occurring in separate, nonoverlapping geographic areas. Often used of populations of related organisms unable to crossbreed because of geographic separation.

allotypic - A biological specimen that is the opposite sex of a holotype.

amphidromous - Moving from fresh water to the sea, or vice versa, for nonreproductive purposes such as feeding.

amphipod - A small crustacean of the order Amphipoda, such as the beach flea, having laterally compressed body with no carapace.

anadromous - Migrating up rivers from the sea to breed in fresh water.

anal fin - An unpaired fin on the ventral surface of the fish, virtually always positioned after the vent.

angulate - Having angles or an angular shape.

anterior - Placed before or in front.

anthropogenic - Caused by humans.

apodeme - One of the processes of the shell which project inwards and unite with one another, in the thorax of many Crustacea.

appendage - A part or organ, such as an arm, leg, tail, or fin, that is joined to the axis or trunk of a body.

aquaculture - The science, art, and business of cultivating marine or freshwater food fish or shellfish, such as oysters, clams, salmon, and trout, under controlled conditions.

arboreal - Relating to or resembling a tree.

ascidian - Any of various sedentary tunicates of the class Ascidiacea, having a transparent sac-shaped body with two siphons.

auricular - Of or relating to the sense of hearing or the organs of hearing.

B

ballast - Heavy material that is placed in the hold of a ship or the gondola of a balloon to enhance stability.

barbel - One of the slender, whiskerlike tactile organs extending from the head of certain fishes, such as catfishes. Also called barb.

basal band - Of, relating to, located at, or forming a base.

basicaudal - On the base of the caudal fin (tail fin).

beak - The raised part of the dorsal margin of the shell; also called the umbo.

beak cavity - The depression or pocket on the inside of each valve leading into the beak.

benthic - Of or relating to or happening on the bottom under a body of water.

benthopelagic - Of or relating to or happening on the bottom under a body of water specifically open oceans or seas rather than waters adjacent to land or inland waters.

biangular - Having two angles or corners.

bib - A patch of colored feathers under the chin of a bird.

bioaccumulation - The accumulation of a substance (as a pesticide) in a living organism.

biomass - The total mass of all living things within a given area, biotic community, species population, or habitat; a measure of total biotic productivity.

biome - A major regional or global biotic community, such as a grassland or desert, characterized chiefly by the dominant forms of plant life and the prevailing climate.

bipectinate - Having two margins toothed like a comb.

biserrate - Serrated on both sides.

bivalve - A mollusk, such as an oyster or a clam, that has a shell consisting of two hinged valves.

book lung - A sacculate respiratory organ found in some arachnids, such as scorpions and spiders, consisting of several parallel membranous folds arranged like the pages in a book.

boreal - Of or relating to the forest areas of the northern North Temperate Zone, dominated by coniferous trees such as spruce, fir, and pine.

brackish - Having a somewhat salty taste, especially from containing a mixture of seawater and fresh water.

bromeliad - Any of various mostly epiphytic tropical American plants of the family Bromeliaceae, usually having long stiff leaves, colorful flowers, and showy bracts. Bromeliads include the pineapple, the Spanish moss, and numerous ornamentals.

brood parasitism - (Also called nest parasitism or breeding parasitism.) The laying of eggs by one bird species in the nest of another bird species and the subsequent brooding of the egg and raising of the young by the parasitized host, usually to the detriment of the host's young. Brood parasitism. (Also called nest parasitism or breeding parasitism.) The laying of eggs by one bird species in the nest of another bird species and the

- subsequent brooding of the egg and raising of the young by the parasitized host, usually to the detriment of the host's young.
- bryozoan - Any of various small aquatic animals of the phylum Bryozoa that reproduce by budding and form mosslike or branching colonies permanently attached to stones or seaweed.
- burrow - A hole or tunnel dug in the ground by a small animal for habitation or refuge.
- bycatch - The portion of a fishing catch that is discarded as unwanted or commercially unusable.
- byssal - A mass of strong, silky filaments by which certain bivalve mollusks, such as mussels, attach themselves to rocks and other fixed surfaces.
- C**
- calcareous - Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone; chalky.
- carapace - A hard bony or chitinous outer covering, such as the fused dorsal plates of a turtle or the portion of the exoskeleton covering the head and thorax of a crustacean.
- cardiform - Small, sharp, slender teeth; arranged like a series of combs.
- cardiomyopathy (enlargement of the heart muscle) - A disease or disorder of the heart muscle, especially of unknown or obscure cause.
- carnivore - Any animal that feeds on flesh.
- carpus - A joint in quadrupeds corresponding to the wrist.
- carrion - Dead and decaying flesh.
- catadromous - Living in fresh water but migrating to marine waters to breed.
- caudal - Of, at, or near the tail or hind parts; posterior
- caudal fin - The tail of fishes and some other aquatic vertebrates.
- caudal spot - A spot or blotch of color contrasting with the base color and located on or near the base of the caudal or tail fin of a fish.
- cercus - Either of a pair of terminal, dorsolateral sensory appendages of certain insects, such as the female mosquito.
- chela - A pincerlike claw of a crustacean or arachnid, such as a lobster, crab, or scorpion.
- chelate - Having chelae or resembling a chela.
- chelicerae - Either of the first pair of fanglike appendages near the mouth of an arachnid, such as a spider, often modified for grasping and piercing.
- cheliped - One or more pairs of thoracic legs of decapod crustaceans that terminate in a chela, or claw. The entire cheliped is often referred to as a claw.
- chlordan - A colorless, odorless, viscous liquid used as an insecticide. It may be toxic to humans and wildlife as a result of its effect on the nervous system.

- chlorosis - The yellowing or bleaching of plant tissues due to the loss of chlorophyll or failure of chlorophyll synthesis. It can be caused by insufficient light or nutrients, and also by certain diseases.
- cladoceran - Any of various small, mostly freshwater crustaceans of the order Cladocera, which includes the water fleas.
- cnidarians - Any of various invertebrate animals of the phylum Cnidaria, characterized by a radially symmetrical body with a saclike internal cavity, and including the jellyfishes, hydras, sea anemones, and corals. Also called coelenterate.
- concave - Curving inward.
- congener - An organism belonging to the same taxonomic genus as another organism.
- conspecific - Of or belonging to the same species.
- continental shelf - A submerged border of a continent that slopes gradually and extends to a point of steeper descent to the ocean bottom.
- copepod - Any of numerous minute marine and freshwater crustaceans of the subclass Copepoda, having an elongated body and a forked tail.
- costa - A rib or a riblike part, such as the midrib of a leaf or a thickened anterior vein or margin of an insect's wing.
- creel - A daily possession or bag limit for the recreational take of fishes.
- creel limit - Number and sizes of fish that can be legally harvested during a particular time period.
- crown - The top of the head.
- crustacean - Any of various predominantly aquatic arthropods of the class Crustacea, including lobsters, crabs, shrimps, and barnacles, characteristically having a segmented body, a chitinous exoskeleton, and paired, jointed limbs.
- ctenoid - Having marginal projections that resemble the teeth of a comb.
- cultch (material) - A natural bed for oysters, consisting of gravel or crushed shells to which the oyster spawn may adhere.
- cycloid scales - A fish scale which is thin and shows concentric lines of growth, without serrations on the margin.

D

- decapod - A crustacean of the order Decapoda, such as a crab, lobster, or shrimp, characteristically having ten legs, each joined to a segment of the thorax.
- demography - The study of the characteristics of populations, such as size, growth, density, distribution, and vital statistics.
- desiccation - To dry out thoroughly.
- detrital - Loose fragments or grains that have been worn away from rock.
- detritivore - An organism that feeds on dead organic and fecal matter.
- detritus - Loose matter resulting from the wearing away or disintegration of a tissue or substance.

- diapause - A period during which growth or development is suspended and physiological activity is diminished, as in certain insects in response to adverse environmental conditions.
- diatoms - Any of various microscopic one-celled or colonial algae of the class Bacillariophyceae, having cell walls of silica consisting of two interlocking symmetrical valves.
- diel - A 24-hour period, usually encompassing 1 day and 1 night.
- Dieldrin - A chlorinated hydrocarbon, C₁₂H₈Cl₆O, used as an insecticide.
- dimorphic - Existing or occurring in two distinct forms; exhibiting dimorphism.
- dioxin - Any of several carcinogenic or teratogenic heterocyclic hydrocarbons that occur as impurities in petroleum-derived herbicides.
- disking - A mechanical method of scarifying the soil to reduce competing vegetation and to prepare a site to be seeded or planted.
- distensible - That can be distended (To swell out or expand from or as if from internal pressure.)
- diurnal - Occurring or active during the daytime rather than at night.
- dorsal - Of, toward, on, in, or near the back or upper surface of an organ, part, or organism.
- dorsal fin - The main fin located on the back of fishes and certain marine mammals.
- drainage basin - The geographical area draining into a river or reservoir.

E

- echinoderm - Any of numerous radially symmetrical marine invertebrates of the phylum Echinodermata, which includes the starfishes, sea urchins, and sea cucumbers, having an internal calcareous skeleton and often covered with spines.
- ecoregion - An area defined by environmental conditions and natural features; a region defined by its ecology.
- ecotone - A transitional zone between two communities containing the characteristic species of each.
- ectocommensal - A commensal organism that lives on the outer body surface of another organism.
- eddy - A current, as of water or air, moving contrary to the direction of the main current, especially in a circular motion.
- effort - A record of effort in units of time (i.e. days or hours) for which a particular gear (i.e. hook and line or various nets) is used to capture fishes or other aquatic species.
- elongate - Long in proportion to width.
- elvers - An eel in its transparent, postlarval stage. Also called glass eels.
- elytra - Either of the leathery or chitinous forewings of a beetle or a related insect, serving to encase the thin, membranous hind wings used in flight. Also called wing case.
- endemic - Native to or confined to a certain region.

- endopod - The medial or interior ramus of a crustacean appendage. In the Isopoda, another name for a thoracic appendage (exclusive of the coxa and basis), although more typically applied to inner ramus of a pleopod or a uropod.
- epibenthic - Located at the surface of the sediments on the bay bottom, generally referring to algae.
- epifauna - Animals that live on the sediment but do not burrow into it.
- epimeron - In insects: The lateral piece behind the episternum.
- epiphytic - A plant, such as a tropical orchid or a staghorn fern, that grows on another plant upon which it depends for mechanical support but not for nutrients.
- epizootic - Affecting a large number of animals at the same time within a particular region or geographic area.
- estuary - The wide part of a river where it nears the sea; fresh and salt water mix.
- etiology - The study of causes or origins.
- euryhaline - Capable of tolerating a wide range of salt water concentrations.
- eurythermal - Adaptable to a wide range of temperatures.
- eutrophication - Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.
- exarate - To plow up; also, to engrave; to write.
- extirpate - To destroy totally; exterminate.
- exuviae - The cast-off skins or coverings of various organisms, such as the shells of crabs or the external coverings of the larvae and nymphs of insects.

E

- facet - One of the lenslike visual units of a compound eye, as of an insect.
- falcate - Curved and tapering to a point; sickle-shaped.
- fathom - A unit of length equal to 6 feet (1.83 meters), used principally in the measurement and specification of marine depths.
- flagella - A long, threadlike appendage, especially a whiplike extension of certain cells or unicellular organisms that functions as an organ of locomotion.
- flange - A protruding rim, edge, rib, or collar, as on a wheel or a pipe shaft, used to strengthen an object, hold it in place, or attach it to another object.
- flock - A collection of small, loosely held masses or aggregates of fine particles, resembling a tuft of wool and suspended in or precipitated from a solution.
- forbs - A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow.
- fratricide - The killing of one's brother or sister.
- frenum - A membranous fold of skin or mucous membrane that supports or restricts the movement of a part or organ.

freshet - A stream of fresh water that empties into a body of salt water.

frons - The anterior, uppermost part of the head of an insect.

fry - Small fish, especially young, recently hatched fish.

fusiform - Tapering at each end; spindle-shaped.

G

gaster - The portion of the abdomen behind the petiole in ants and other hymenopterous insects.

gastropods - Any of various mollusks of the class Gastropoda, such as the snail, slug, cowrie, or limpet, characteristically having a single, usually coiled shell or no shell at all, a ventral muscular foot for locomotion, and eyes and feelers located on a distinct head.

genotype - The genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms.

gill rakers - Generally stout projections extending from the gills (or better gill arches that support the gills) of fishes that are used to filter appropriate food items while allowing most inedible items to pass out of a fish's operculum or gill-cover.

glass eel - An eel in its transparent, postlarval stage. Also called an elver.

glochidia - The parasitic larva of certain freshwater mussels of the family Unionidae, having hooks for attaching to the gills or other external parts of a host fish.

gonopodium - A modified portion of the anal fin (fin on the lower abdomen posterior to the vent) in males of fishes in the live-bearer family (Poeciliidae) that functions as an organ that transports sperm during internal fertilization or copulation.

gorgonian - Any of various corals of the order Gorgonacea, having a flexible, often branching skeleton of horny material.

granivore - Feeding on grain and seeds.

granulation - 1. Small, fleshy, beadlike protuberances, consisting of outgrowths of new capillaries, on the surface of a wound that is healing. Also called granulation tissue.
2. The formation of these protuberances.

gular pouch - a pouch of bare skin between the lower mandibles (bottom bill parts), seen in such birds as the Brown Pelican. The word "gular" means "pertaining to the throat," and arises from the same Latin word as "gullet."

H

hammock island - Vegetated islands of 0.05 to 404.5 hectares (0.125 to 999.9 acres) in size that are surrounded by tidal wetlands and that are located inland of barrier islands. These uplands are generally not inundated by tide waters and frequently lie within large expanses of tidal-impacted marshland, called 'marsh islands,' that are bordered by tidal waterways.

hard bottom - Also called 'live bottom,' this includes areas of consolidated sediments, rock or other hard substrates that are usually quickly encrusted by living, stationary animals and algae. Such areas frequently have relief or vertical extension into the water

column greater than that of surrounding unconsolidated sand, shell, mud or mixed 'soft' bottoms.

heavy metal - A metal with a specific gravity greater than about 5.0, especially one that is poisonous, such as lead or mercury.

hemispherical - A half of a sphere bounded by a great circle.

hemolymph - The blood analogue used by all arthropods and most mollusks that have an open circulatory system. In these animals there is no distinction between blood and interstitial fluid. The liquid fills all of the interior (hemocoel) of the body and surrounds all cells.

hepatic - Of, relating to, or resembling the liver.

herbivore - An animal that feeds chiefly on plants.

hermaphroditic - Of animal or plant; having both male female reproductive organs

heterogeneity - The quality or state of being heterogeneous. (Consisting of dissimilar elements or parts; not homogeneous.)

holometabolous - Having complete metamorphosis.

holotype - The single specimen or illustration designated as the type for naming a species or subspecies or used as the basis for naming a species or subspecies when no type has been selected. Also called type.

hood (prothoracic covering of the head) - An expanded part, crest, or marking on or near the head of an animal.

hydroid - Any of numerous characteristically colonial hydrozoan coelenterates having a polyp rather than a medusoid form as the dominant stage of the life cycle.

I

imperilment - To put into peril.

impoundment - A body of water, such as a reservoir, made by impounding.

indicator species - An organism whose presence or state of health is used to identify a specific type of biotic community or as a measure of ecological conditions or changes occurring in the environment.

indigenous - Originating and living or occurring naturally in an area or environment.

infauna - Aquatic animals that live in the substrate of a body of water, especially in a soft sea bottom.

infaunal - Organisms that live within the sediment.

inflorescence - 1. A characteristic arrangement of flowers on a stem. 2. A flower cluster.

infraorder - Scientific classification or biological classification refers to how biologists group and categorize extinct and living species of organisms.

instar - A stage of an insect or other arthropod between molts.

interorbital - Situated or extending between the orbits of the eyes.

intertidal - Of or being the region between the high tide mark and the low tide mark.

introgression - Infiltration of the genes of one species into the gene pool of another through repeated backcrossing of an interspecific hybrid with one of its parents.

invertebrate - An animal, such as an insect or mollusk, that lacks a backbone or spinal column.

irruptive migrant - Migrations that are not seasonally or geographically predictable, irruptions may occur in one year but not again for many years. Distances and numbers of individuals involved are less predictable than for partial or complete migrants.

isochronal spawning - To release and fertilize eggs at the same time or interval.

isopod - Any of numerous crustaceans of the order Isopoda, characterized by a flattened body bearing seven pairs of legs and including the sow bugs and gribbles.

isotope - One of two or more atoms having the same atomic number but different mass numbers.

K

karyotypic - Studying the raw genetic information.

keel - A structure, such as the breastbone of a bird, that resembles a ship's keel in function or shape.

keystone species - A species that plays a pivotal role in an ecosystem and upon which a large part of the community depends.

kype - Hooked jaw acquired by trout and salmon, especially at spawning time; it is comprised of cartilage.

L

lacustrine - Living or growing in or along the edges of lakes.

larva - The newly hatched, earliest stage of any of various animals that undergo metamorphosis, differing markedly in form and appearance from the adult.

lentic - Of or relating to or living in still waters (as lakes or ponds).

leptocephalus - One of the small, flat, transparent larvae of eels and certain other fishes, characterized by a long, narrow head.

littoral - A coastal region; a shore.

littoral zone - The region of the shore of a lake or sea or ocean.

live bottom - See hard bottom.

longline - A heavy fishing line usually several miles long and having a series of baited hooks.

lore - The space between the eye and the base of the bill of a bird or between the eye and nostril of a snake.

lotic - Of or relating to or living in actively moving water.

lunule - A small crescent-shaped structure or marking.

M

malacological - The branch of zoology that deals with mollusks.

- malacology - The branch of zoology that deals with mollusks.
- malar stripe - Area at the sides of the chin. Synonym(s): whisker, mustache, malar streak.
- mangrove - A tropical tree or shrub bearing fruit that germinates while still on the tree and having numerous prop roots that eventually form an impenetrable mass and are important in land building.
- mast - The nuts of forest trees accumulated on the ground.
- maxilliped - One of the three pairs of crustacean head appendages located just posterior to the maxillae and used in feeding.
- medus - The tentacled, usually bell-shaped, free-swimming sexual stage in the life cycle of a coelenterate, such as a jellyfish.
- Megalops (megalopal stage) - A larva, in a stage following the zo["e]a, in the development of most crabs. In this stage the legs and abdominal appendages have appeared, the abdomen is relatively long, and the eyes are large.
- melanistic (black) - Dark coloration of the skin, hair, fur, or feathers because of a high concentration of melanin.
- melanophore - A pigment cell that contains melanin, especially as found in the skin of amphibians and reptiles.
- merus - The proximal segment of the hind limb; the thigh.
- mesial - Of, in, near, or toward the middle.
- mesic - Of, characterized by, or adapted to a moderately moist habitat.
- mesohaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 5 ‰ (or ppt = parts per thousand) to 18 ‰.
- mesonota - The upper surface covering the middle segment of the thorax of insects.
- mesoscutellum - The visible triangular piece of the mesonotum between the bases of the elytra.
- mesoscutum - The scutum or dorsal plate of the middle thoracic segment of an insect.
- mesotrophic - Refers to a region with moderate concentrations of nutrients and moderate biological productivity (compare eutrophic and oligotrophic).
- metamorphose - To change into a wholly different form or appearance; transform.
- metanota - The dorsal plate of the last (third) segment of the thorax.
- microhabitat - The microenvironment in which an organism lives.
- mollusk - Any of numerous chiefly marine invertebrates of the phylum Mollusca, typically having a soft unsegmented body, a mantle, and a protective calcareous shell and including the edible shellfish and the snails.
- molt - To shed periodically part or all of a coat or an outer covering, such as feathers, cuticle, or skin, which is then replaced by a new growth.
- montane - Of, growing in, or inhabiting mountain areas.
- morphology - The form and structure of an organism or one of its parts.

morphotype - Morphologically distinguishable portions of populations of a single taxon.

motile - Moving or having the power to move spontaneously.

mottled - To mark with spots or blotches of different shades or colors.

musk – 1. A greasy secretion with a powerful odor, produced in a glandular sac beneath the skin of the abdomen of the male musk deer and used in the manufacture of perfumes.
2. A similar secretion produced by certain other animals, such as the otter or civet.

N

nail - The button-like formation at the end of the mandibles is called the "nail" and is hard, much like a human fingernail.

nape - The back of the neck.

neap tides - The lowest tides of the lunar month, which occur in the second and fourth quarters of the moon.

nektonic - The collection of marine and freshwater organisms that can swim freely and are generally independent of currents, ranging in size from microscopic organisms to whales.

nest parasitism - See brood parasitism.

nocturnal - Most active at night.

nodus - A circumscribed mass of tissue; a node.

nonpoint - Not found or located at a single, definable point, as pollution whose source cannot be ascertained.

nonpoint source pollution - Pollutants detected in a concentrated water source such as a stream, river or lake, that come from a wide range of sources. These pollutants come from sources the common person has control over.

nota - The dorsal part of the thoracic segment of an insect.

nuptial - Of, relating to, or occurring during the mating season.

O

obligate - Able to exist or survive only in a particular environment or by assuming a particular role.

oblique - Having a slanting or sloping direction, course, or position; inclined.

oblong - Having a somewhat elongated form with approximately parallel sides.

obtuse - Not sharp, pointed, or acute in form; blunt.

ocellus (light sensing organ) - A small simple eye, found in many invertebrates, usually consisting of a few sensory cells and a single lens.

oligohaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 0.5 ‰ (or ppt = parts per thousand) to 5 ‰.

oligotrophic - Lacking in plant nutrients and having a large amount of dissolved oxygen throughout. Used of a pond or lake.

olivaceous - Olive-green.

- omnivore - An animal that feeds on both animal and vegetable substances.
- omnivorous - Eating both animal and vegetable foods.
- opercle - Any one of the bony plates which support the gill covers of fishes; an opercular bone.
- operculum - A lid or flap covering an aperture, such as the gill cover in some fishes or the horny shell cover in snails or other mollusks.
- opithosoma - The middle section of the carapace.
- organophosphates - Any of several organic compounds containing phosphorus, some of which are used as fertilizers and pesticides.
- ornithology - The branch of zoology that deals with the study of birds.
- osmoconformer - An invertebrate whose ion concentrations match those in the ocean.
- otolith - Any of numerous minute calcareous particles found in the inner ear of certain lower vertebrates and in the statocysts of many invertebrates.
- ovate - Shaped like an egg; oval.
- overstory - The uppermost layer of foliage that forms a forest canopy.
- oviparous - Producing eggs that hatch outside the body.
- ovipositor - A tubular structure, usually concealed but sometimes extending outside the abdomen, with which many female insects deposit eggs.

P

- palatine - Of or relating to the palate.
- palustrine - Of, pertaining to, or living in, a marsh or swamp; marshy.
- papillose - Having small nipplelike projections, such as a protuberance on the skin, at the root of a hair or feather, or at the base of a developing tooth.
- paramere - One of the symmetrical halves of any one of the radii, or spheromeres, of a radiate animal, as a starfish.
- paranota - Lateral expansions of pronotum.
- pathogen - An agent that causes disease, especially a living microorganism such as a bacterium or fungus.
- pectoral fin - Either of the anterior pair of fins attached to the pectoral girdle of fishes, corresponding to the forelimbs of higher vertebrates.
- peduncle - A stalklike structure in invertebrate animals, usually serving as an attachment for a larger part or structure. A stalklike bundle of nerve fibers connecting different parts of the brain.
- pelage - The coat of a mammal, consisting of hair, fur, wool, or other soft covering, as distinct from bare skin.
- pelagic - Of, relating to, or living in open oceans or seas rather than waters adjacent to land or inland waters.

- pelvic fin - Either of a pair of lateral hind fins of fishes, attached to the pelvic girdle and corresponding to the hind limbs of higher vertebrates.
- penaeid - A inclusive term referring to shrimps in the family Penaeidae, which includes the commercially and recreationally valuable marine and estuarine shrimps of South Carolina.
- peraeopod - One of the thoracic legs of a crustacean.
- perched water table - The water table of a relatively small groundwater body lying above the general groundwater body.
- phenotype - The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.
- photoreceptor - A nerve ending, cell, or group of cells specialized to sense or receive light.
- physiography - The study of physical features of the earth's surface.
- phytophagous - Feeding on plants, including shrubs and trees. Used especially of certain insects.
- phytoplankton - Minute, free-floating aquatic plants.
- pincers - The articulated prehensile claws of certain arthropods, such as the lobster.
- piscivorous - Habitually feeding on fish; fish-eating.
- plankton - The collection of small or microscopic organisms, including algae and protozoans, that float or drift in great numbers in fresh or salt water, especially at or near the surface, and serve as food for fish and other larger organisms.
- planktonic - Of or relating to plankton The collection of small or microscopic organisms, including algae and protozoans, that float or drift in great numbers in fresh or salt water, especially at or near the surface, and serve as food for fish and other larger organisms.
- plastron - The ventral part of the shell of a turtle or tortoise.
- pleopod - one of the paired abdominal appendages of certain aquatic crustaceans that function primarily for carrying the eggs in females and are usually adapted for swimming.
- polychaete worm - Chiefly marine annelids possessing both sexes and having paired appendages (parapodia) bearing bristles.
- polychlorinated biphenyl - Any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are toxic environmental pollutants which tend to accumulate in animal tissues called also PCB.
- polyhaline - A zone of estuaries or tidal waterways where salinity (ocean-derived salt content of the water) ranges 18 ‰ (or ppt = parts per thousand) to 30 ‰.
- polyps - A coelenterate, such as a hydra or coral, having a cylindrical body and an oral opening usually surrounded by tentacles.
- polytene - Relating to or having large multistranded chromosomes whose corresponding chromomeres are in contact.

posterior - Located behind a part or toward the rear of a structure.

precocious - Characterized by or characteristic of exceptionally early development or maturity.

prehensile - Adapted for seizing, grasping, or holding, especially by wrapping around an object.

preopercular - Situated in front of the operculum, a lid or flap covering an aperture, such as the gill cover in some fishes or the horny shell cover in snails or other mollusks.

primary - One of the main flight feathers projecting along the outer edge of a bird's wing.

proboscis - The slender, tubular feeding and sucking organ of certain invertebrates, such as insects, worms, and mollusks.

pronotum - The dorsal plate of the prothorax in insects.

propodus - Second part from the distal end of a leg or maxilliped. In a cheliped the propodus consists of a palmar portion and a narrower, immovable finger

prosoma - The anterior or cephalic portion of the body of certain invertebrates, such as arachnids, in which segmentation is not evident.

protogyny - A state in hermaphroditic systems characterized by the development of female reproductive organs, or maturation of their gametes, before the appearance of the corresponding male product, thus insuring against self-fertilization.

pterostigma - A thickened opaque spot on the wings of certain insects.

punctate - Having tiny spots, points, or depressions.

pupae - The nonfeeding stage between the larva and adult in the metamorphosis of holometabolous insects, during which the larva typically undergoes complete transformation within a protective cocoon or hardened case.

R

raptorial - Subsisting by seizing prey; predatory.

recruitment - The influx of new members into a population by reproduction or immigration.

relict - 1. An organism or species of an earlier time surviving in an environment that has undergone considerable change. 2. Something that has survived; a remnant.

respiratory lamellae - A thin scale, plate, or layer of bone or tissue, as in the gills of a bivalve mollusk or around the minute vascular canals in bone.

rhizomes - A horizontal, usually underground stem that often sends out roots and shoots from its nodes.

rhomboid - A parallelogram with unequal adjacent sides.

riffle - A rocky shoal or sandbar lying just below the surface of a waterway.

riparian - Of, on, or relating to the banks of a natural course of water.

riverine - Located on or inhabiting the banks of a river; riparian.

rostrum - A rostrum (Latin beak) is an anatomical structure resembling a bird's beak, such as part of the carapace of a crustacean. Since the rostrum is typically located about the thorax of an arthropod, it is differentiated from the cauda or tail.

S

sabellid worms - Marine segmented worms (phylum Annelida) in the polychaete class and the family Sabellidae. Sabellid worms build membranous or sand tubes, are sedentary or stationary, and may be called fanworms, feather dusters or Christmas tree worms.

scapular - One of the feathers covering the shoulder of a bird.

scapulets - A secondary mouth fold developed at the base of each of the armlike lobes of the manubrium of many rhizostome medus[ae].

scavenger - An animal, such as a bird or insect, that feeds on dead or decaying matter.

sclerite - A chitinous or calcareous plate, spicule, or similar part of an invertebrate, especially one of the hard outer plates forming part of the exoskeleton of an arthropod.

sclerotized - Hardened by deposition of the protein sclerotin.

scyphomedusae - One of the two subdivisions of the Hydrozoa.

secondary - Of, relating to, or being the shorter flight feathers projecting along the inner edge of a bird's wing.

sessile - Permanently attached or fixed; not free-moving.

seta - A stiff hair, bristle, or bristlelike process or part on an organism.

sexually dimorphic – Physical features such as body size and color differs between the males and females of this species.

sinusoidal - Having a succession of waves or curves.

siphon - A tubular organ, especially of aquatic invertebrates such as squids or clams, by which water is taken in or expelled.

snag - A rough, sharp, or jagged protuberance, as a tree or a part of a tree that protrudes above the surface in a body of water. Also called sawyer.

spatulate - Shaped like a spatula.

spawn - To deposit eggs; produce spawn.

speculum - A bright, often iridescent patch of color on the wings of certain birds, especially ducks.

spermatheca - A receptacle in the reproductive tracts of certain female invertebrates, especially insects, in which spermatozoa are received and stored until needed to fertilize the ova.

spermathecae - A small sac connected with the female reproductive organs of insects and many other invertebrates, serving to receive and retain the spermatozoa.

spermatophore - A capsule or compact mass of spermatozoa extruded by the males of certain invertebrates and primitive vertebrates and directly transferred to the reproductive parts of the female.

spinous - Resembling a spine or thorn.

spinule - A small spine or thorn.

spumaline - A sticky, frothy substance used by adult moths as an adhesive to attach eggs to bark or twigs.

squamous - Covered with or formed of scales; scaly.

stemmata - A small, circular, simple eye present in various insect larvae.

subimago - A stage in the development of certain insects, such as the May flies, intermediate between the pupa and imago. In this stage, the insect is able to fly, but subsequently sheds a skin before becoming mature. Called also pseudimago.

subrhomboidal - Roughly resembling a rhomboid, a parallelogram with unequal adjacent sides (rectangle w/o right angles).

substrata - A layer of rock or soil beneath the surface of the earth; a sedimentary bed.

supercillium - The eyebrow.

supraloral - Situated above the lores; as, the supraloral feathers of a bird.

suture - A seamlike joint or line of articulation, such as the line of dehiscence in a dry fruit or the spiral seam marking the junction of whorls of a gastropod shell.

swash zone - The swash zone is the area of the nearshore that is intermittently covered and uncovered by wave run-up.

symbiotic - A close, prolonged association between two or more different organisms of different species that may, but does not necessarily, benefit each member.

sympatry - The occurrence of organisms in overlapping geographical areas, but without interbreeding.

T

tannic acid - Black or tannic acid rivers and streams have usually clear, tea-colored water that is stained by tannins or fulvic acids that are derived from decaying leaves and other vegetation. Tannic acid or black rivers are generally contained within the Coastal Plain and carry less silt than do the larger, longer rivers that originate in the Piedmont or Mountain ecoregions. Rivers that originate in the Piedmont or farther inland are often called red rivers because of the red or orange color of the water created by high silt loads during high flows.

tarsi - The distal part of the leg of an arthropod, usually divided into segments.

telemetry - The science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources, as from space vehicles, to receiving stations for recording and analysis.

telson - The “tail” of the carapace.

teneral - Of, pertaining to, or designating, a condition assumed by the imago of certain Neuroptera, after exclusion from the pupa. In this state the insect is soft, and has not fully attained its mature coloring.

- terga - The upper or dorsal surface, especially of a body segment of an insect or other arthropod.
- tergite - A sclerite forming one of the constituents of a tergum.
- terrestrial - Of or relating to the earth or its inhabitants.
- thorax - The second or middle region of the body of an arthropod, between the head and the abdomen, in insects bearing the true legs and wings.
- tibia - The fourth division of an insect's leg, between the femur and the tarsi.
- tidal bore - A high wave (often dangerous) caused by tidal flow (as by colliding tidal currents or in a narrow estuary).
- tide pool - A pool of water remaining after a tide has retreated.
- transverse - Lying across the long axis of the body or of a part.
- trapezoid - A quadrilateral having two parallel sides.
- trawl - A conical fishnet dragged through the water at great depths.
- tributary - A stream that flows into a larger stream or other body of water.
- trophic - Of or involving the feeding habits or food relationship of different organisms in a food chain.
- tubercle - A small rounded projecting part or outgrowth, such as a wartlike excrescence on the roots of some leguminous plants or a knoblike process in the skin or on a bone.
- tunicate - Any of various chordate marine animals of the subphylum Tunicata or Urochordata having a cylindrical or globular body enclosed in a tough outer covering and including the sea squirts and salps.

U

- ubiquitous - Being or seeming to be everywhere at the same time; omnipresent.
- umbo - A knoblike protuberance arising from a surface, as the prominence near the hinge of a bivalve shell or the projection at the scale tip of a seed-bearing cone.
- understory - An underlying layer of vegetation, especially the plants that grow beneath a forest's canopy.

V

- vent - The excretory opening of the digestive tract in animals such as birds, reptiles, amphibians and fish.
- ventral - Relating to or situated on or close to the abdomen; abdominal.
- vermiculate - Bearing wavy, wormlike lines.
- vertical niche partitioning - An evolved feeding or foraging strategy in whales by which they primarily feed at different depths or vertical distances above the ocean floor to limit competition between species.
- vestigial - Occurring or persisting as a rudimentary or degenerate structure.

W

watershed - The region draining into a river, river system, or other body of water.

X

xeric - Of, characterized by, or adapted to an extremely dry habitat.

Z

zooplankton - Animal constituent of plankton; mainly small crustaceans and fish larvae.