SOUTH CAROLINA'S
STATE WILDLIFE ACTION PLAN
(SWAP)
2025

SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES
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FINAL
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FOREWORD

South Carolinians are proud of the wealth of natural resources in our state: over 11,000 miles of rivers, 30,000 miles of streams, 11 major lakes, and a degree of plant and animal diversity that is one of the highest in the nation. The State of South Carolina is 20 million acres in size, yet conserved land equates to 17% or 3,400,000 acres, above the national average of 13%. This is a strong testament to our citizenry's commitment to preserving our sense of place and cultural heritage, which is defined in large part by our natural resources.

The South Carolina Department of Natural Resources has a 119-year history, and despite name changes and restructuring over the years, the mission has been and remains "to serve as the principal advocate for and steward of South Carolina's natural resources." South Carolina has a strong fishing and hunting heritage, but these game species represent only 3% of the full array of species in our State. By taking a more holistic view of managing ecosystems, all species and their habitats will benefit, maintaining biodiversity. This biodiversity is what keeps food webs intact, biological processes functioning (e.g. pollination, nutrient cycling), and water quality protected, among other benefits. Every species has its own intrinsic value, but it also is part of a larger network that is vitally important to the health and well-being of human beings. We need only look at the $3.7 billion in free pest control services that our native bats provide and the 130 agricultural products vital to our nation's economy that are pollinated by insects to realize the interconnectedness of our natural world and how dependent we are on its health. It is these robust, fully functioning ecosystems that increase resiliency to stressors like emerging diseases and a changing climate.

Through South Carolina's State Wildlife Action Plan (SWAP), we are taking a proactive approach to conservation instead of a reactionary one, and to that end, we have identified 889 animal and 874 plant species for a total of 1,773 Species of Greatest Conservation Need (SGCN) that require additional attention for maintaining healthy populations. Many of these species may be future candidates for listing under the Endangered Species Act if we do not mitigate for impacts now. Stressors include habitat loss or conversion, environmental contamination, persecution by humans, illegal harvest, non-native invasive species, emerging diseases, the illegal pet trade, and climate change. Sometimes it is a lack of knowledge of the species and its life history that is the concern which can be a limitation to our ability to manage it. Thankfully, technology is rapidly progressing so that new mapping tools, genetic research methods, and tracking technologies are available to help further our knowledge base.

This Action Plan is a guide for addressing threats affecting species' persistence on the South Carolina landscape. Strategies and tools are discussed that can be implemented by SCDNR and its partners to reverse declines. The Plan 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 wildlife and plant resources that are so important to our own lives. It is my hope that you will study the SWAP carefully and join us in helping implement its recommendations.

Robert H. Boyles
Director
South Carolina Department of Natural Resources

ACKNOWLEDGEMENTS

South Carolina's State Wildlife Action Plan (SWAP) represents the hard work of many individuals; without their efforts, this work would not have been possible. Thanks are due the members of the original 2005 Development Committee, the 2005 Conservation Action Committee, and the 2015 Revision Committee, without whom we would not have had such a nice framework from which to develop the 2025 edition. For this 2025 SWAP revision, **Anna Huckabee Smith, CWB®**, SWAP Coordinator at the South Carolina Department of Natural Resources (SCDNR), was the lead writer/editor. SCDNR biologists, partners in conservation and academia, and private citizens that staffed the Taxa Committees spent many hours reviewing and discussing the thousands of species that inhabit this state, prioritizing species and developing the lists that are included in this Plan. Many of these individuals went on to write the detailed reports that are included in the Supplemental Volume and from which all recommended priority actions were developed. Many additional professionals donated their time to help author reports, and their names appear at the top of each species or guild account. Those generous individuals who provided species photographs for this Plan are identified in the Supplemental Volume species and guild accounts.

Besides the lead editor, additional contributors and their affiliations for this 2025 version are listed below by SWAP chapter to which they contributed. A special thanks is given to Joe Lemeris, GIS/Data Manager with SCDNR's Natural Heritage Program, who created the SGCN decision support tool used to determine the SGCN and many of the maps and tables. Photo credits are listed in their captions throughout the Plan chapters and are attributed to free-lance photographers, SCDNR scientific staff, and South Carolina Wildlife (SCW) Magazine staff.

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Supplemental Volume – Species and Guild Accounts: Individual authors are listed for each report. A cultural icon appears on accounts that coincide with Chapter 7 cultural documentation.

Lastly, we would like to thank our conservation partners that have assisted with the implementation of the SWAP over the last 20 years and for their input on how to address data deficiencies, mapping needs, habitat restoration practices, emerging threats, and many others. Your continued devotion to the natural resources of this state is extremely important and needed. Thank you.

"A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."
- **Aldo Leopold**

EXECUTIVE SUMMARY

In May of 2002, the South Carolina Department of Natural Resources (SCDNR) began a process to develop what was then called 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 Strategy was to be cooperative in nature with partnerships formed among agencies, non-governmental organizations, and conservation-minded citizens of our great State. South Carolina's 2005-2010 Strategy was accepted in January 2006.

In 2010, a revision process was initiated and the CWCS was subsequently renamed the **State Wildlife Action Plan (SWAP)** to standardize the name nationally. Due to the rapidly evolving changes in knowledge of the various priority species and Agency personnel changes, the final draft of the 2015 SWAP was accepted in September 2015. In 2023, the SCDNR began the third revision of the SWAP which is presented here. All eight of the required elements have been addressed: (1) list of priority species in need of management, (2) location and condition of required habitats, (3) threats, (4) action items to mitigate for threats, (5) monitoring regimes, (6) procedures for SWAP revisions, (7) coordination with partners, and (8) public participation in Plan review and implementation.

The diversity of animals in South Carolina is vast. Habitats in this state range from the Appalachian Mountains to the Atlantic 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 SWAP; as such, 16 taxonomic groups are included in the Strategy: mammals (terrestrial and marine), birds, reptiles (terrestrial and marine), amphibians, freshwater fishes, diadromous fishes, marine fishes, marine invertebrates, crayfishes, freshwater shrimps, freshwater mussels, freshwater snails, freshwater sponges, leeches (aquatic and terrestrial), insects and allies (freshwater and terrestrial), and plants.

The SCDNR identified 1,774 total species of flora and fauna to include on the State's List of Species with the Greatest Conservation Need (SGCN). Reports were prepared for each species or guild (minus plants and insects); in these reports, authors described the species, their status, population and abundance, habitat needs, challenges faced, conservation accomplishments thus far, and conservation actions still needed. 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 document, the **Supplemental Volume – Species and Guild Accounts**, contains these reports in their entirety. The SCDNR also identified habitats critical for the priority species considered in the SWAP. Both terrestrial and aquatic habitats were considered and Chapter 3 discusses these fine and course-scale habitats organized within 5 ecoregions as well as 5 ecobasins which characterize the freshwater aquatic habitats of the State.

As conservation strategies were developed for each species, it became evident that they could be separated into 7 overarching categories which we have designated as Conservation Action Areas (CAAs). These CAAs are: Land Management, Invasive and Non-native Species Control, Habitat Protection and Restoration, Education and Outreach, Partnerships and Collaborations, Research

and Survey, and Regulatory Actions. Within each CAA, conservation actions were either derived from overarching threats facing a myriad of species or actions that pertain to more specific species or habitat needs. Conservation partners external to the agency also helped identify and refine these action items and their suggestions incorporated.

It is also critical that we monitor priority species, their habitats, and the effectiveness of the actions that are implemented to conserve them. Competitive State Wildlife Grant (C-SWG) and regular SWG projects are monitored to make sure data yields are expanding our knowledge-base and on-the-ground habitat work is truly producing results. Chapters 8 and 9 describe strategies to monitor results of implementation such as creating data storage standards, sharing data, and expanding the use of citizen science networks.

From the beginning of the SWAP effort back in 2005, SCDNR and the planning team sought to realize successful partnerships and public involvement in the development of the Plan. Those relationships carried over into the implementation of the SWAP and the latest revision process. 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. Back in 2005, task forces were convened to assist in determining important natural resource issues in South Carolina. Taxa teams were assembled in 2005 and again in 2013 to determine challenges to species and conservation actions to address those challenges. Public meetings were held in both 2005 and 2012 to gather input from the citizens of the State on various topics. These priority items created during the foundation stages of the SWAP by these early teams have remained relevant, but the data surrounding them have been updated for 2025 through internal and external review and revision processes.

Although SGCN have been added or subtracted over the years from the SWAP, the common themes remain the same. It has been determined that 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 SWAP is a step toward instituting these actions.

"Conservation is a state of harmony between men and land."

– Aldo Leopold

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CHAPTER 1: INTRODUCTION TO THE STATE WILDLIFE ACTION PLAN

The last word in ignorance is the man who says of an animal or plant, "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering. ***- Aldo Leopold***

Historical Context

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

As times and conditions changed, new laws were enacted. In the early 1970s, the Endangered Species Act, Clean Water Act, and Clean Air Act all were developed and companion state laws and programs enacted. At the time, the South Carolina Department of Natural Resources (SCDNR) had a Nongame and Endangered Species Program, so to provide early direction to it, a statewide symposium on endangered species was held in 1976. At that meeting, committees of specialists in vertebrate taxa (mammals, birds, herpetofauna, and fish) were formed to provide information about species that had uncertain status or were believed to be in jeopardy (Forsythe and Ezell 1976). Out of this meeting came the formation of the nation's first Heritage Trust Program wherein the taxa committees continued to meet periodically and update the lists of species to be tracked under the Program. Rare plants were also added to the list of species tracked. The plight of nongame species had begun to be recognized and the fact that there was no comparable funding source to game species that would assist with research, surveys, and restoration projects. This would require planning and prioritizing species and actions. A national push for conserving the breadth of biodiversity had begun.

The charge to state wildlife agencies to develop comprehensive strategies had its origins in the Wildlife Conservation and Recreation Program (WCRP) that was created in the federal Appropriations Act of 2001. Appropriations language provided that funds may be used for "...the planning and implementation of [a state's] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education,

and wildlife-associated recreation projects" (114 STAT. 2762A -118 PUBLIC LAW 106–553 — APPENDIX B — Title IX).

The WCRP appropriations language challenged the states to develop projects in the three major areas anticipated in the Teaming with Wildlife initiative: conservation, education, and recreation. WCRP appropriations language also provided that "Within five years of the date of the initial apportionment, [the states shall] develop and begin implementation of a wildlife conservation strategy based upon the best available and appropriate scientific information and data …." Specific criteria for wildlife conservation strategies were developed. South Carolina committed to developing its "wildlife conservation strategy" within the required five years 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 emphasized conservation projects alone and charged the states "…to develop by October 1, 2005, a comprehensive wildlife conservation plan [strategy], consistent with criteria established by the Secretary of the Interior, that considers the broad range of the State, territory, or other jurisdiction's wildlife and associated habitats, with appropriate priority placed on those species with the greatest conservation need and taking into consideration the relative level of funding available for the conservation of those species…" (115 STAT. 414 PUBLIC LAW 107-63 — APPENDIX A). The document that all states ultimately prepared in response to this mandate was referred to as a Comprehensive Wildlife Conservation Strategy (CWCS) or State Wildlife Action Plan (SWAP). As per Required Element 6 of the original legislation, all states made a commitment to review and revise their plans within 10 years. Over time, the Strategy became referred to as the State Wildlife Action Plans or SWAPs.

Since 2015, new initiatives have come forth to try to secure permanent and substantial funding for implementing the SWAPs. One of these initiatives has been the Recovering America's Wildlife Act (RAWA) of 2021, which grew out of recommendations by the Blue Ribbon Panel of 2016. To match the magnitude of the problem, it was determined that $1.3 billion was needed to invest in the conservation and restoration of species listed in SWAPs to avoid further declines in biodiversity. State wildlife agencies and conservation partners continue to push for its eventual funding. Figure 1-1 outlines the history of nongame funding initiatives resulting in SWAPs. Additional resources can be found at Association of Fish and Wildlife Agencies (AFWA).

South Carolina has made its SWAP action items, listed both in Chapter 9 and the Supplemental Volume under each species or guild, at scales that can be accomplished through State Wildlife Grants and those requiring the additional funding of RAWA. This "RAWA-ready" approach to South Carolina's SWAP will make the transition to a larger implementation regime easier should funding be forthcoming.

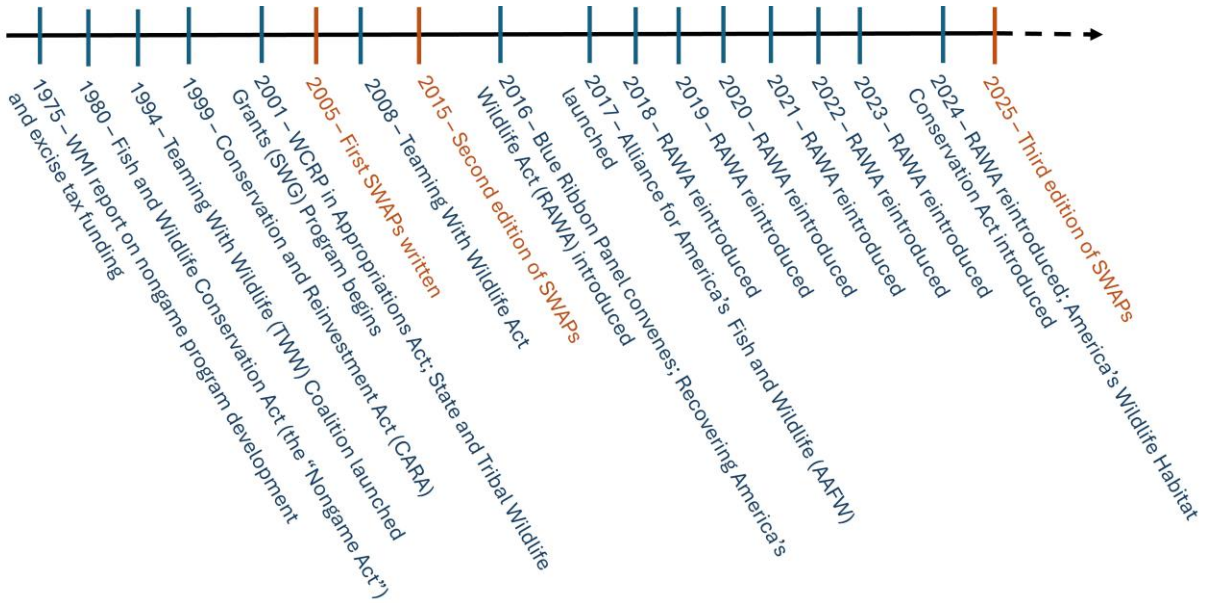

FIGURE 1-1: A timeline of conservation initiatives and funding proposals resulting in SWAP development and SWG funding and the push for additional SWAP implementation funding through RAWA.

Agency Authority and Capacity for SWAP Preparation and Implementation

South Carolina's Constitution of 1895, as revised, mandates in Article XII, Section 1 that "the health, welfare, and safety of the lives and property of the people of this State and the conservation of its natural resources are matters of public concern." Article III, Section 34 states in relevant part: "that the General Assembly is empowered to divide the State into as many game zones as may appear practicable, and to enact legislation that may appear proper for the protection of game in the several zones."

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

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

> and other action by the General Assembly in its judgment conducive to the conservation of wildlife.

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

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

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

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

In October 2020, South Carolina passed the "Turtle Law" (§50-15-70) to regulate the collection, possession, and transfer of native turtles, all of which were SWAP Species of Greatest Conservation Need (SGCN) at the time the law was enacted. In March of 2024, SCDNR's Natural Heritage database was granted a Freedom of Information Act (FOIA) exemption under §50-15-100, protecting the locations of the State's sensitive species and habitats.

The men and women of SCDNR's Law Enforcement Division are instrumental in protecting both game and nongame species within South Carolina's jurisdictional boundary but also cooperating with neighboring states. Photo by SCDNR media staff.

South Carolina's SGCN are utilized by SCDNR's Office of Environmental Programs to advocate for avoidance and minimization of impact to sensitive species and their habitats through existing regulatory frameworks, such as the Federal Clean Water Act and Federal Energy Regulatory Commission processes and state regulatory authority related to mining, state navigable waters, water quality certification and coastal wetlands and tidelands. Additionally, the SWAP is utilized as a resource for environmental practitioners when developing habitat information for threatened and endangered species for Clean Water Act compensatory mitigation banking instruments and threatened and endangered species assessments associated with environmental impacts.

The Partner and Public Participation Process

Since the creation of the first SC SWAP in 2005 (the Comprehensive Wildlife Conservation Strategy or CWCS, as it was originally named), the SCDNR and SWAP planning team have sought to realize successful partnerships and public involvement in the creation and implementation of the Plan. It is understood that successful conservation is furthered by the existence of a strong collaborative involvement between all resource stakeholders, private or public, governmental or non-governmental. In July 2003, a Neighboring States meeting was held

in association with our regional Federal Assistance coordinators to discuss issues common to all as well as to develop an outline and format for our Action Plans. Participating states included Virginia, North Carolina, South Carolina, Georgia and Alabama. The model created was one of two used by the US Fish and Wildlife Service as an example for the rest of the nation to emulate.

The SCDNR retained the Clemson Institute for Economic and Community Development (CIECD) to manage and conduct the Public Participation Process with planning beginning in January 2004. The team used a parallel participation process (focus groups and public meetings) to ensure that both the professional and general public concerns and comments were separately heard and acknowledged. The team identified the issues of most prominent concern for wildlife conservation from both the perspective of agency staff and that of individuals and groups outside of the SCDNR. First, focus groups were developed to determine the wildlife conservation priorities of the SDCNR's partners. Representatives from partner groups were invited to share their ideas with the planning team. These partner organizations included federal and state agencies such as the United States Fish and Wildlife Service, the United States Forest Service, Clemson University, and the South Carolina Forestry Commission. Likewise, non-governmental organizations like The Nature Conservancy, South Carolina Sporting Protection League, South Carolina Native Plant Society, Safari Club International, and local land trusts were also involved. To ensure that SCDNR received input from partners with more diverse interests in wildlife conservation, other non-governmental organizations also participated in the focus groups including developers, local and county planners, professional foresters, and representatives from the agricultural community.

Five focus group meetings were held across the State in 2004 and were facilitated by our partners at Clemson Extension. Participants were invited via email and phone calls. The goal of these meetings was to identify general actions that would protect priority species in South Carolina and effective monitoring programs. After the focus group meetings, the SCDNR conducted four public meetings throughout South Carolina to allow all segments of the population to provide their opinions on priorities for wildlife conservation in the State. Announcements for the meetings were advertised in newspapers, mentioned on local television news reports, and an interview with the SWAP (CWCS) Coordinator was conducted by ETV radio. The information obtained through the focus groups allowed the SCDNR to be better prepared to answer questions that might arise during these public meetings. Public meetings were attended by representatives of groups similar to those present at the focus group meetings as well as members of the general public. The public meetings brought together a wider array of people and concerns. However, the dominant actions were similar to those stated in the focus groups: public education, land use planning, habitat acquisition and protection, research and monitoring, water quality protection, inter- and intra-agency collaboration, and landowner incentives. Therefore, in 2005, Conservation Action Committees were formed to further define main topics that came from the focus groups and public meetings. These became Conservation Action Areas (CAAs) and included eight topics: education and outreach, habitat protection, invasive and non-native species control, private land cooperation, public land management, survey and research needs, urban and developing lands. After the 2005 SWAP (CWCS) was completed, in 2006 SCDNR drafted an Implementation Plan which made suggestions for priority research. Many of these suggested topics went on to become State Wildlife Grant proposals that were chosen for funding and have been successfully completed.

While planning for the second edition of the SWAP (released in 2015), the topic of climate change was recognized as a ninth CAA. In 2012, the South Carolina State Climatology Office produced "The Climate Connection Workshop Series: Climate Variability and Impacts to South Carolina's Natural Resources" which was held three times in three different locations across the State and attracted 151 total participants representing federal, state, and local governments; scientists; land and water resource managers; utility representatives; non-governmental organizations (NGOs); the media; private companies; and other interested stakeholders. The purpose of these workshops was to increase awareness and utilization of climate knowledge to improve natural resource management. There exists a genuine need for new approaches and partnerships to cope more effectively with climate variability. The series was advertised to the general public on the State Climatology Office's website, but also invitations were sent to approximately 350 select individuals / organizations that had attended like conferences and workshops in the past. As with the 2005 focus groups and public meetings, workshops were strategically located across the State: Charleston, Columbia, and Greenville. Over 26 speakers participated. A PowerPoint presentation on the State Wildlife Grants program and South Carolina's State Wildlife Action Plan (SWAP) was presented at each workshop. Feedback gathered from these workshops was distilled into meaningful action items for the 2015 SWAP by the editor and editing teams.

In 2013, an effort was made to better engage Indigenous Peoples (tribes), starting with South Carolina's only federally recognized tribe residing in-state, the Catawba Indian Nation. Suggestions that came out of that initial meeting and subsequent ones for the 2025 edition are addressed in Chapter 7 of this SWAP. The draft 2015 SWAP was posted on the SCDNR's website for public review for 35 days and constructive suggestions incorporated into the final Plan which was also posted online. After the advertised rollout of the 2015 SWAP edition, SCDNR's Information Technology (IT) department began tracking usage of the various chapters of the SWAP by partners and the public. Based on this data and through feedback from partners, the 2025 revision was streamlined to remove non-essential, reporting-out portions and those actions that have already been implemented. The highest use of the SWAP occurred around grant proposal submittal windows when Project Investigators were citing specific information for their grants. Also, species that had recently been in the news were queried in the SWAP.

Throughout the intervening years before the 2025 revision began, a volunteer/citizen science website was created with opportunities for implementation of the SWAP. A display was created for use at school career days and agency events with representative SGCN from the five ecoregions and multiple taxa groups. Species and guild accounts found in the Supplemental Volume were utilized by grade-school and college students for projects highlighting South Carolina's SGCN. The Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Wildlife Diversity Committee had subcommittee discussions and planning for SWAP standardization across the states and oversaw the creation of Regional Species of Greatest Conservation Need (RSGCN) lists for both animals and plants. SCDNR expanded its tribal and cultural group engagement while also providing outreach and education to a Master Naturalist group wanting to learn to identify SGCN plants. The Natural Resources Conservation Service (NRCS) was educated on the SWAP through a year-long Learning Series highlighting species included in the 2015 SWAP (and to be included in the 2025 edition) by taxa group and habitat.

Final reports from research done since the inception of SWAPs was uploaded to the SCDNR SWAP website for information sharing with scientists. One of the biggest achievements that occurred relating to data gathering by partners to inform future SWAPs was the upgrading of the Natural Heritage Program database and creation of multiple sighting forms for use by the general public and found on an updated portal. This database upgrade was funded through a partnership with the South Carolina Department of Transportation (SCDOT).

The development of every South Carolina SGCN list for the past three SWAPs, as well as the species and guild accounts for listed species contained in the Supplemental Volume, has been a broad, collaborative effort through the years that has involved partners from all over the Southeastern United States and from every facet of natural history background. The taxa teams responsible for creating the species lists were selected from among agency staff but also included subject matter experts from universities, museums, other agencies, and conservation organizations. Taxa leaders often sought input from colleagues from all over the country. Without this vast network, the creation of the SGCN list would not have been possible.

Long-standing partnerships and new partnerships were formed for the 2025 SWAP chapter revision process too. The Camo Coalition, begun in 2007, meets intermittently and is composed of 30 organizations that represent the outdoors/sportsman community which focuses on habitat and maintaining sporting traditions. On September 17, 2024, the SWAP Coordinator gave a virtual presentation to 12 members representing 8 participating organizations on the SWAP revision process and a request for review of Chapters 8 addressing action items. On October 16, 2024, the SWAP Coordinator repeated the presentation to the Conservation Leaders' Summit, a coalition composed of 48 organizations that meet annually to discuss natural and cultural resource alignment with economic development for proper environmental stewardship for South Carolina's citizens. Held on Seabrook Island, this meeting was attended by 50 participants representing multiple organizations in a SWAP break-out session. The South Carolina Wildlife Federation (SCWF) oversaw the compilation of partner comments from both coalitions. Relevant edits and suggestions were incorporated into the draft SWAP and went through a final internal review before being placed on the SCDNR's website for a 30-day public review period. A summary of this input is visualized in the timeline depicted in Figure 1-2. Implementation is discussed in more detail in Chapter 8 and a more extensive list of conservation partners can be found in Appendix 1. Appendix 6 includes the online content for the public review and associated survey.

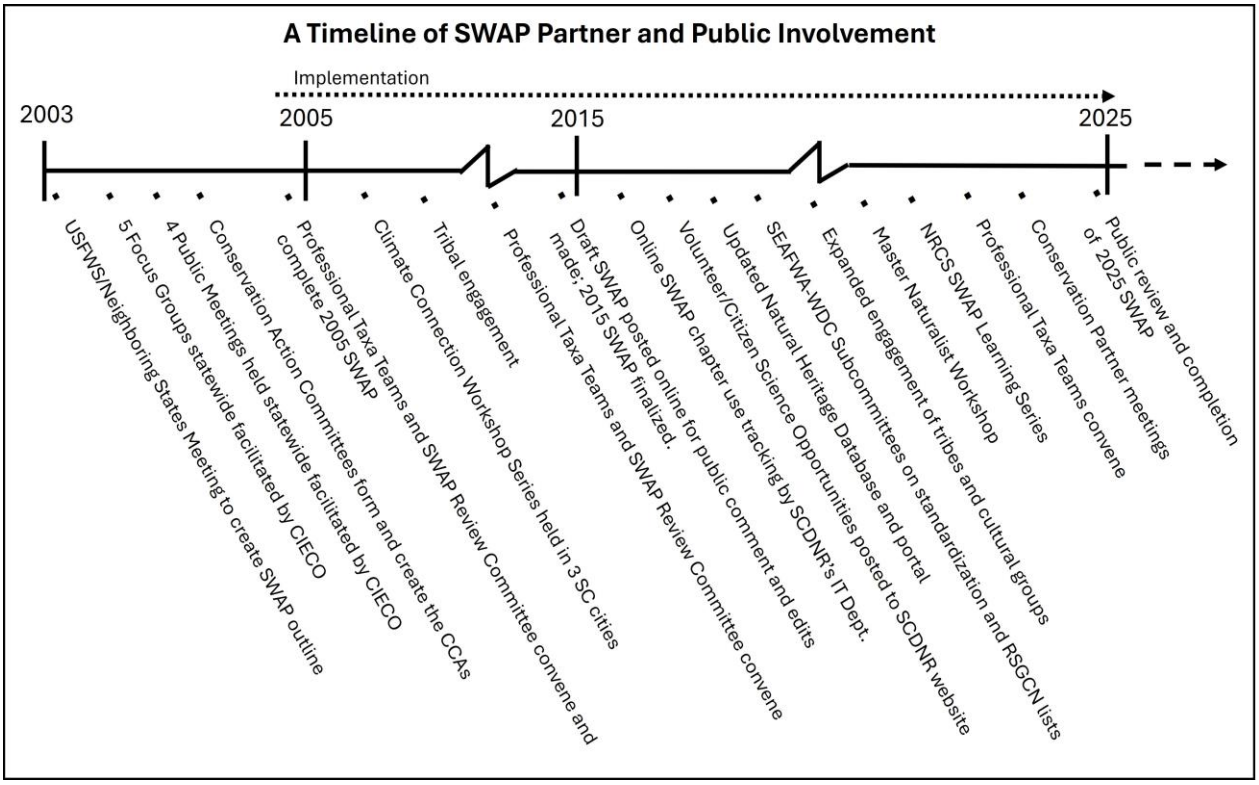

FIGURE 1-2: A timeline of public and partner participation in the creation and implementation of the SWAPs.

Changes to This Edition of the SWAP

The first edition of the SC SWAP was released in 2005 and was a written document that was published and distributed as requested. Threats to the species listed within this SWAP were acknowledged and action items identified. Subsequently, the 2015 edition reported on the progress made towards implementation of these action items and also included plants for the first time as SGCN. This edition was not printed but instead hosted on the SCDNR's website with a CD version available. Also, beginning in 2021, the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Wildlife Diversity Committee began the discussion through a subcommittee of how member states could better standardize their SWAPs. Products included a standard lexicon, a succinct methodology, utilizing the Southeast Regional List of Greatest Conservation Need (RSGCN) for both animals and plants as part of a regional chapter, and creating Conservation Opportunity Areas (COA) maps that follow hydrologic unit codes instead of geopolitical boundaries. These suggestions were incorporated into South Carolina's SWAP for this 2025 revision as well as a standardized threat list adapted from the Georgia Conservation Measures Partnership (CMP 2016).

Additionally, the parent Association of Fish and Wildlife Agencies (AFWA), in association with the United States Fish and Wildlife Service (USFWS), lead a 2023-2024 subcommittee to produce a guidance document; South Carolina's SWAP Coordinator was a member of this drafting subcommittee. Based on the May 2024 release of the Digital SWAP Interim Guidance (USFWS and AFWA 2024), South Carolina's 2025 will remain a web-hosted SWAP presented as a single document for download as a PDF or printed. There are two parts to South Carolina'

SWAP: (1) a main document with introductory material and overarching themes and (2) a supplemental volume containing species and guild (group) accounts for the SGCN. The Supplemental Volume – Species and Guild Accounts will be online only and appear as links to specific accounts.

As South Carolina's SWAP is meant to be web-hosted, new links have been added to point the reader to primary sources, mapping programs, initiatives, agency websites, and other planning documents. There are a multitude of other plans and initiatives within the State, Southeastern region, and nation, and therefore are referenced in Appendix 2 or in the Literature Cited sections of each chapter. As their content is extensive and often overlaps with or complements the SWAP, this 2025 edition of the SWAP will not duplicate efforts and will instead call attention to these additional resources. As South Carolina's SWAP has become well-known, it is often referenced in other State plans and initiatives and is often a required citation in grant applications aimed at land acquisition or restoration projects.

For the **2025 South Carolina State Wildlife Action Plan**, all statistics were updated as needed. A new geology section was added to further describe the unique landscape in South Carolina. The habitat chapter went through a complete re-write to better define vegetative classifications by ecoregion and incorporate more marine habitats. Threats and stressors were consolidated into a single chapter. Conservation actions and monitoring strategies that have been fulfilled or have become obsolete since the 2015 SWAP were removed from the text. Those that are ongoing are represented in the appropriate sections of this SWAP. A new cultural chapter draws attention to Indigenous peoples (tribal) relationships with South Carolina's flora and fauna. The Gullah/Geechee cultural community is also addressed in this chapter. A new chapter on international conservation was added to acknowledge cross-national conservation needs of some SGCN.

A revised methodology was introduced this revision cycle which first required a review of the subnational ranks (S-ranks; state ranks) of all species occurring in South Carolina and tracked through NatureServe. These are also important for NatureServe to receive as they are then used to inform global ranks (G-ranks) for the species. Using a rubric developed by the Southeastern Association of Fish and Wildlife Agencies Wildlife Diversity Committee's SWAP Standardization Subcommittee (SEAFWA-WDC 2022), of which the South Carolina SWAP Coordinator was a member, all S-ranks of native species of South Carolina were reviewed and edited as needed, and those that fit the criteria for SWAP inclusion were auto-sorted into priority bins of highest, high, moderate, and data deficient. The data deficient category is new for this SWAP iteration and helps capture those species prioritized for inclusion but for which not enough information is available to adequately sort into a defensible priority category. The new methodology resulted in some species from past iterations of the SWAP being dropped from the list of Species of Greatest Conservation Need (SGCN) and new ones being added. More information on this method revision can be found in Chapter 6, and the SEAFWA recommendations report can be accessed on Georgia Department of Natural Resource's SWAP Revision Support website where it is hosted. Additional species were added or subtracted due to new data on population trends. Taxonomic advances resulted in some species receiving common and scientific name changes. Lastly, some species changed priority bins, especially with the

addition of a fourth choice, "data deficient", which was more descriptive than previously lumping these into the "moderate" category with other species with better known life histories.

The **Supplemental Volume – Species and Guild Accounts**, under separate cover, underwent a revision of each species account or guild account, and some new guilds were formed to better represent assemblages versus single-species accounts. These consolidations made both ecological and editorial sense. A new taxa group, freshwater sponges, was added this iteration of the SWAP. Table 1-1 summarizes the changes in species number by taxa from 2015 to 2025. Figures 1-3 and 1-4 visualize the change in taxa representation in the SWAP from the 2015 version to this 2025 edition. In the 2025 SWAP edition, there are 899 animals and 874 plants, for a total of 1,773 species. Overall, the number of SGCN more than doubled this iteration.

TABLE 1-1: Changes in Species Number by Taxa (2015-2025)

TAXA	2015	2025	Net Change
Mammals (including marine)	32	37	+5
Birds	164	80	-84
Herpetofauna (including marine)	54	69	+16
Freshwater Fishes	57	53	-4
Diadromous Fishes	6	6	0
Crayfishes	24	30	+6
Freshwater Shrimps	1	3	+2
Freshwater Mussels	28	23	-5
Freshwater Snails	3	16	+16
Leeches	4	6	+2
Freshwater Sponges	0	17	+17
Marine Fishes	37	79	+42
Marine Invertebrates	54	97	+43
Insects (& Allies)	32	383	+351
Plants	332	874	+542
TOTALS	**828**	**1,773**	**+945**

Insects and plants took on a much larger role in this 2025 edition as they are recognized for their importance in the base of the food chain. Insects and their allies are an extremely important taxa group for their roles in pollination, natural pest control, and decomposition (deMaynadier et al. 2024). In South Carolina, invertebrates (e.g. freshwater mussels) are animals and considered "wildlife" in state statute; therefore, by extension of that definition, so are insects and their allies. For this edition of the SWAP, even though most of the insects are data deficient, 42 distinct groups had members considered eligible SGCN. Having insects and related species included in the South Carolina SWAP provides visibility and encourages research and management efforts (deMaynadier et al. 2024) for this huge base of the food web and ecosystem. Already, some groups have been gaining attention since half of the Endangered Species Act (ESA)-listed insects are pollinators as their ranges have shrunk nationwide. It is estimated that 80-90% of pollinators are insects (NPS 2023) and 90% of flowering plants require pollination (EPA 2019), inextricably linking these two taxa groups together.

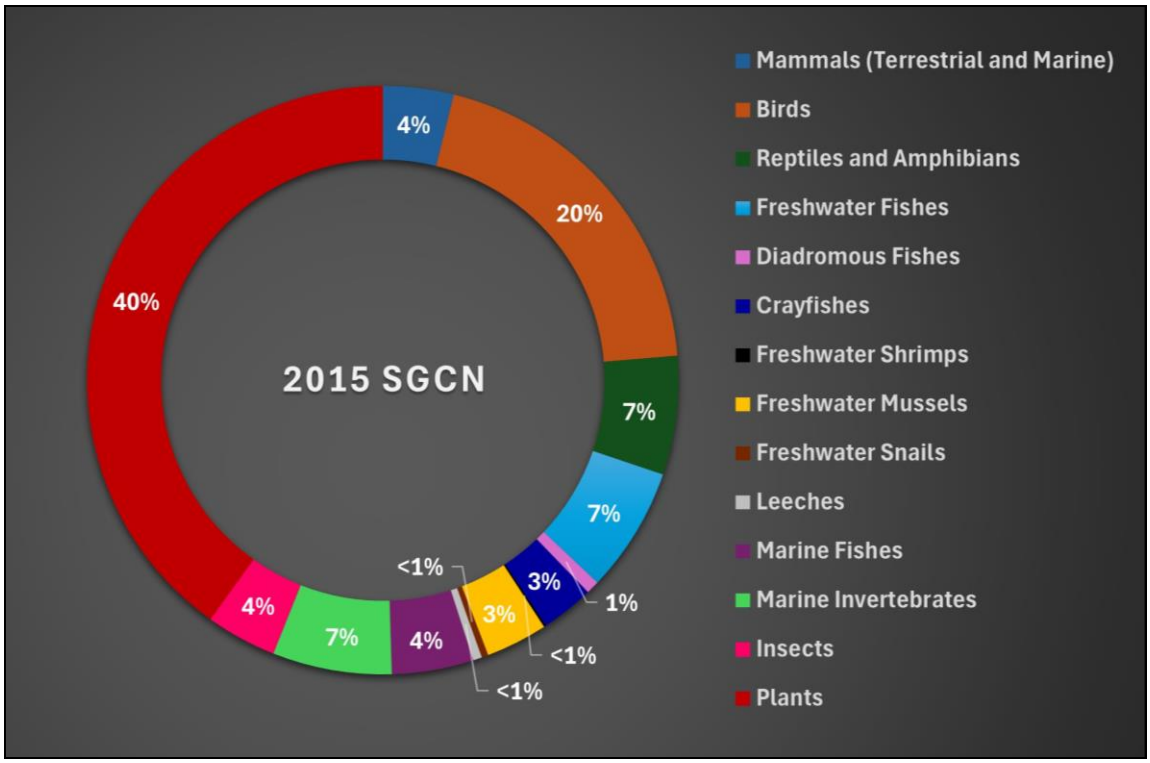

FIGURE 1-3: SGCN by taxa percentage appearing in the 2015 SWAP. Note that freshwater sponges were not included in the 2015 Plan (0%) and are new for 2025.

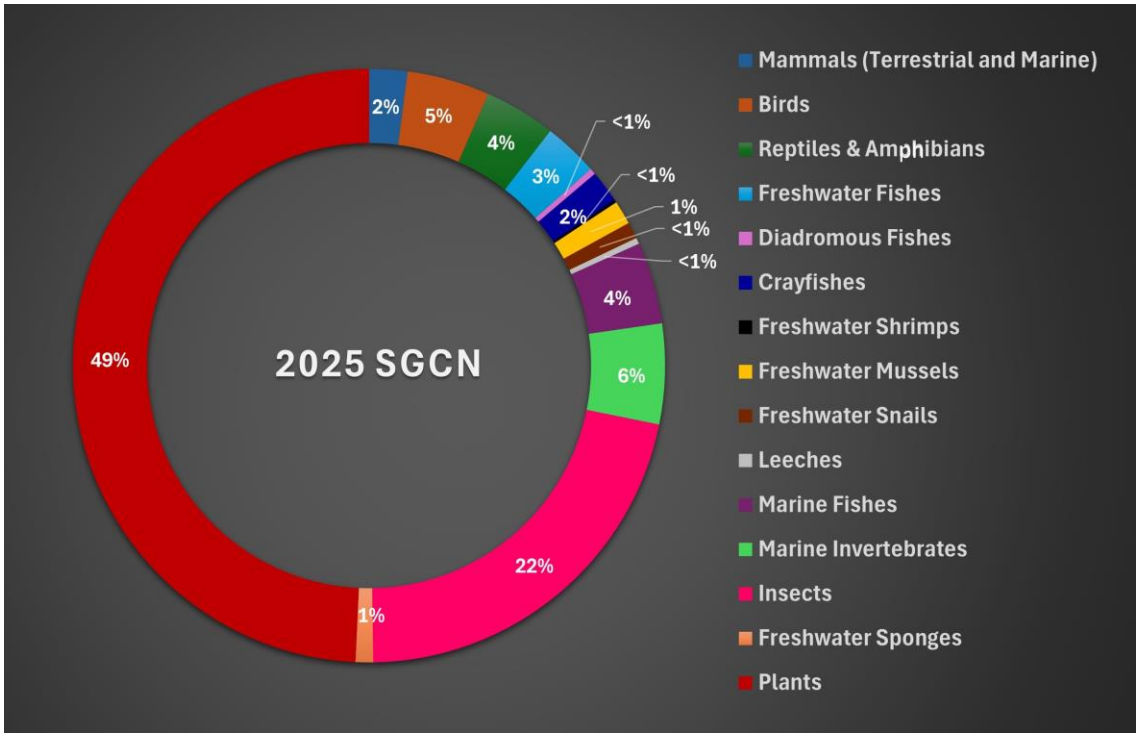

FIGURE 1-4: SGCN by taxa percentage appearing in the 2025 SWAP. A new addition is the freshwater sponges taxa group.

The SCDNR has filed **Emerging Issues letters** in the past to address mid-cycle needs for such species as Monarch Butterfly and Carolina Hammerhead. This revision cycle, in June 2016, a letter was submitted to allow for the pooling of funds with other states to create the Southeast At-Risk Species (SEARS) Program through the SEAFWA Wildlife Diversity Committee. It was utilized to complete three projects before ending in 2018. In May 2021, the "Hanukkah" Darter (*Etheostoma binotatum*) was added to South Carolina's SGCN list followed in July 2021 by the Monarch Butterfly (*Danaus plexippus*) utilizing Emerging Issues Letters. Additionally, the Gray Bat (*Myotis grisescens*), a federally endangered species, was discovered for the first time in Upstate South Carolina in August 2023. An Emerging Issues letter was filed in 2024 so that SWG funding could be utilized to study this population.

Carolina Hammerhead. Photo by James Strange, SCDNR.

Interestingly, the "Hanukkah" Darter was suspected to be a genetically distinct species needing to be addressed alongside its already SGCN-listed kin. The Monarch Butterfly is now being considered for federal listing under the ESA. However, only the Monarch Butterfly now appears in this 2025 version of the SC SWAP. The Christmas Darter in South Carolina's 2015 SWAP occurs in the Savannah basin (Georgia / South Carolina) as well as the Altamaha River basin of Georgia. For a long time, ichthyologists have recognized that the one occurring in the Savannah and the one in the Altamaha appear physiologically different and are probably distinct species. The Savannah form has been proposed in some literature as the "Hanukkah" Darter (*E. binotatum*). However, this has not yet universally been officially accepted (i.e. the American Fisheries Society names committee did not include it in their most recent [2023] version). If and when this "split" becomes official, South Carolina's form of this fish will be re-named the Hanukkah Darter while the Christmas Darter will be retained by the Altamaha fish. Therefore, at this time, the Hanukkah Darter is not be listed in the 2025 SWAP.

The SCDNR enlisted the help of Southeast Conservation Adaptation Strategy (SECAS) staff to draft Chapter 10: South Carolina: A Regional Perspective which addresses how South Carolina is doing its part to achieve success in the Southeast. Landscape-level topics include habitat connectivity across geopolitical boundaries, climate change modeling for the Southeast, Sentinel Landscapes, habitat restoration (to help reach SECAS report card goals), and RSGCN responsibility.

SWAP Organization and the Eight Required Elements

South Carolina's State Wildlife Action Plan is organized to first make the reader aware of the need for a strategy with its prioritization of species, an introduction to South Carolina's unique landscape, and then to discover how the actual Plan was developed and is being implemented. Each state's SWAP must identify and prioritize "Species with the Greatest Conservation Need"

(SGCN), yet still address the "full array of wildlife" and wildlife-related issues. They must provide and make use of the core required elements identified in Box 1-1.

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 item 1.
3. Descriptions of **problems** which may adversely affect species identified in item 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** proposed to conserve the identified species and habitats and priorities for implementing such actions.
5. Proposed plans for **monitoring species** identified in item 1 and their habitats, for monitoring the effectiveness of the conservation actions proposed in item 4, and for adapting these conservation actions to respond appropriately to new information or changing conditions.
6. Descriptions of **procedures to review the plan** at intervals not to exceed ten years.
7. Plans for **coordinating** the development, implementation, review, and revision of the plan with Federal, State, and local agencies and Native American 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. **Public participation** during development and implementation of the Plan.

The contents in the main body of the SWAP are summarized as follows:

- **Chapter 1:** A discussion of the need for the SWAP, timeline of its creation, and the legislative mandate that allows SCDNR to develop and implement such a strategy is presented. This chapter also emphasizes the role of public participation in both the creation and implementation of the SWAP. The SCDNR formed extensive partnerships during the initial development of the SWAP and has retained them through past and current revision processes. The organizational layout and roadmap to the Eight Required Elements are defined. Also, changes to this edition of the SWAP are identified.
- **Chapter 2:** A picture of South Carolina's landscape is presented through descriptions of the basic ecoregions found therein, aquatic resources, soils composition, geology, typical climate, ecosystem functionality (connectivity, resiliency, carbon sequestration, natural fire return intervals), land ownership patterns (public vs. private), demographics, economics, urbanization trends, and miliary presence. The State's conservation portfolio is explained through the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3 Rs"). Carbon sequestration and fire return intervals further define the landscape of the State and the resulting habitats.
- **Chapter 3:** The various habitat types found in the State are defined by ecoregion with priority habitats emphasized. These habitats have various scales from course to fine, but all help determine the Conservation Opportunity Areas (COAs) summarized in a map

representation (in Chapter 8) that focuses research/survey efforts, land acquisition, and restoration projects.

- **Chapter 4:** The reader is introduced to the state of the 16 taxa groups covered in this SWAP, threats facing them from a whole taxa perspective, and opportunities available to mitigate for these threats.
- **Chapter 5:** Following the taxa group descriptions and threats specific to these groups, this chapter takes a wider view of 19 threat categories and their secondary impacts common to most of the species identified as SGCN in the South Carolina SWAP.
- **Chapter 6:** The methodology used to identify South Carolina's priority wildlife species that appear as SGCN in this SWAP is discussed and a spreadsheet listing the 1,773 SGCN are the main substance of this chapter.
- **Chapter 7:** Some of South Carolina's SGCN and priority habitats are also of cultural significance, and this chapter emphasizes the connection between these and cultural groups. These include the Indigenous Peoples (Tribes) with ancestral ties to the State and the Gullah-Geechee Nation of African descent residing in the Lowcountry of South Carolina.
- **Chapter 8:** The Conservation Opportunity Areas map provided in this chapter visually represents focus areas for land acquisition. Also, actions proposed to mitigate threats and stressors identified in both Chapter 5 and in individual species/guild accounts are outlined by seven broad topic groups known as Conservation Action Areas (CCAs): Land Management, Invasive and Non-native Species Control, Habitat Protection and Restoration, Education and Outreach, Partnerships and Collaborations, Research and Survey, and Regulatory Actions. These actions are more comprehensive in their approaches and are both habitat-based and species based. Also, effectiveness monitoring of these actions is addressed. A list of ongoing monitoring programs and projects in South Carolina is provided.
- **Chapter 9:** SWAP Implementation comes in the form of technical research and survey work done by conservation partners and academia, land acquisition and habitat restoration by state agencies and partners, and through the conservation efforts of the general public. The Plan review and revision process is explained as well as hopes for future improvements as science and technology provide new mechanisms for tracking and managing species and habitats. The grant funding mechanisms associated with implementing the SWAP—State Wildlife Grants and Competitive State Wildlife Grants—are explained and summaries/abstracts of completed projects are provided, representing successes in implementation.
- **Chapter 10:** South Carolina's role in the landscape continuum of the Southeast is addressed. Topics shared with other Southeastern states include Regional Species of Greatest Conservation Need (RSGCN), fire return intervals, and climate change impacts. Species vulnerability and resilience are addressed.
- **Chapter 11:** As some species do not complete their entire life cycles within the United States, a final chapter on International Conservation is included to draw attention to these species and the fact that management of them is made more difficult by their trans-national migrations.
- **Appendices** associated with the SWAP include a list of conservation partners; a list of conservation plans and initiatives; lists of non-native invasive plants and animals; a more

detailed explanation of the selection process for Freshwater Fish SGCN; and the methodology for the public review and survey process.

A **Supplemental Volume – Species and Guild Accounts** is also part of this State Wildlife Action Plan. The Supplemental Volume contains "mini recovery plans" for the SGCN (priority species) which include a description of the distribution and abundance of each species and its habitat requirements, the challenges that the species faces, and specific conservation actions for addressing those challenges. Additionally, some of these reports discuss ways to work with public and private entities toward conservation as well as strategies for monitoring species, habitats, and effectiveness of conservation actions. When species share similar habitats or life history traits, they are assembled into guilds for ease of discussion.

The Supplemental Volume to South Carolina's SWAP provides a unique look into challenges and conservation actions that pertain to each of the species on this state's SGCN list. By providing species-specific actions, the SCDNR can use the SWAP 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 or guild-specific approach in the Supplemental Volume allowed for the development of very concise conservation actions for each species or grouping, which are expected to permit SCDNR or its partners to easily convert those actions to project proposals/plans.

Roadmap to the Required Elements in South Carolina's SWAP

As part of the national guidance, states are instructed to highlight the location of information specific to the eight elements so that reviewers of the SWAP can easily locate them. Therefore, Table 1-2 presents this information.

TABLE 1-2: Roadmap to the Eight Required Elements in the SC SWAP

ELEMENT	SC SWAP CHAPTER	LOCATION
1. SGCN identified	Chapter 1	some discussions p. 1-10 to 1-13
	Chapter 6	methodology throughout chapter; Table 6-2
	Supplemental Volume	by species/guild account
2. Location and relative condition of key habitats	Chapter 3	entire chapter
	Supplemental Volume	by species/guild account
3. Threats to SGCN	Chapter 4	entire chapter
	Chapter 5	entire chapter
	Appendices 3A, 3B, & 4	entire lists
	Supplemental Volume	by species/guild account
4. Conservation actions described	Chapter 8	entire chapter (state/local scale)
	Chapter 11	entire chapter (national/international scale)
	Supplemental Volume	by species/guild account
5. Monitoring and adaptive management implementation	Chapter 8	monitoring: p. 8-24 to 8-26; Table 8-2
	Chapter 9	adaptive management: p. 9-4 to 9-6
	Supplemental Volume	by species/guild account
6. Review and revision process for the SWAP	Chapter 9	p. 9-6 to 9-7
7. Coordinating with agencies and Native American	Chapter 1	p. 1-5 to 1-8
	Chapter 7 (Cultural Chapter)	Tribal & Gullah Geechee: entire chapter

tribes.	Chapter 8	see action items throughout chapter
	Chapter 9	coordination: throughout chapter
	Appendix 2	partner list
8. Public participation	Chapter 1	p. 1-5 to 1-8
	Chapter 9	p. 9-6
		See also Element #7 listings

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CHAPTER 2: SOUTH CAROLINA'S CONTEMPORARY LANDSCAPE

> "To keep every cog and wheel is the first precaution of intelligent tinkering."
>
> **- Aldo Leopold**

The State of South Carolina, one of the 13 original colonies, lies within the Southeastern part of the United States, and as such, is in a hotspot of ecological diversity because of its sub-tropical climate, aquatic diversity, habitat types, and variety of soils and topography. Because of this climate (USDA plant hardiness zones 7a-9a), the State was an historic producer of cotton, indigo, rice, and other staple agricultural products, with timber production now the number one agricultural product. Growing industries in South Carolina include automotive, aerospace, and tourism. The following sections detail current landscape features, historical features, and modern demographics, economics, human population patterns and expansions.

General Ecoregion Descriptions

Five general ecoregions exist in South Carolina and are visualized in Figure 2-1. Each ecoregion is classified by its soils, geology, and floristic and faunal components. Ecoregions delineated for the SWAP are largely based on the EPA's Ecoregions of South Carolina (Griffith et al. 2002); however, to more generally reflect variations in habitat/ecosystems across the State, several modifications were implemented:

- Blue Ridge and Piedmont Ecoregions are directly delineated from the EPA dataset's Level III Blue Ridge and Piedmont regions;
- The 'Sandhills' Ecoregion is predominantly the Level IV Sand Hills region, extending coverage along the border of the Piedmont region;
- The 'Coastal Plain' Ecoregion is comprised of the Level III 'Middle Atlantic Coastal Plain' plus the 'Southeastern Plains' (excluding the sandhills);
- The 'Coastal Zone' Ecoregion is derived from the Level III 'Southern Coastal Plain region, which was then extended northward along the shoreline of Horry County to include shoreline/dune habitats in this part of the coast.

Blue Ridge (Mountain) Ecoregion – A narrow belt forming the Southeastern terminus of the Blue Ridge Physiographic Province, which extends from southern Pennsylvania to northern Georgia, ranging from about 200-1,083 m (656-3,554 ft.) in elevation, characterized by steep slopes on Paleozoic crystalline rocks, narrow river valleys, and high-gradient streams; predominantly vegetated by extensive hardwood and hardwood-conifer forests. The ecoregion concept in this SWAP follows Griffith et al. (2002).

Piedmont Ecoregion – A portion of the Piedmont Physiographic Province characterized by rolling hills with highly weathered soils, often severely eroded, overlying mostly Paleozoic crystalline rock substrates, with low-gradient streams on narrow floodplains; vegetation consists mostly of pine and pine-hardwood forests interspersed with agricultural land. The ecoregion concept in this SWAP follows Griffith et al. (2002).

Sandhills Ecoregion – A nearly continuous belt of broad, rolling hills along the Fall Line, generally having sandy soils derived from coarse Cretaceous and Tertiary marine sediments; predominantly vegetated by pine forests interspersed with agricultural land, with hardwood forests on narrow floodplains along medium-gradient streams. For the SWAP, we treat the Sandhills as a distinct ecoregion, including the contiguous Savannah River floodplain. This differs from Griffith et al. (2002) who treated it as a subregion of the "Southeastern Plains," the Inner Coastal Plain. We also include a small, isolated area of the Southeastern Plains at the intersection of Aiken, Edgefield, and Saluda counties to maintain continuity.

Coastal Plain Ecoregion – A series of broad belts derived from a variety of marine sediments, all oriented somewhat parallel to the coastline, the innermost consisting of rolling hills and the outermost consisting of flat terraces. The vegetation consists of pine-dominated forests interspersed with agricultural land on better-drained sites, hardwood forests occupying broad floodplains along low-gradient streams, and extensive pine forests on less well-drained terraces. For this SWAP, we combine the "Southeastern Plains" and "Middle Atlantic Coastal Plain" into a single ecoregion, as well as the contiguous Savannah River floodplain, differing from Griffith et al. (2002). We also include the High Hills of Santee region of Sumter County in this ecoregion, rather than as a disjunct area of the Sandhills ecoregion. Note that other literary sources further divide the Coastal Plain into Inner and Outer Coastal Plains and delineate the Slate Belt above the Sandhills at the Fall Line where the Piedmont "falls away" into the flatter Coastal Plain.

Coastal Zone Ecoregion – The seaward extension of the Coastal Plain Ecoregion, extending from the inland boundary of saltwater influence, seaward to the artificial three-mile offshore limit. Habitat types range from forested variants of Coastal Plain types at inland sites, seaward to sand flats and pine-hardwood forests on unstable emergent coastal sediments, and finally to emergent marshes and submerged bottoms in association with open water. The SWAP differs slightly from Griffith et al. (2002) by extending the ecoregion north along the coast to the North Carolina border, including the entire coast of Horry County.

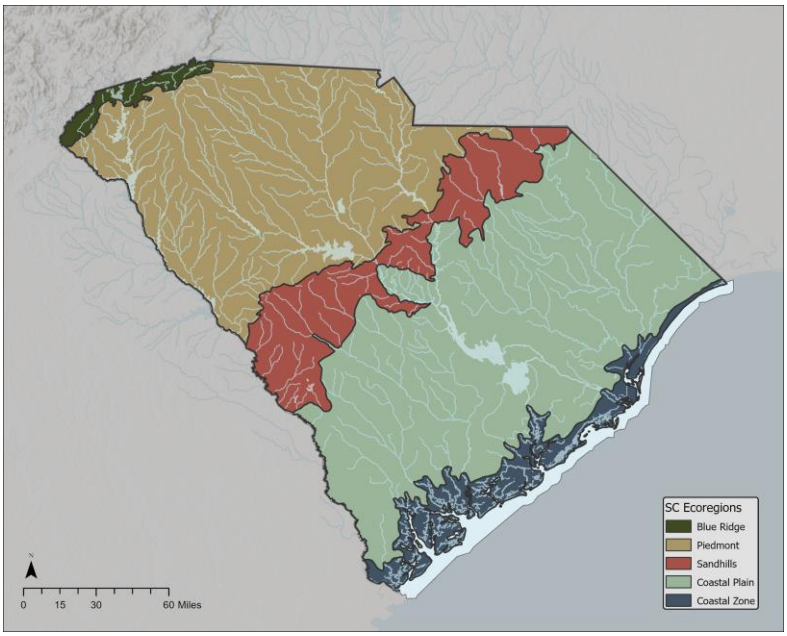


FIGURE 2-1: The five ecoregions of South Carolina, adapted from Griffith et al. (2002) with modifications to account for floristic and faunal assemblages.

Aquatic Resources

One fourth of the land base of the State of South Carolina is classified as wetlands. South Carolina possesses over 17,703 km (11,000 mi.) of permanently flowing rivers and over 48,280 km (30,000 mi.) of permanent and non-permanent streams. The land area that drains to a common river is called a drainage basin, with water flowing from the smallest ephemeral streams into larger streams and eventually rivers. South Carolina is drained by four major river basins--the Savannah, Santee, Pee Dee, and Ashepoo/Combahee/Edisto (ACE) (Figure 2-2). The Santee basin is often subdivided further into the Broad, Congaree/Lower Santee, Catawba/Wateree, and Saluda basins, with the state represented by 7 basins. These, in turn, are made up of 39 sub-basins with their own hydrologic unit codes (HUCs). According to the US Forest Service's Forests to Faucets 2.0 Data Explorer (USFS 2024), South Carolina has 2,100 watersheds, 847 surface water intakes, and 6.6 million of the population using surface water. Except for the ACE Basin, each of the basins originate in the Blue Ridge Ecoregion and pass through the Piedmont, Sandhills, Coastal Plain, and Coastal Zone. Part of the ACE Basin, the Edisto River is the third longest undeveloped free-flowing river in the Southeastern United States. Twenty of South Carolina's rivers connect directly with the State's coastal estuaries, and all rivers and receiving estuaries are dependent on upstream lands and tributaries. There are 11 major lakes in South Carolina, all of which are man-made. The South Carolina Department of Natural Resources' (SCDNR) State Lakes Program stocks and manages 17 small lakes and ponds across the State, a majority of which are in the Piedmont. South Carolina's major water bodies, rivers, and bays are illustrated in Figure 2-3. South Carolina's coastline is the 11th longest in the nation at 301 km or187 mi. If all convolutions (bays, inlets, etc.) are included, South Carolina ranks 12th with 4,628 km or 2,876 mi. of shoreline. The marine ecosystem occurs along all of South Carolina's Atlantic Ocean coastline and extends offshore to the State 4.8 km (3 mi.) jurisdictional boundary, incorporating a surface area of nearly 140,000 ha (345,946 ac.).

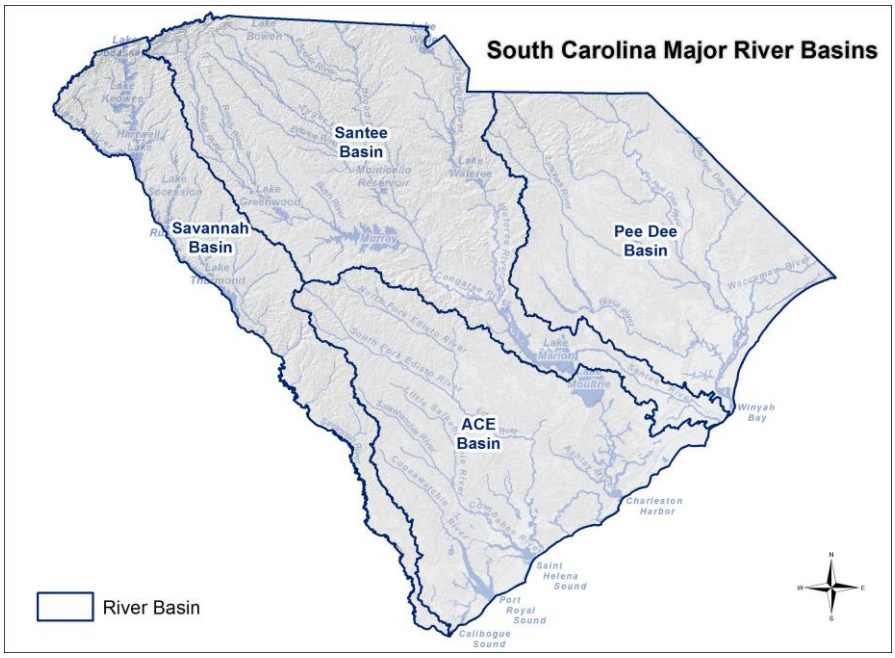


FIGURE 2-2: South Carolina's major river basins.

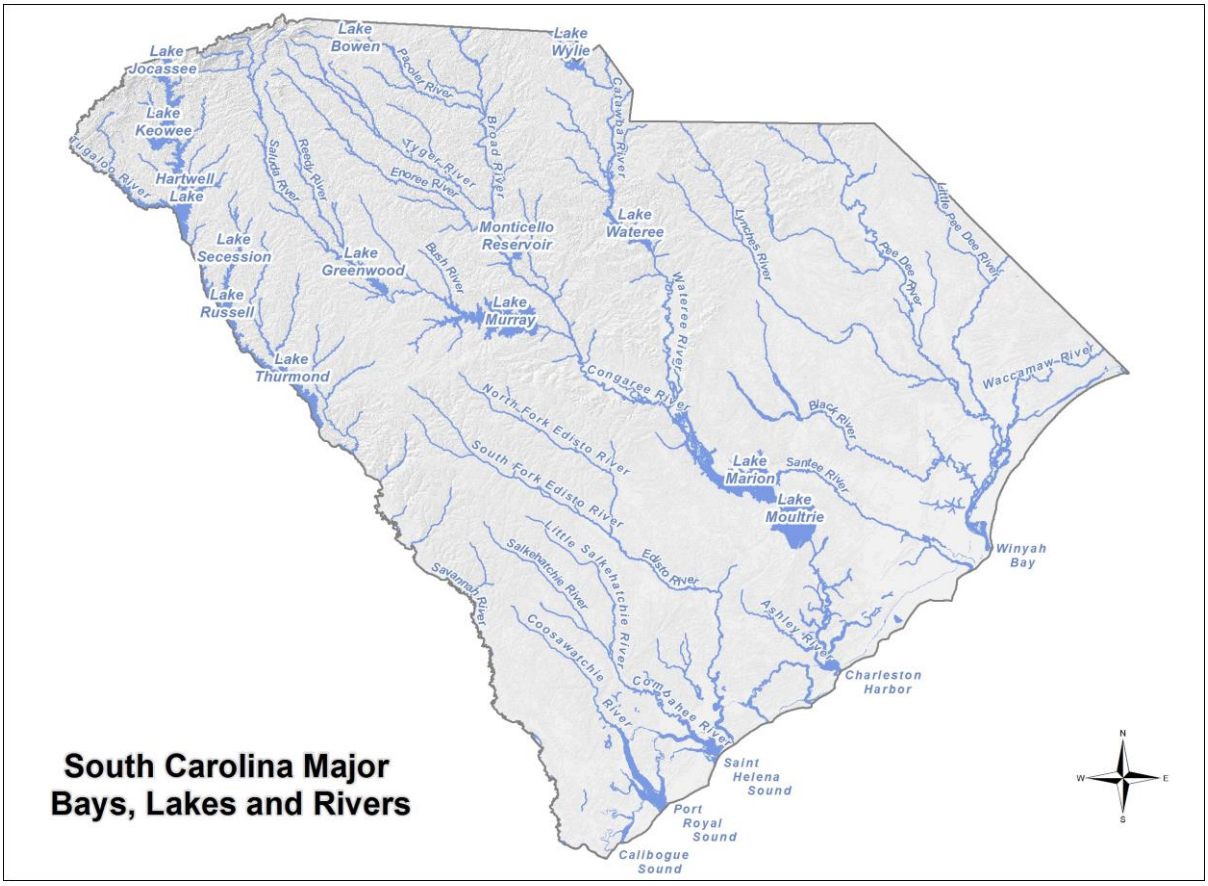


FIGURE 2-3: South Carolina's major bays, lakes, and rivers.

A view of Lake Marion from the Orangeburg County, SC side. Photo by Anna Smith, SCDNR.

Soils

Of the approximately 20,000 soil taxonomic series that are identified and classified in the United States, South Carolina has 278. South Carolina soils typically have an organic matter content of less than 5% (closer to 1% or less across the Piedmont region). Some wetland soils, however, may have greater than 50%. Figure 2-4 depicts the generalized arrangement of ecoregional soils, and Official Soil Series Descriptions (OSD) can be found on the Natural Resources Conservation Service's (NRCS) website.

The majority of soils in the Coastal Plain are sandy or loamy sand in texture. They generally have minimal organic matter, a low cation exchange capacity and water holding capacity, and are infertile. Water rapidly percolates through the soils and can potentially carry contaminates to the shallow water tables and hydrologically connected surface waters. Closer to the coast, depressions and low-lying areas have more poorly drained soils with finer textured subsoil.

Soil texture becomes finer the further west and northward into the State. The "Sandhills," were so named after prehistoric dune remnants. The Sandhills area is a transitional zone located between the Coastal Plains and the Piedmont regions. Soils in this area have textures that range from a fine sand to loam. As with the Coastal Plain soils, Sandhills soils have minimal organic matter. Many soils have a finer textured subsoil (clay hardpan) that can limit deep rooting, and result in horizontal movement of rapidly percolating waters above the hard pan to receiving water bodies.

Soils of the Piedmont and Blue Ridge Ecoregions are commonly termed "Piedmont soils." The soils are predominately loamy clay to clay in texture. The majority are deep soils except for soils on steep slopes and tops of mountains. In these two environments, the soils are shallow with the parent material close to the surface. These heavier textured soils have minimal organic matter but high cation exchange capacity and water holding capacity. Water infiltrates slowly, so rapid rainfall can result in surface water runoff and minimal infiltration.

Soil horizons. Photo by SCDNR.

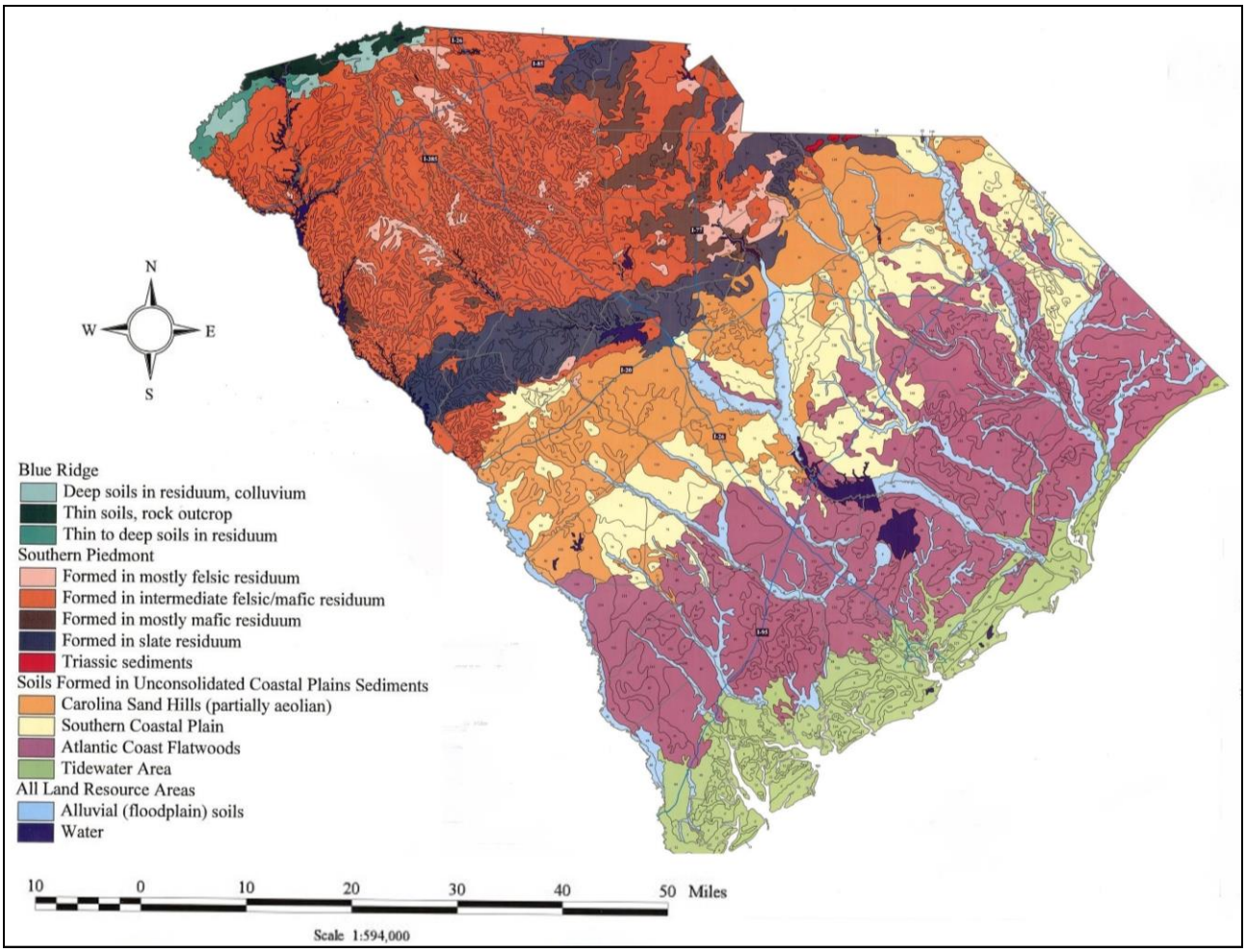


FIGURE 2-4: General Soil Map of South Carolina. Produced by SCDNR for the SCMAPS Program in cooperation with USDA-NRCS (1997).

Geology

South Carolina's geology can be broadly separated into two provinces: The Piedmont/ Blue Ridge, and the Atlantic Coastal Plain. The Piedmont/ Blue Ridge lies west of Columbia and consists of South Carolina's oldest rocks. Gneisses that are 1.1 billion-year-old (BYO) lie west of the Blue Ridge escarpment and represent part of Rodinia, the supercontinent that formed prior to Pangea. East of the escarpment, there are 300-500 million-year-old (MYO) igneous and metamorphic rocks that formed part of a now extinct ocean basin and a series of volcanic island arcs. Well-known granite balds such as Table Rock and Caesars Head intruded into the overlying metamorphic rocks as they were thrust onto the North American continent when Pangea developed. Piedmont rocks are prospective sources of

Fossilized Megoladon teeth are often found in coastal rivers and estuaries of South Carolina. Photo by Anna Smith, SCDNR

dimension stone, lithium, gold, base metals, and rare earth elements. The Carolina Slate Belt is a 550 MYO volcanic arc that hosts some of the United States earliest worked gold deposits.

The "Wando Whale," an ancient species found in Charleston County 32-30 MYA when the county was under the Atlantic Ocean. Photo taken at the Mace Brown Museum of Natural History at the College of Charleston by Anna Smith, SCDNR.

The Atlantic Coastal Plain is east of Columbia and consists of Triassic (180 MYO) and younger sedimentary rocks deposited following the breakup of Pangea and the opening of the Atlantic Ocean. In the Upper Coastal Plain, the Carolina Sandhills are capped by wind-swept eolian dunes formed over the last 3 million years. Beneath the dunes are sands and clays that record the rise and fall of sea level over the last 65 million years. Exposed in the incised valleys of the Coastal Plain are fragments of extinct deltas, river systems, beaches, and shallow seas. Within these rocks we find fossil evidence of the creatures that inhabited those environments – shark teeth, whale bones, mollusks, and plant life. In parts of the Coastal Plain, caves formed in shallow marine limestones provide habitat for bats and other land-dwelling creatures. In South Carolina, Snows Island in Florence County contains the epicenter of the 11-mi. radius of the Johnsonville Crater created 200-90 MYA during the Mesozoic Era (Talwani et al. 2003). It is the only verified impact crater in South Carolina. The Pee Dee River curves around the inner rim and streams flow into the center in a radial pattern.

Eroded sandstone pillars at Peachtree Rock Heritage Preserve in Lexington County, SC recall a time when this part of the State was under the ocean. Photo by Anna Smith, SCDNR.

Approaching the Lower Coastal Plain, subtle hills, valleys, and ridges mark other remnant shorelines, salt marshes, Carolina Bays, and barrier islands that were at one time ocean-front real estate in South Carolina. Along the modern-day coastline, the dynamic ebb and flow of the wind

and the waves can be seen, simultaneously building and destroying the beaches and dunescapes, reminding South Carolinians that understanding present-day processes are the key to unlocking Earth's past and future.

The High Hills of the Santee, the remnant of an ancient ocean shoreline, can be seen in the distance from the overlook at Wateree Heritage Preserve. These hills run for 25 miles through Sumter and Lee Counties in South Carolina. Photo by Anna Smith, SCDNR.

South Carolina is one of the most seismically active States on the eastern seaboard (Figures 2-5 & 2-6), recording on average about 20 earthquakes per year. The average magnitude is roughly around M2.0. All earthquake activity in South Carolina is classified as Intraplate. It is not caused by the interaction of two or more tectonic plates at their edges like on the West Coast, Turkey, or Japan. Intraplate earthquakes occur within major plates in supposedly stable areas. The earthquakes occur on faults that formed during previous events (i.e. inherited structures). It is proposed that the assembly and separation of Pangea during the Mesozoic is the origin of South Carolina's inherited structures.

South Carolina has had some notable seismic events, especially the 1886 Charleston earthquake which occurred on the evening of August 31st that registered between M6.0 and M7.3. It killed 60 people and caused widespread damage to the city of Charleston. The Charleston area has historically been the most active area for seismic activity. It was and still is the largest known earthquake to have occurred in eastern North America. This remains an enigmatic event as the source area is buried by a few thousand feet of Coastal Plain deposits. There were surficial disturbances associated with it, such as sand blows, liquefaction areas, twisted railroad tracks, and damaged buildings, but a surficial expression of the source fault has never been identified. Modern seismicity indicates clustering of epicenters around Summerville defining three fault segments: The North and South Woodstock Faults, and a short connecting fault, the Sawmill

Branch fault. The more extensive Woodstock Fault is considered a candidate source structure for the 1886 earthquake.

Since late 2021, however, a swarm of over 100 earthquakes has been occurring northeast of Columbia in the Elgin-Lugoff area, along what is known as the Eastern Piedmont Fault System (EPFS). The EPFS was recognized in the late 1970's from aeromagnetic data. This system extends from Georgia to South Carolina and into North Carolina approximately parallel to the Piedmont-Coastal Plain contact, the Fall Line. The EPFS is a network of anastomosing linear faults (NE and ENE trending) that create a highly complex pattern of interconnected faults. Seismicity in the EPFS is frequent, but magnitudes are much less than the 1886 Charleston event. A major state-sponsored earthquake study from the early 2000's suggests that the greatest magnitude to be expected would be approximately M5. Most earthquakes are in the M2-3 range (Figure 2-5).

Reservoir Induced Seismicity are small earthquakes associated with changing water levels in large bodies of water (i.e. Monticello Reservoir, Lake Jocassee). Changing water levels create differences in pore pressure of fluids at depth. An increase in pore pressure can induce an earthquake to occur. These are small magnitude events, typically not exceeding M2.

Small earthquakes do occur outside the three areas previously described. They are typically low magnitude events that cause no damage or concern.

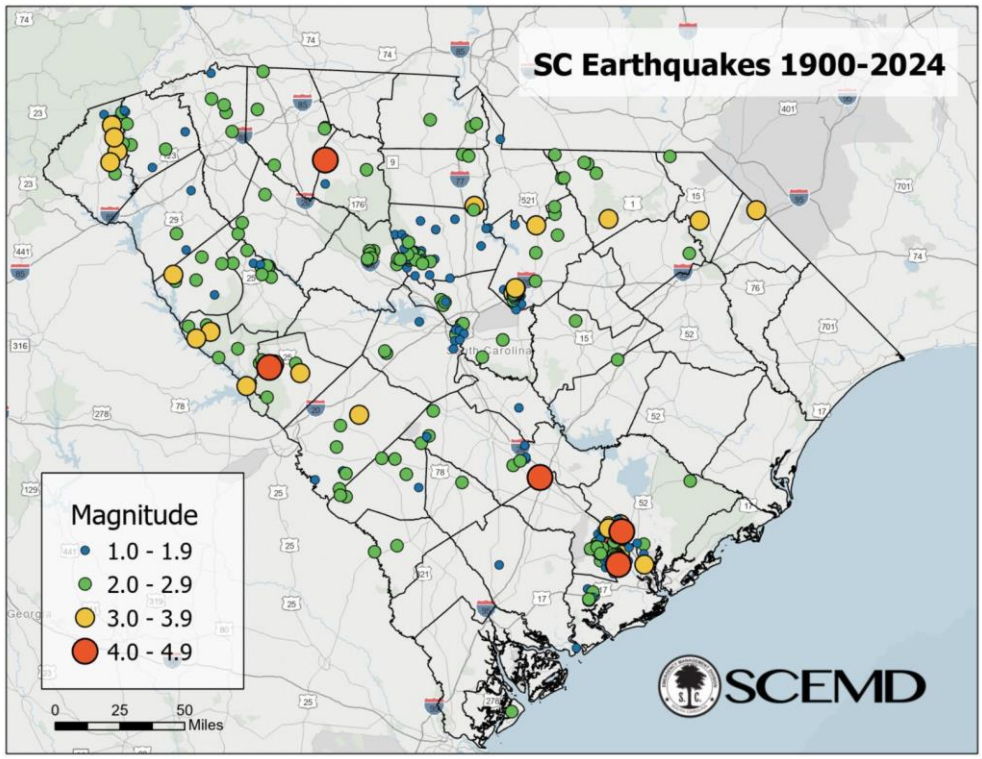


FIGURE 2-5: Magnitude tracker for earthquakes in South Carolina over the last 124 years.

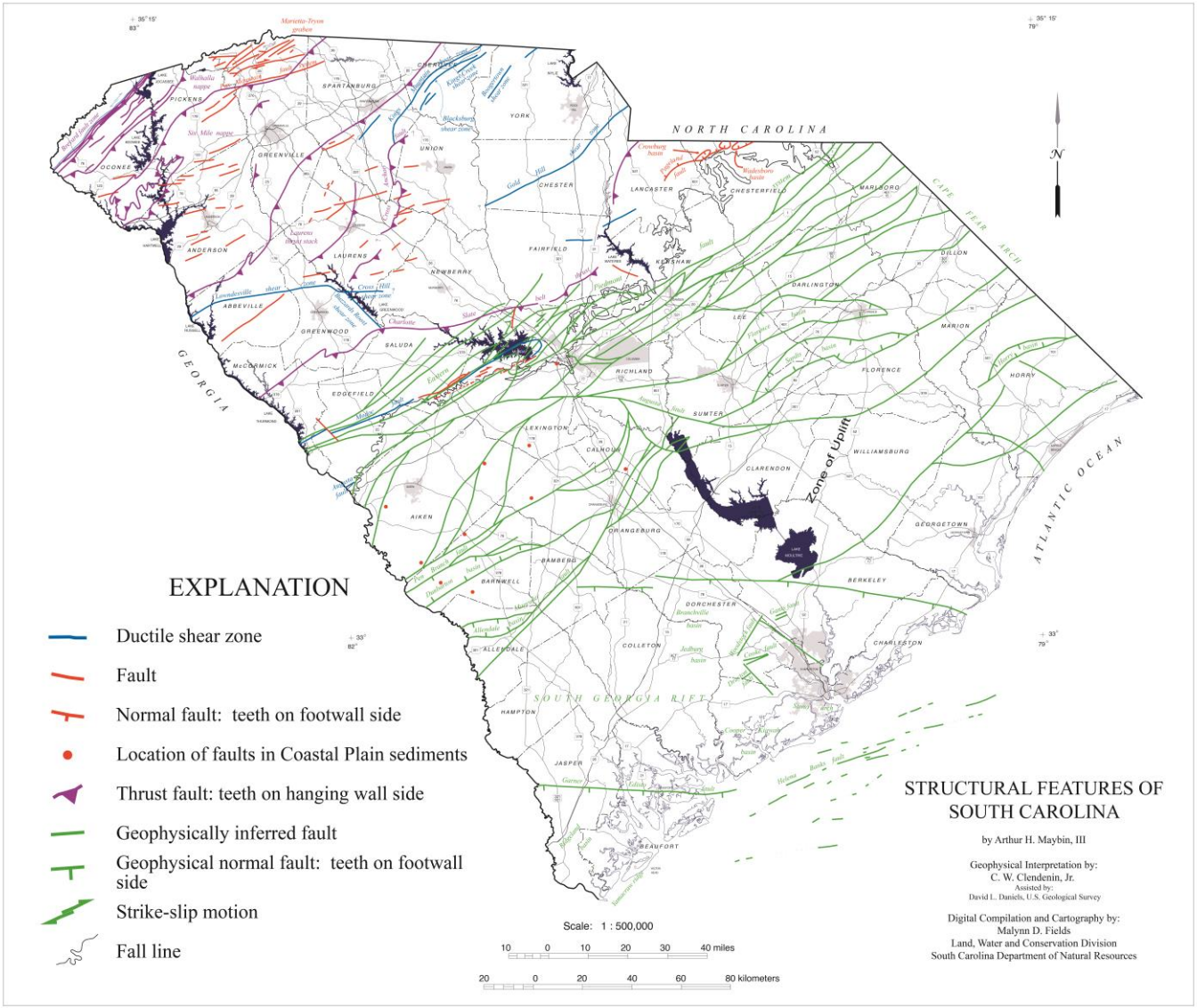


FIGURE 2-6: Faults and other structural features in South Carolina.

Current Climate

Despite its modest size, South Carolina harbors a remarkably diverse climate. Most of the State falls within the humid subtropical (Cfa) Köppen Climate Classification, leading to hot, humid summers and mild winters. However, the mountainous regions in the South Carolina Upstate exhibit fewer tropical characteristics, adding a unique twist to the State's climate. Several distinctive factors, including its continental position and elevation, contribute to the intriguing temperature and precipitation patterns observed within its borders.

Due to South Carolina's position within the mid-latitudes, the prevailing westerly winds help steer weather systems across the region, affecting the state's climate and weather. Seasonally, the winds are primarily out of the southwest during the summer and the northwest during the winter. Its position on the continent's eastern coast makes the State susceptible to cold air masses moving in from the northwest. The Appalachian Mountains tend to block most cold air outbreaks, contributing to the State's mild winters. However, cold air damming events occur mainly from October to May when cool air masses flow from the northeast and are funneled along the Appalachians' windward side. The downsloping winds, which warm the air by compression, can contribute to the warmer temperatures and rain shadow observed in the Midlands.

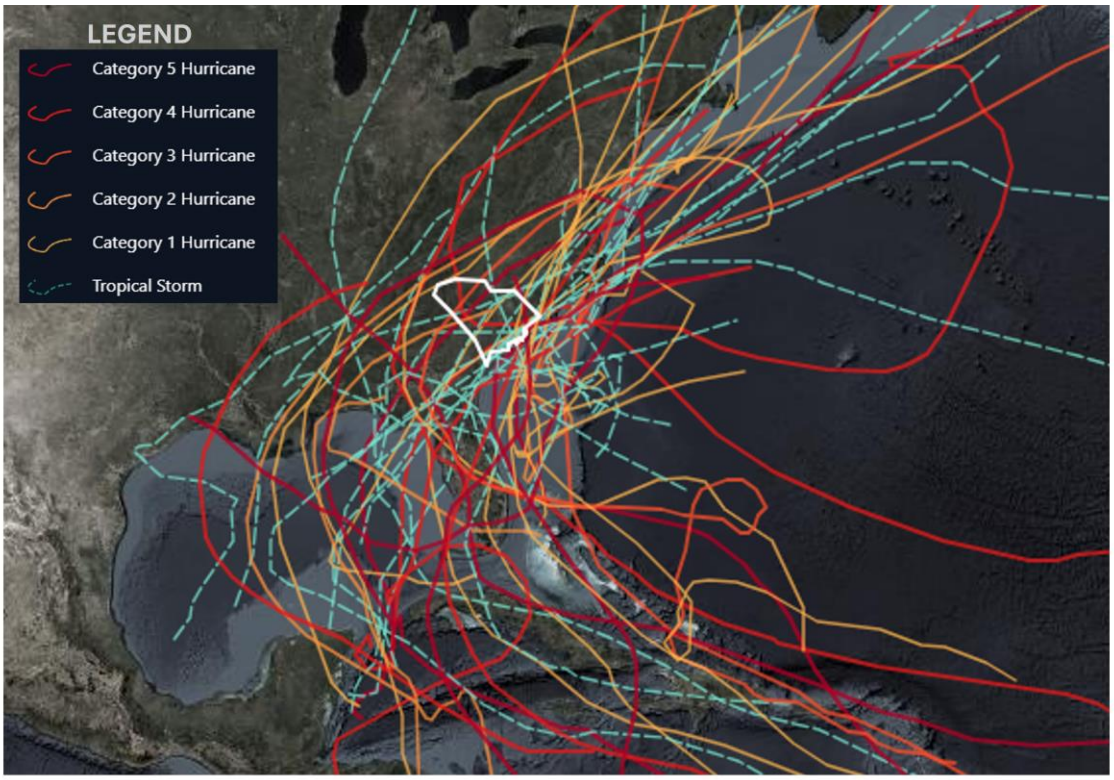
The presence of the Atlantic Ocean, with the Gulf Stream flowing northward off the coast, is important since land and water heat and cool at different rates. The position of the Bermuda High dominates South Carolina's weather during the warm season, which provides a persistent flow of warm, moist air into the region. While the elevation changes from sea level along the 187-mile South Carolina coast to 3,560 feet at the State's highest point, Sassafras Mountain in Pickens County, more than 90% of the State is at an elevation of fewer than 1,000 feet. These elevation changes impact the temperature and precipitation trends observed across the Lowcountry, Midlands, Pee Dee, and Upstate regions.

The State's annual average temperature varies from the mid-50s in the Upstate to the low-60s along the coast. Since the late 1800s, the statewide annual average temperatures have gone through multiple periods of above and below-normal temperatures. Despite the year-to-year variability, the overall pattern of average temperatures across South Carolina has increased since the mid-1970s. A substantial rise in minimum temperatures has driven this increase. The warmest year on record for the State was 2017, with an average temperature of 65.1°F, and seven of the top ten warmest years have occurred since 2010.

Drought conditions are a threat to many species that depend on aquatic habitats for all or a portion of their life cycle. Photo by Anna Smith, SCDNR

The State's geography plays a pivotal role in shaping its precipitation

patterns. The statewide annual rainfall average from 1895-2021 is 47.80 inches, with significant variations across South Carolina. Annual rainfall ranges from less than 40 inches in the Sandhills to over 80 inches in the higher elevations of the Appalachian Mountains in the western portion of the State. The absence of a distinct dry season and the highly variable nature of rainfall throughout the year are direct results of the State's unique geography. The passage of cold fronts and low-pressure systems contributes to precipitation in non-summer periods, while convective shower activity during the warm season drives summer precipitation. Some locations of the Coastal Plain experience higher rainfall totals due to sea-breeze thunderstorms. Tropical cyclones, especially from August through October, significantly contribute to rainfall during the hurricane season. South Carolina is ranked fifth nationally in hurricane impacts. The driest year was 1954, with a statewide average rainfall of 31.72 inches, and many locations in the Midlands and Pee Dee regions recorded less than 30 inches. Ten years later (1964), the state reported the wettest year on record, with an annual average of 69.32 inches. Historic flood events, droughts, heat waves (Griffin and SCDNR 2018 a, b, c) provide data that climatologists use to track trends in South Carolina's weather and overall climate changes. More information on South Carolina's climate can be found online in an Overview of South Carolina's Climate and Hazards (SCDNR 2021, *in revision*).



Hurricanes and tropical storms impacting South Carolina from 2004-2023.
Data from https://www.dnr.sc.gov/climate/sco/hurricanes/#map

Habitat Connectivity and Resiliency

The Nature Conservancy's terrestrial resilience analysis evaluates the capacity of inland habitats to continue supporting biodiversity and ecosystem function in the face of climate change, while

their coastal resilience analysis evaluates the capacity of coastal habitats to migrate to adjacent lowlands in order to sustain biodiversity and natural services under increasing inundation from sea-level rise. When these two assessments are taken together, roughly 30% of the State of South Carolina scores above average on climate resilience, 28% average, 24% below average, 12% developed, and the remaining 6% not assessed (which includes open water, Tribal lands, etc.). Therefore, over half of the State (58%) is considered resilient. Additionally, the Southeast Conservation Blueprint (SECAS 2024) identifies 55% of the state of South Carolina as a priority for a connected network of lands and waters; 12% is rated as highest priority, 17% highest, 22% medium, and 4% priority connections.

Carbon Sequestration Potential

Greenhouse gases are a concern in the State and across the Nation. In 2020, South Carolina's total gross emissions were estimated to be 73.746 MMTCO2e and total net emissions at 50.179 MMTCO2e (calculated by subtracting sinks from total gross emissions). Major contributors to this were electric power generation and transportation (exhaust). Land conservation and restoration is therefore a strategy to employ to reduce greenhouse gas impacts. [PAQC 2024]

Southeastern forests are especially efficient carbon sinks (Kreye 2023) with more species-rich forests storing up to 70% more carbon than monocultures (Warner et al. 2023). Trees of various species take up carbon differently as some grow fast but die sooner (e.g. pines) while others grow slower but live longer (e.g. hardwoods) (Kreye 2023). Sequestration rates are calculated based on stand densities (Kreye 2023). According to the Trust for Public Land's Conservation Carbon Map (2024), the current average rate of carbon sequestered in living biomass on all acreage in South Carolina is over one billion metric tons/acre/year. Because most of the State is in private ownership, it is significant to note that these private tracts alone provide 0.8 metric tons/acre/year whereas the national average is 0.55 metric tons/acre/year. The average social value (economic impacts and health due to climate change) of keeping South Carolina's 12.8 million forested acres forested is significant at over $199.8 billion with a yearly sequestration potential of over $1.6 billion. South Carolina's market value of total carbon is over $133 billion with a yearly sequestration potential of over $1 billion. Climate change, however, adds uncertainty to the future productivity of forests (Johnsen et al. 2014) which will impact their carbon sequestration potential.

A Timber Rattlesnake (coastal Canebrake variety) takes refuge in a stump hole during a prescribed fire. Photo by Zachary Orr.

South Carolina's forests are not the only sources of carbon sequestration. Carbon is sequestered and stored in coastal wetlands and salt marshes at ten times the rate of mature tropical forests, making them critical moderators of climate change impacts (SASMI 2023). Approximately 23% or 4.5 million acres of South Carolina's land area is made up of wetlands; 10% or 350,000 acres of these are coastal marshes with the

remaining 90% freshwater (Purcell et al. 2019). Unfortunately, since the mid-1700s, South Carolina has lost 27% or 1,755,000 acres of its wetlands, mostly due to development (Purcell et al. 2019). Carbon can also be stored in native grasslands. Studies have shown that in an unstable climate where droughts cause increases in wildfires, native grasslands can often sequester more carbon than forests (Dass et al. 2018, MN BWSR 2019). This is because most of their carbon is stored underground in their extensive root systems where it remains post-fire. Pre-European settlement, South Carolina had open prairie and savanna ecosystems mostly prominent in the Piedmont (Noss 2013), but like wetlands, they too have been lost to development over time.

Natural Fire Return Intervals

Fire suppression in the Southeastern United States began to be institutionalized between 1910 and 1930 (Frost 1993; Ware et al. 1993); it came to be viewed as an agent of destruction and was actively and effectively suppressed. However, pre-European contact, South Carolina was part of a pyric (fire-adapted) landscape that burned frequently. According to the Physical Fire Frequency Model (PC2FM) and visualized in Figure 2-7, the natural fire return intervals for the State range from four to six years across much of the Coastal Plain and Piedmont (Guyette et al. 2012). Only the highest peaks in the mountains had longer return intervals, approaching 17 years and even longer in some small areas of the Blue Ridge Ecoregion (Guyette et al. 2012).

Prescribed burn on private lands in Clarendon County, SC.
Photo by Johnny Stowe, SCDNR

Fire management using prescribed burns across the State is based on these natural fire return intervals, current habitats, and desired future conditions. Prescribed fire is used by managers to enhance habitat for wildlife, lessen wildfire risk through the reduction of fuel loads, suppress woody vegetation, encourage the growth of fresh forage, and recycle nutrients. Burns are also beneficial to wetland areas. Peer-reviewed research demonstrates that proper fire rotation within wetlands increases desirable moist-soil plants by up to 70% while improving water quality (i.e. Laubhan 1995; de Szalay and Resh 1997; and Gabrey et al. 1999). This can result in three times more migratory waterfowl being supported in managed versus in unmanaged areas (Ducks Unlimited 2023).

State of South Carolina

Governor's Proclamation

WHEREAS, prescribed burning is the skilled application of fire under planned weather and fuel conditions to achieve specific forest and land management objectives; and

WHEREAS, ecosystems throughout the Palmetto State evolved in an environment in which understory fires occurred naturally every few years; and

WHEREAS, prescribed burning is not only the most effective, economical protection against wildfires because it reduces accumulated fuels, but it is also a key tool in managing and maintaining the ecological integrity of South Carolina's woodlands, grasslands, agricultural areas, and wildlife habitats; and

WHEREAS, many plants and animals require fire for their survival; and

WHEREAS, the approximately 500,000 acres of South Carolina land that are prescribed-burned annually represent only half of the estimated one million acres that could benefit from its strategic application.

NOW, THEREFORE, I, Henry Dargan McMaster, Governor of the great State of South Carolina, do hereby proclaim March 2025 as

PRESCRIBED FIRE AWARENESS MONTH

throughout the state and encourage all South Carolinians to learn more about prescribed burning and the essential role fire plays in the stewardship of our natural resources and protection of our citizens.

HENRY DARGAN MCMASTER
GOVERNOR
STATE OF SOUTH CAROLINA

For South Carolina, reduction in fire frequency in intervals greater than five years leads to elimination of the herbaceous layer in pine woodlands (Frost 1990) and eliminates much of the habitat value of early successional stages. Burns can be conducted in either the dormant season (winter) or the growing season (spring and summer), benefiting different assemblages of plants depending on the season in which they occur (American Forest Foundation 2007). The benefits of prescribed burns, especially those conducted during spring and summer months, are now more widely appreciated; however, burning is increasingly hampered by liability concerns. Expanding urban areas and proliferating highways are such that the smoke from a prescribed fire often creates extremely dangerous conditions. See Chapter 10 for further discussion of possible climate change impact on prescribe burning regimes in the Southeast.

Nature needs fire; sometimes the most powerful conservation tools come from working with natural processes, not against them. Recently, South Carolina Governor Henry McMaster proclaimed March 2025 as Prescribed Fire Awareness Month, underscoring its evolutionary significance to wildlife diversity, its reduction of wildfire risk, and the need for more of it statewide. Chapter 10 discusses potential changes in burning windows in coming decades due to changes in climate.

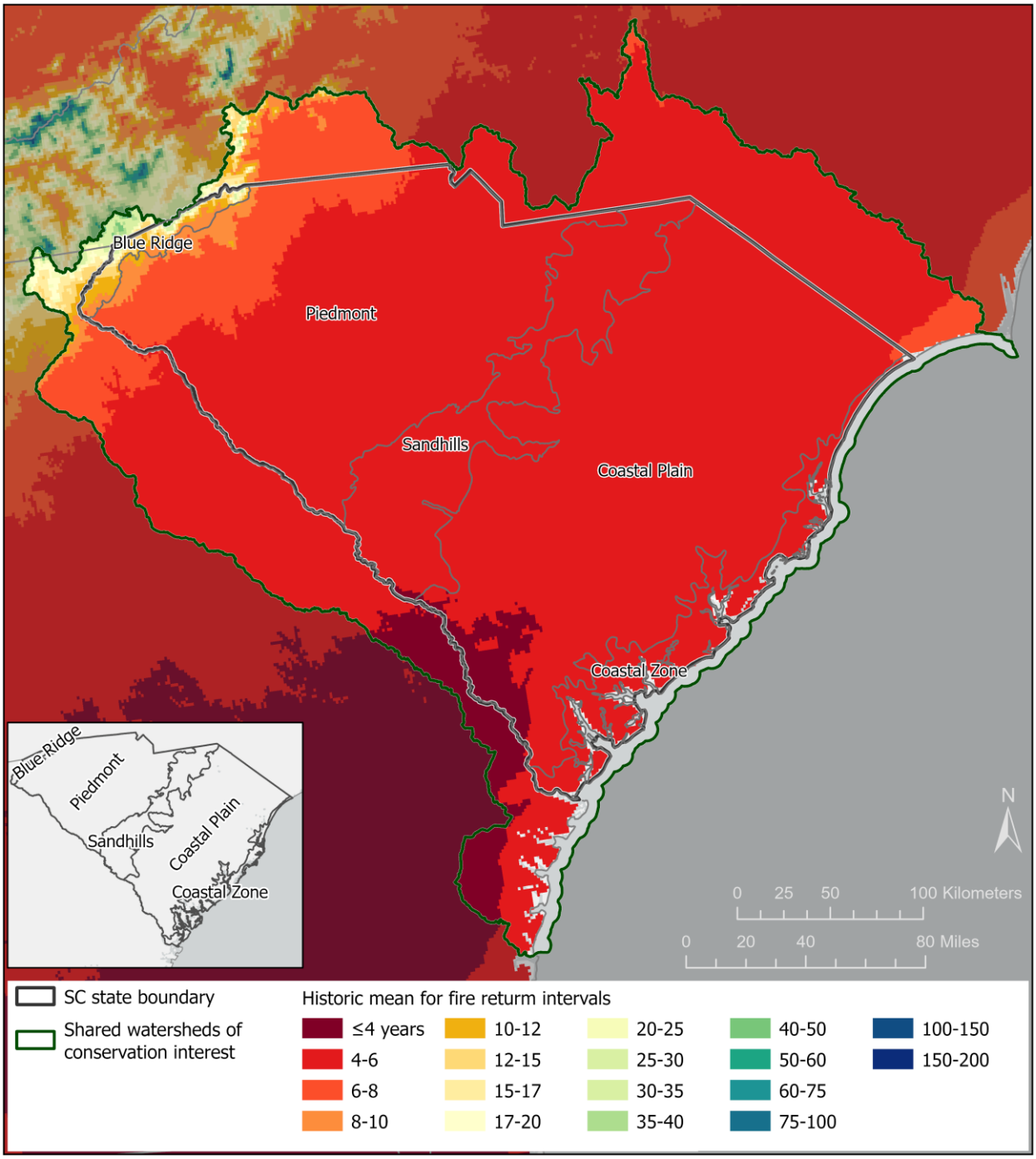


FIGURE 2-7: Fire return intervals for South Carolina.

Land Ownership Patterns

Private ownership dominates in South Carolina with 90% being held by individuals, families, and corporations. State and local municipalities constitute 3.2% of the land base while 6.8% is held by federal entities. Figure 2-8 visualizes this division of ownership graphically and correlates to Table 2-2. Lakes and other waters are included in these percentages.

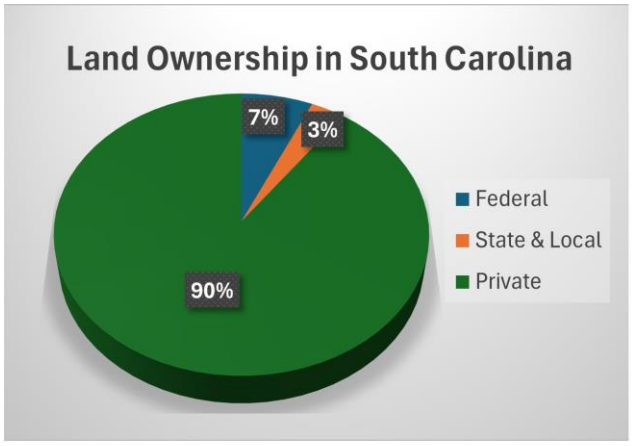


FIGURE 2-8: Land ownership percentages in South Carolina.

South Carolina's Protected Lands Portfolio

South Carolina supports a wide diversity of habitats, culturally and historically significant landscapes, and ecosystems that provide benefits to the State as well as the broader Southeast Region. The South Carolina Department of Natural Resources (SCDNR) follows the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs") when assessing lands for fee simple acquisition and encouraging private landowners to place prime examples of common, rare, and declining habitat types under conservation easement. Locations of highly resilient lands, or those that can be restored to higher resiliency, are assessed for protection. Representative examples of each habitat type are protected across the State while making sure enough examples of each habitat are conserved. This same concept extends to both common species and SGCN residing within these habitats.

> "Wilderness is a resource which can shrink but not grow... creation of new wilderness in the full sense of the word is impossible."
>
> **- Aldo Leopold**

Based on conserved lands data, more than three million acres (17%) of the State are considered protected (Figure 2-9), more than the national average of 13%. The SCDNR and its partners have done a tremendous job of conserving valuable habitat in each ecoregion of the State. This includes important landscapes like National Wildlife Refuges, National Forests, State Wildlife Management Areas, Heritage Preserves, State Parks, and private conservation easements. The following tables illustrate that fact; Table 2-1 summarizes the percentage of each ecoregion protected in South Carolina while Table 2-2 shows the statewide acreages in conservation status by ownership, all as of July 8th, 2024. The 'Other' category statistics in Table 2-2 includes Clemson University, Santee Cooper, US Department of Energy, US Deptartment of Defense, and the US Army Corps of Engineers. Conservation Lands data was used to complete these tables and coincides with the SC Conservation Bank's reporting. GIS acres are used rather than deed acres.

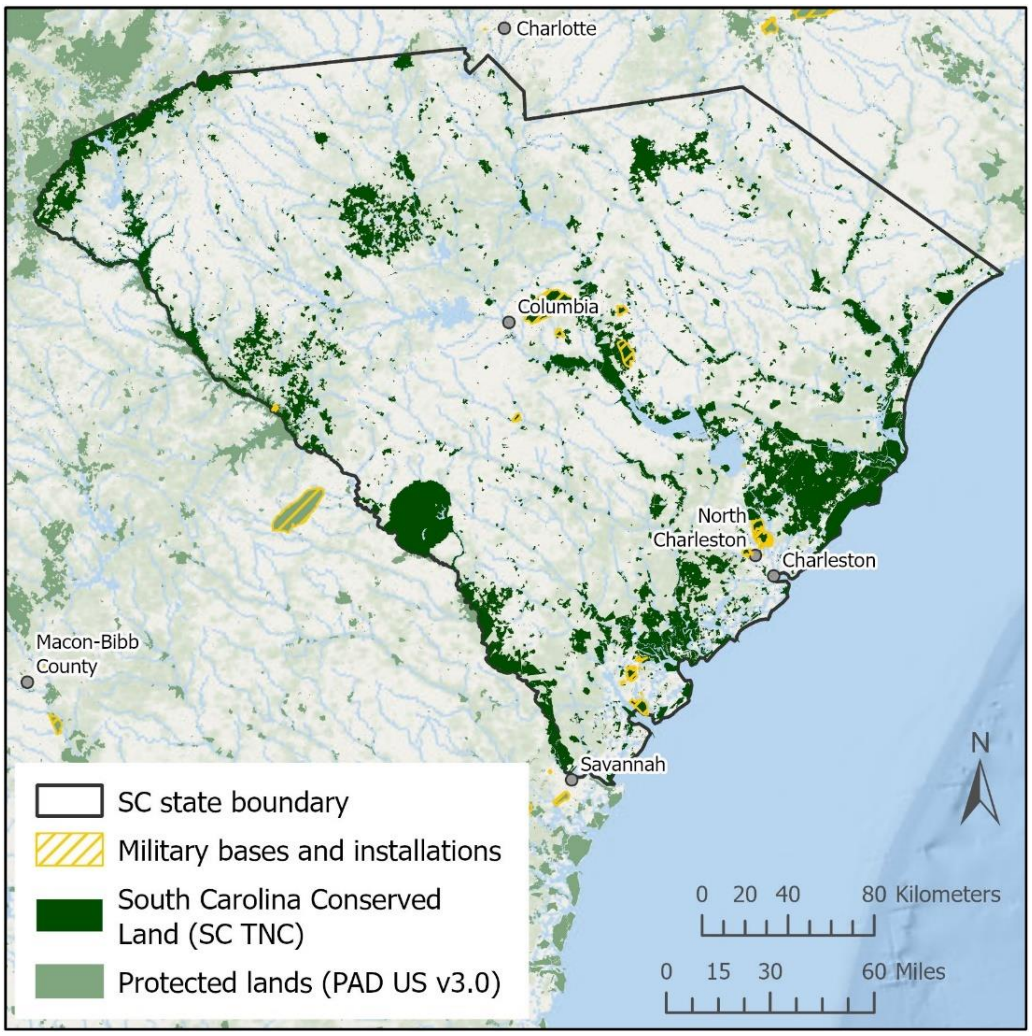


FIGURE 2-9: Conserved lands in South Carolina (SC TNC) and protected lands throughout the region (PAD US 3.0). Within South Carolina, conserved lands data is managed by The Nature Conservancy South Carolina (SC TNC) and supported by data contributions from participating members of the SC Land Trust Network and other conservation partners. The data is updated every six months. Last update: June 2024.

TABLE 2-1: Acreages protected by ecoregion.

	Ecoregion Area (Acres)	Ecoregion Area (Hectares)	Conservation Areas (Acres)	Conservation Area (Hectares)	Percentage in Conservation Status
Blue Ridge	308,830	124,980	198,738	80,427	64.4%
Piedmont	6,897,367	2,791,277	670,844	271,482	9.7%
Sandhills	2,394,196	968,901	404,400	163,656	16.9%
Coastal Plain	8,871,575	3,590,213	1,284,135	519,673	14.5%
Coastal Zone	1,311,253	530,647	450,714	182,398	34.4%
Total	**19,783,221**	**8,006,018**	**3,008,831**	**1,217,636**	**15.2%**

TABLE 2-2: Statewide acreages protected by entity.		
Type	**Acres**	**Hectares**
Federal	894,801	362,115
State	577,404	233,668
Local	49,133	19,884
Private	1,032,059	417,661
Other	455,434	184,308
Total	**3,008,831**	**1,217,636**

Demographics, Urban Growth, and Economic Drivers

In addition to contributing to the conservation landscape of the Southeast, South Carolina's lands and waters also benefit the State's economy. In 2022, the US Bureau of Economic Analysis estimated that the outdoor recreation economy generated $7.6 billion in value for the State's Gross Domestic Product and another $3.3 billion in wages and salaries. Beyond providing recreational value, natural landscapes also support working lands such as agriculture and timber. As of 2023, South Carolina supported more than 4.6 million acres of farmland across 22,600 farms, and crop production alone was valued at more than $986 million (USDA-NASS 2023). However, the timber industry is the number one crop and number one export in South Carolina with an annual impact of $23.2 billion, supporting more than 100,000 jobs and $5.5 billion in salaries (SCFC 2024).

Master Naturalist field day April 2024 at Caw Caw Interpretive Center. Photo by Anna Smith, SCDNR.

South Carolina entered a period of rapid economic expansion starting in the 1970s and human population growth that continues to this day. In 2008, the population of South Carolina was projected to reach 5 million by 2030 (Miley, Gallo and Associates LLC 2008); this milestone was realized a full decade earlier than expected with 5.2 million residents recorded in the 2020 US Census (US Census Bureau 2020). South Carolina now has an estimated population of 5.5 million with the biggest population increases currently occurring are in the Upstate, coastal counties, and around the capital (Lexington and Richland Counties) (US Census Bureau 2024). The 2020 COVID-19 pandemic fueled an increase in the number of people that turned to natural resource outlets for recreation, according to data from the federal Bureau of Economic Analysis, making the outdoor sector 2.6% of the State's gross domestic product and a 4.4%

increase in outdoor recreation employment (Archote 2024). This trend has not slowed, and with this growing appreciation for South Carolina's greenspace and amenities so close in proximity to each other, South Carolina is now the number one fastest growing state in the nation with a 1.71% population increase (Pew Charitable Trusts 2024). Projected future urbanization is shown in Figure 2-10.

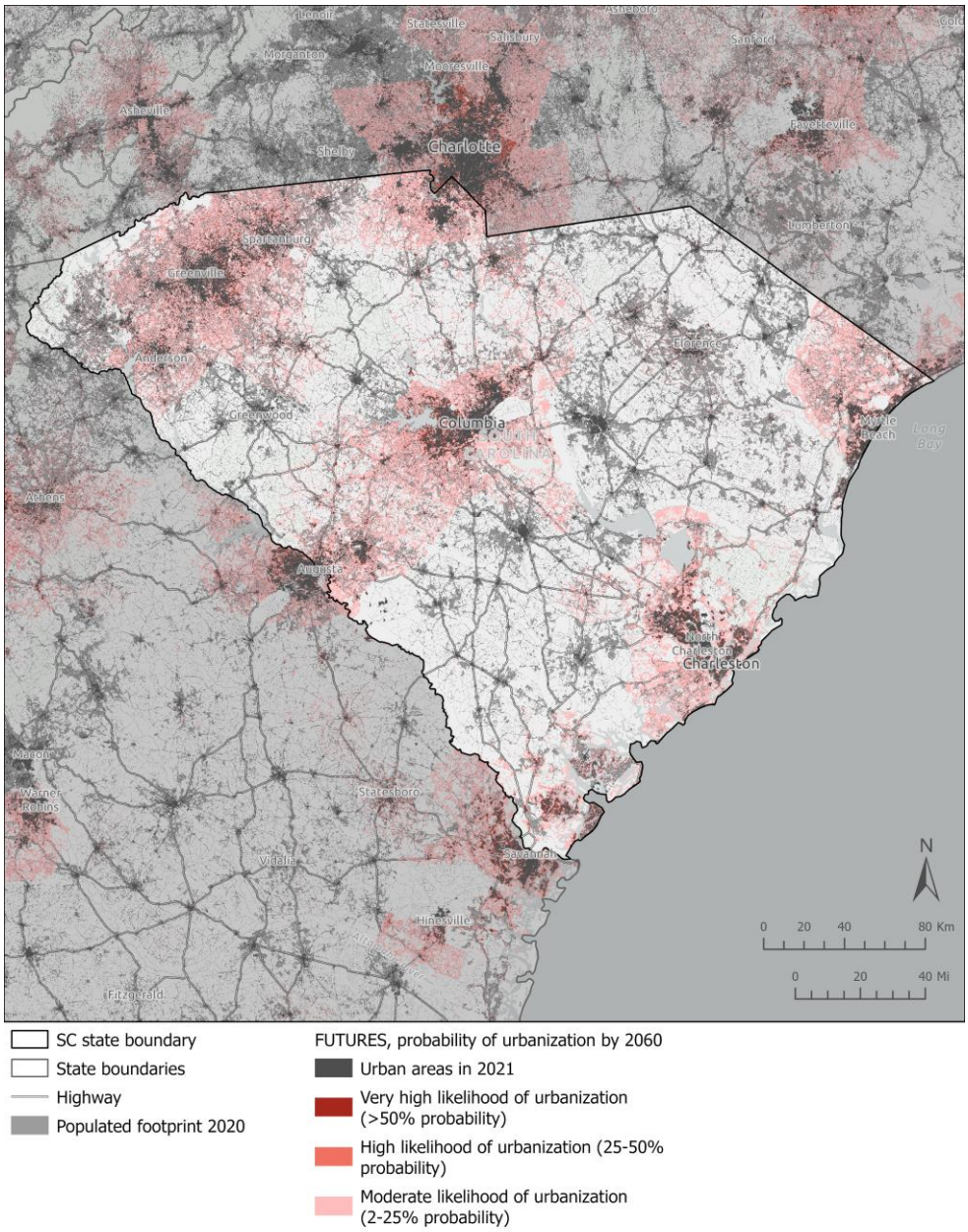


FIGURE 2-10: This map represents the current developed landscape of South Carolina and potential future urban development by 2060. The populated footprint areas represent an estimate of the footprint of human settlement in 2020 and captures places that have been altered for human use like developed areas and agricultural areas. The populated footprint was derived from the 2020 slice of the WorldPop Population Density 2000-2020 100m and 1km layers using imagery datasets and population data. The FUTURES urban growth model predicts the likelihood that an area will urbanize by 2060. Developed areas from the 2021 National Landcover Database serve as the baseline for current urban areas. The model simulates landscape change based on trends in population growth, local development suitability factors, and an urban patch-growing algorithm.

> "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect"
>
> **- Aldo Leopold**

The increase in population is changing the rural character and landscape of South Carolina as timber and small agricultural farms are converted to residential and industrial development. Growth is possible, in part, due to 90% of the State's 20.5 million acres (32,020 square miles) being in private ownership. Parcelization of once large, generational landholdings is one of the biggest threats to wildlife habitat in South Carolina (SCFC 2020). Economic development has attracted a variety of major companies to the State's counties in the last 20 years including BMW (Spartanburg), Boeing (Charleston), Volvo (Berkeley), Michelin (Greenville), and Volkswagen (Richland).

Because of South Carolina's geologic past and present, the State has mineral deposits that are also economically important including clay, sand, vermiculite, limestone, shale, gold, and granite. The South Carolina Department of Health and Environmental Control (SCDHEC) currently permits around 500 mining operations which can be viewed on their Active Mines Viewer (SCDHEC 2024). Sand is the most commonly extracted deposit with the majority of mines located in the Coastal Plain.

A granite mine in Rock Hill, SC. Photo by Keith Bradley, SCDNR.

Another growing industry in the State is industrial-scale solar farming that contributes over $1.5 billion to the States economy (Hefner & Burnett 2020). There are 111 active solar farms operating statewide, impacting 8,758 acres (SCEO 2023, USPVDB 2024), and many more are planned based on recent sales to solar companies. Although a renewable energy source, the downside to solar farms is the required razing of all trees on site and the installation of panels, effectively limiting biodiversity on site. To help mediate this problem, the South Carolina Legislature passed the South Carolina Solar Habitat Act in 2018 (South Carolina Code of Laws, Chapter 4, Section 50-4-10), directing the SCDNR to provide a Solar Habitat Guide to solar developers on how to voluntarily create pollinator habitat on their solar farms and utilize a Solar Siting Tool (mapping application) to steer prospective solar farm developers away from sensitive habitats.

Military Presence

South Carolina contains military installations (Figure 2-11) servicing the United States Marines, Air Force, Army, National Guard, and the Navy. Integrated Natural Resource Management Plans (INRMPs) govern natural resource management on Department of Defence lands and are

required by the Sikes Act. South Carolina's bases harbor many SGCN as well as state and federally listed species so that military cooperation on management is crucial for the continued survival and recovery of these species. The SCDNR reviews INRMPs on a regular schedule and offers suggestions for new ways to monitor and manage for species present. South Carolina also has the 2,256,592-acre Lowcountry Sentinel Landscape (LSL). It encompasses three military installations: the Marine Corps Air Station Beaufort, the Marine Corps Recruit Depot (Parris Island), and the Naval Support Facility Beaufort. The LSL is also discussed in Chapter 10. Its goals are the following and mirror South Carolina's SWAP goals:

- Reduce vulnerabilities to climate change by promoting nature-based solutions to restore and/or enhance the inherent resilience of the landscape and protect critical infrastructure.
- Protect and enhance ecologically significant areas to support imperiled species.
- Protect source water quality and supplies.
- Support and protect working farms and forests to ensure equitable access to conservation programs to prevent development that is incompatible with military operations.
- Establish and promote the Lowcountry Sentinel Landscape to ensure long-term military readiness.

FIGURE 2-11: Military Installations within South Carolina. Map created by the SC Office of Resilience.

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CHAPTER 3: SOUTH CAROLINA'S TERRESTRIAL AND AQUATIC HABITATS BY ECOREGION

South Carolina is divided into five ecoregions as one moves from the northwest corner of the State to the southeast: Blue Ridge (Mountains), Piedmont, Sandhills, Coastal Plain, and Coastal Zone. Other sub-zones often demarcated in the State include the Fall Line (where the rolling hills of the Piedmont "fall away" into the flatter Coastal Plain) and the Slate Belt (running southwest from Lancaster County through Saluda County). Likewise, the five ecoregions are sometimes further divided into upper, lower, inner, or outer. This chapter summarizes the State's habitats that are found in each ecoregion, first beginning at a course scale and then discussing finer scale habitats that may be categorized under each or embedded within. Some may themselves contain microhabitats which various plant and animal Species of Greatest Conservation Need (SGCN) rely upon. It is important to the overall diversity of the State, and the greater Southeastern Region, that representative examples of all native habitats be a part of South Carolina's portfolio of protected lands. These priority habitats may be at either the course or the fine scale or even be the ecotones between habitat types. The South Carolina Department of Natural Resources (SCDNR) strives to follow the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs") when conserving habitats and the species therein across the State so that all native habitat types are a priority for conservation. This chapter also discusses more "unnatural" habitat types like pine plantations and man-made structures utilized by wildlife as they too are present on the landscape although not prioritized for conservation. Figure 3-1 visualizes the main basins overlaid on the ecoregions to create the ecobasins map referenced in aquatic habitats.

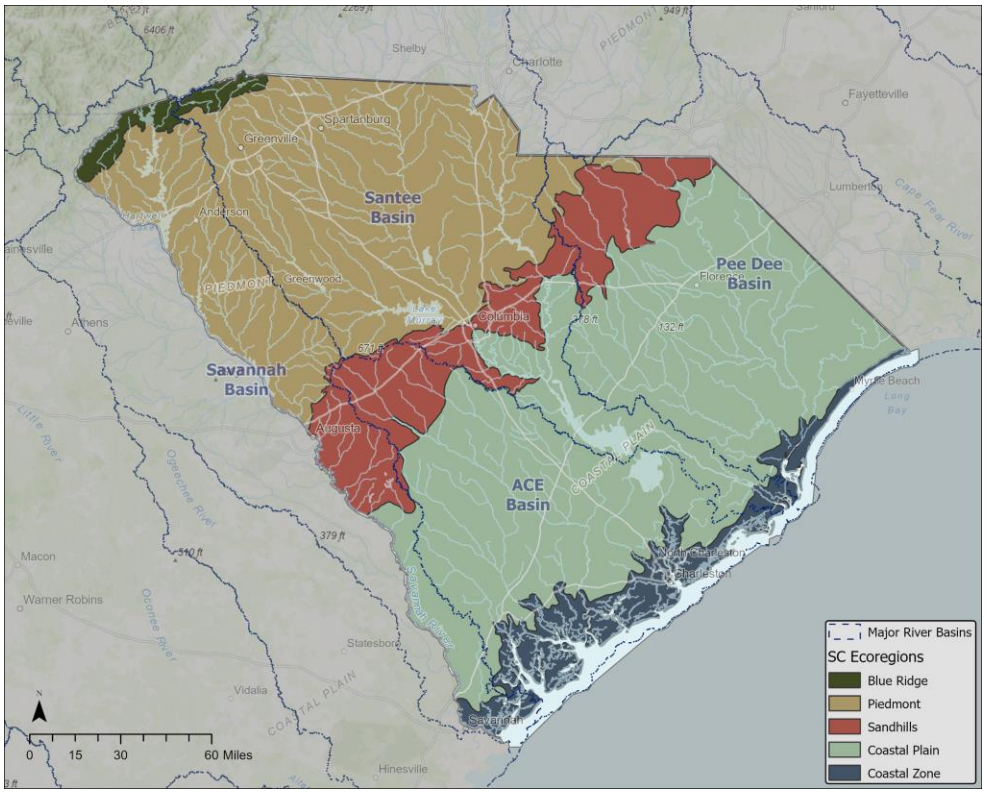

FIGURE 3-1: Ecobasins of South Carolina

Blue Ridge Ecoregion

Montane Rock Outcrops and Glades

Rock outcrops of widely varying sizes and slopes occur throughout the region. This includes communities defined as "Granitic Dome" and "Acidic Cliff" (Nelson 1986; McMillan et al. 2022) and corresponds to several themes in Schafale (2024) including "High Elevation Rock Outcrops", "Low Elevation Cliffs and Rock Outcrops", and "Piedmont and Mountain Glades and Barrens". The equivalent United States National Vegetation Classification (USNVC) ecosystem is "Eastern North American Cliff and Rock Vegetation". This ecosystem forms on exposed granite/gneiss. Slopes range from nearly horizontal to nearly vertical and vary widely in areal extent. Vegetation ranges from absent (bare rock), to lichen/moss dominated, 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 at these sites. Crevices and ledges can only provide habitats for larger plants once sufficient soil has accumulated. Vegetative communities are influenced by drought/wet cycles and sometimes fires, thus outcrops may have areas of extreme dry to moist microhabitats. Steeper rock faces, called "Acidic Cliffs" by Nelson (1986), are mostly unvegetated but can be critical habitat for wildlife. Often associated with rock outcrops, "Glades" may form in area of slightly deeper but still thin soils over rock. These habitats feature dense graminoid and forb assemblages in sunny gaps or areas with sparse tree canopies. Vegetation composition of rock outcrops and glades varies with underlying geology, with herbs such as Rock Spikemosses (*Bryodesma* spp.), Beadle's Mountain-Mint (*Pycnanthemum beadlei*), Cliff Saxifrage (*Micranthes petiolaris*), Appalachian Rock-Pink (*Phemeranthus teretifolius*), Mountain Dwarf-Dandelion (*Krigia montana*), and Pineweed (*Hypericum gentianoides*) more common in moderately acidic areas, and Alumroots (*Heuchera* spp.), Beardtongues (*Penstemon* spp.), and Lipferns (*Myriopteris* spp.) more common over areas of richer gneiss geology.

Pine-Oak Heath

This community is new to this revision. In 2015 the SWAP omitted any ecosystem in the Blue Ridge Ecoregion with a significant presence of pine species. The concept here follows the "Pine-Oak Heath" of both Nelson (1986) and McMillan et al. (2022), of "Pine Forests" by Barry (1980), and the "Pine-Oak/Heath (Typic Subtype)" of Schafale (2024). The equivalent USNVC classification is "Southern Appalachian Virginia Pine-Table Mountain Pine Woodland Group". Pine-Oak Heath communities form at middle to high elevations on acidic well-drained soils such as ridges, steep south-facing slopes, and mountain tops. This is an open-canopied woodland ecosystem. Yellow pine species are usually dominant, including Virginia Pine (*Pinus virginiana*), Pitch Pine (*P. rigida*), Shortleaf Pine (*P. echinata*), and sometimes Table Mountain Pine (*P. pungens*). Hardwoods are usually present and include xeric-adapted oaks such as Rock Chestnut Oak (*Quercus montana*) and Blackjack Oak (*Q. marilandica*), and other hardwoods including Sourwood (*Oxydendrum arboreum*), Sassafras (*Sassafras albidum*), and Sour Gum (*Nyssa sylvatica*). Most or all pine-oak heaths are likely fire-dependent (McMillan et al. 2022). The shrub layer is usually dense and dominated by Mountain Laurel (*Kalmia latifolia*). Sites maintained with fire can have diverse and dense graminoids and forbs. Common species are

Common Little Bluestem (*Schizachyrium scoparium*), Poverty Oat-Grass (*Danthonia spicata*), and Woodland Coreopsis (*Coreopsis major*).

Appalachian Oak Forest

This concept includes the montane examples of "Chestnut Oak Forest" and "Oak-hickory Forest" of Nelson (1986) and McMillan et al. (2022), in addition to "Montane Oak-hickory Forests" of McMillan et al. (2022), and the "Ridgetops and Upland Oak Forests" of Barry 1980. Schafale (2024) treats "Mountain Oak Forests" broadly as a theme, with several subtypes each of "Chestnut Oak Forest", "Montane Oak-Hickory Forest", and "High Elevation Red Oak Forest" (which may not be in South Carolina at all), as well as "Low Montane Red Oak Forest" and "High Elevation White Oak Forest". The USNVC classification is "Southern Appalachian Oak Forest & Woodland Group". These forests compose the predominant vegetation type throughout the Blue Ridge Ecoregion. Vegetation composition and structure are highly variable, depending on exposure, position on slope, soil moisture, and underlying geology. On dry, acidic upper slopes, Rock Chestnut Oak (*Quercus montana*) may be dominant, often co-occurring with other oak species including Scarlet Oak (*Q. coccinea*), Spanish Oak (*Q. falcata*), Black Oak (*Q. velutina*), and hickories (*Carya* spp.), with an understory dominated by heaths such as Hillside Blueberry (*Vaccinium pallidum*) and Mountain Laurel (*Kalmia latifolia*). On mid-low slopes and richer soils, White Oak (*Q. alba*) and Northern Red Oak (*Q. rubra*) increase in abundance, and the herb layer becomes more diverse. American Chestnut (*Castanea dentata*) was formerly common or co-dominant in Appalachian Oak Forests. Appalachian Oak Forests are differentiated, floristically, from oak-dominated forests of the Piedmont by containing species characteristic of the mountains and rarely if ever seen in the Piedmont, such as Buffalo-Nut (*Pyrularia pubera*), Bear Huckleberry (*Gaylussacia ursina*), Fraser Magnolia (*Magnolia fraseri*), Eastern Hemlock (*Tsuga canadensis*), and Great Laurel (*Rhododendron maximum*).

Rich Cove Forest

This concept includes the "Cove Forest" of Nelson (1986), in part the "Mixed Mesophytic-Cove Segregate" and "Mixed Mesophytic-Slope Segregate" of Barry (1980), and "Rich Cove Forest" of McMillan et al. (2022). Schafale (2024) in North Carolina, subdivides this further into Montane and Intermediate subtypes based on elevation. The equivalent USNVC community is "Appalachian Mesic Forest". Rich Cove Forests occuppy 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 and high pH (generally greater than 6). Tulip-Tree (*Liriodendron tulipifera*), White Beech (*Fagus grandifolia* var. *caroliniana*), and Mountain Basswood (*Tilia americana* var. *heterophylla*) typically dominates the overstory, and Common Silverbell (*Halesia tetraptera*) is a characteristic species in the mid-story or understory. The shrub layer is typically sparse or absent. Herb species richness and cover are among the highest for any Blue Ridge Ecoregion plant community type. Characteristic ground flora species include Bloodroot (*Sanguinaria canadensis*), Escarpment Foamflower (*Tiarella austrina*), Partridge-Berry (*Mitchella repens*), Hill Cane (*Arundinaria appalachiana*), and Ginseng (*Panax quinquefolius*). Rich Cove Forests are recognized generally as supporting high densities and/or providing optimal habitat for many species of breeding birds and having high salamander species diversity (Hunter et al. 1999).

Acidic Cove Forest

This concept includes the "Hemlock Forest" of Nelson (1986), in part the "Mixed Mesophytic-Cove Segregate" of Barry (1980), and the "Acidic Cove Forest" of McMillan et al. (2022). Schafale (2024) also delineates this as "Acidic Cove Forest", with several subtypes. The USNVC classification is "Southern Appalachian-Interior Mesic Forest Group." Acidic Cove Forest occurs on well-drained, relatively sheltered sites in stream bottoms, along ravines of small streams, or on hill slopes. This landcover type is more prevalent on north-facing slopes or lower positions on other slopes. Eastern Hemlock (*Tsuga canadensis*) is the characteristic tree, occurring either as the dominant overstory or understory tree, while rhododendron dominates the shrub layer, occurring in thickets or solitary clumps. Tulip-Tree (*Liriodendron tulipifera*), White Pine (*Pinus strobus*), Hickories (*Carya* spp.), Sweet Birch (*Betula lenta*), and White Beech (*Fagus grandifolia* var. *caroliniana*) are common associates. White pine becomes much more dominant along with Eastern Hemlock in the Ellicott Rock/Chattooga River basin in the western portion of the Blue Ridge. With the decline of Eastern Hemlock due to the Hemlock Woolly Adelgid, Red Maple (*Acer rubrum*) and Sweet Birch (*Betula lenta*) have increased in relative abundance.

Mountain Alluvial Communities

The variable wetland ecosystems along rivers and creeks are delineated here as alluvial communities. This concept includes Nelson's "Shoal & Stream Bar" as well as "Small Stream Forest", and Barry's (1980) "Riverbanks and Alder Zones" and "Floodplain Forests", and in McMillan et al. (2022) the "Rocky Streamside" and "Canebrakes". Schafale recognizes these communities as subtypes of "Montane Alluvial Forest", "Rocky Bar and Shore", or "Piedmont/Mountain Canebrake". USNVC classifications include "Central Hardwoods Floodplain Forest" and "Eastern North American Rivershore Vegetation", in part. This habitat forms naturally along the riparian vegetation zone on streams and rivers—typically along wadable 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). Canopy trees, where present, can include Sweet Gum (*Liquidambar styraciflua*), Tulip-Tree (*Liriodendron tulipifera*), Sycamore (*Platanus occidentalis*), and River Birch (*Betula nigra*). Tag Alder (*Alnus serrulata*) is a characteristic shrub species that occurs at a relatively high abundance. Other common shrubs are Yellowroot (*Xanthorhiza simplicissima*), Virginia-Willow (*Itea virginica*), Azaleas (*Rhododendron* spp.), and occasionally Black Willow (*Salix nigra*) and Mountain Sweet-Pepperbush (*Clethra acuminata*). Canebrakes were once vast stands of River Cane (*Arundinaria gigantea*) along floodplains, thought to be fire-maintained and associated with settlement patterns of Native Americans (Platt & Brantley 1997). They are now largely gone from floodplains, though smaller patches of River Cane are often seen in broader floodplain communities.

Fens and Spray Cliffs

This concept includes montane seepages as well as the spray cliffs and humid gorges associated with waterfalls. These are often small patch communities embedded within larger community types such as rock outcrops, rich coves, or Appalachian Oak Forests. The concept encompasses

Nelson's (1986) "High Elevation Seep", "Spray Cliff", "Upland Bog", and several communities described in detail by McMillan et al. (2022) including "Spray Cliffs", "Humid Gorge Outcrops", "Cataract Fens", and "Southern Appalachian Fens". The concept also includes Hill's (1999) description of "Ice Ponds", a unique community formed from frozen seepage forming pools below a north-facing cliff, and home to a relict flora characteristic of bogs or fens in cooler climates. Fen ecosystems in Schafale (2024) are classified as "Low Elevation Seep" and "Swamp Forest-Bog Complex", and other parts of this concept are included as "Upland Seepages and Spray Cliffs" theme. The USNVC equivalent community is "Central & Southern Appalachian Seep & Seepage Bog Group". As McMillan et al. (2022) detail, true "Bogs" are derived from precipitation, and most or all communities that have been referred to as bogs in the South Carolina Upstate are actually fens, with water and nutrients derived from seepage. The highly variable landforms within the Southern Blue Ridge Ecoregion include numerous wet places that increase local and regional habitat diversity, and they are often microhabitats within a mosaic of other vegetation but are quite distinctive. Open seeps of variable size occur on granitic cliffs and domes, with the best developed forming diverse fens. These form along wet seepage areas at the heads of or along the margins of small streams which are nearly always saturated. They are characterized by peat mosses (*Sphagnum* spp.) and other wetland species such as orchids and sedges. Vegetation in these fens is apparently fire-controlled in some places, but likely also influenced by beaver activity and flood/drought cycles, nutrient influx, and perhaps extinct megafauna. In the absence of burning or other limiting factors, succession leads to a wetland community dominated by woody vegetation. Perpetually moist habitats along waterfalls, seeps, and in humid gorges are also important for wildlife and rare plants.

Mountain Pools and Impoundments

This concept includes wetlands without flowing water and not covered under "Mountain Alluvial Communities" or "Fens and Spray Cliffs". These are small patch communities dominated by emergent, floating, marshy, or shrubby vegetation seen in floodplain depressions or along the margins of ponds or lakes. These communities are not discussed by Barry (1980), Nelson (1986), or McMillan et al. (2022) but correspond to Schafale's (2024) concepts of "Floodplain Pools" and "Piedmont/Mountain Semipermanent Impoundments". USNVC classification includes "South-Central Interior Small Stream and Riparian", "South-Central Interior Large Floodplain", "Southern Piedmont Large Floodplain Forest", and "Southern Piedmont Small Floodplain and Riparian Forest" communities. Natural examples are rare in the Blue Ridge Ecoregion. In many areas small, often ephemeral, wetlands may form from rainwater or local sources and hold standing water. These communities are important breeding grounds for amphibians. Vegetation may range from open marshes dominated by grasses, sedges, and wetland herbs to dense shrub thickets of Tag Alder (*Alnus serrulata*), Black Willow (*Salix nigra*), Red Maple (*Acer rubrum*), or Buttonbush (*Cephalanthus occidentalis*). Man-made impoundments are also important wildlife habitat and thus also included here.

Pine Plantation

This community is new to this revision. In the 2015 SWAP it was treated as part of the broad "Upland Pine" community of the Piedmont Ecoregion and "Pine Woodland" of the Coastal Plain and Coastal Zone Ecoregions. Those classifications, however, also included natural pine-dominated communities. The USNVC classification for these timber production areas is

"Temperate & Boreal Plantation". Planted pine plantations have less prominence in the Blue Ridge Ecoregion than in other parts of the State. Still, they are an important part of the region's landscape. These timber production areas are more common at lower elevation areas, especially along the Blue Ridge Escarpment. Like the rest of the State, Loblolly Pine (*Pinus taeda*) is the typical species, although White Pine (*P. strobus*) plantations are also frequent. Pine plantations are generally poor wildlife habitat, lacking in both the food and cover needed by native wildlife.

Early-Successional Habitats

Early successional habitats in the Blue Ridge Ecoregion make up less cover than in other Ecoregions but are still important habitats for wildlife species that depend on these open areas. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual and perennial forbs and graminoids, and variable coverage of shrubs, vines, and small trees. A variety of open landcover types represent this category and can include old field sites, open canopy gaps, shrub thickets, recently re-forested areas, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports, and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early successional habitat. Maintenance of early successional habitat requires periodic disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished using timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of a variety of successional, or seral, stages.

Freshwater Streams, Rivers, Lakes, and Ponds

Although the Blue Ridge is the smallest ecoregion in South Carolina, encompassing only 1,204 km^2 (465 mi^2), 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**.

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 733 km^2 (283 mi^2). Most of the land is publicly owned with a significant portion protected by federal and state entities including the Jocassee Gorges Recreation Area, the Greenville Watershed Easement, and Sumter National Forest Wild and Scenic River Corridor along the Chattooga River. The Ecobasin encompasses approximately 599 km (372 mi.) of lotic habitat and 3,358 ha (8,298 ac.) of impoundments. There are 586 km (364 mi.) of wadeable streams in the Savannah-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 453 km^2 (175 mi^2). Most of the land is privately owned; however, a significant portion is protected by state, municipal, and private entities. The ecobasin

encompasses approximately 394 km (245 mi.) of lotic habitat. There are 409 km (254 mi.) of wadeable streams in the Santee-Blue Ridge Ecobasin.

Aquatic habitats in the Blue Ridge change physically, chemically, and biologically as water flows from the headwaters to streams, larger streams, and ultimately rivers while being influenced by the surrounding watershed and landscape (Hynes 1975, Vannote et al. 1980). Higher elevation streams are contained in their channels by erosion-resistant bedrock. Step-pools are commonly interspersed with riffle-run-pool habitats containing boulders, cobble, and gravel beds. Water pH is generally neutral, ranging from 6.4 to 7.4, with low dissolved solids and low hardness (Jennings et al. 2023). Habitat complexity and species diversity increase with stream size, producing a continuum of aquatic species assemblages from headwaters to the largest rivers. Whereas certain species are generalists and occur along the entire continuum in varying abundance, others are highly specialized for the precise set of physical and chemical characteristics produced by the underlying geology and surrounding landscape and only occur in certain stream sizes or habitat types within the Ecoregion.

Wadeable streams are the dominant aquatic classification in the Blue Ridge Ecoregion, and overall water quality is good. Wadeable streams are defined as streams with Strahler stream orders of 0 to 3 that generally 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 are less common in the Blue Ridge Ecoregion with only about 32 km (20 mi.) 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. Lakes of the area are man-made, with artificial species management; they are not pertinent habitat for the conservation of native species.

In an aquatic bioassessment framework developed by Denison et al. (2021) utilizing fish assemblage data, streams of the Blue Ridge Ecoregion responded similarly to those of the Piedmont Ecoregion to change in environmental and watershed characteristics (i.e. upland physical and chemical characteristics, disturbance). Across this Ecoregion, differences in fish assemblage composition and response to disturbance are primarily attributable to taxonomic differences between the Savannah and Santee River Basins due largely to the presence of "sister species" (i.e. taxonomically distinct but ecologically equivalent species) (Figure 3-2). The response of Blue Ridge streams to changes in environmental disturbance would therefore be expected to be most similar among streams within river basins.

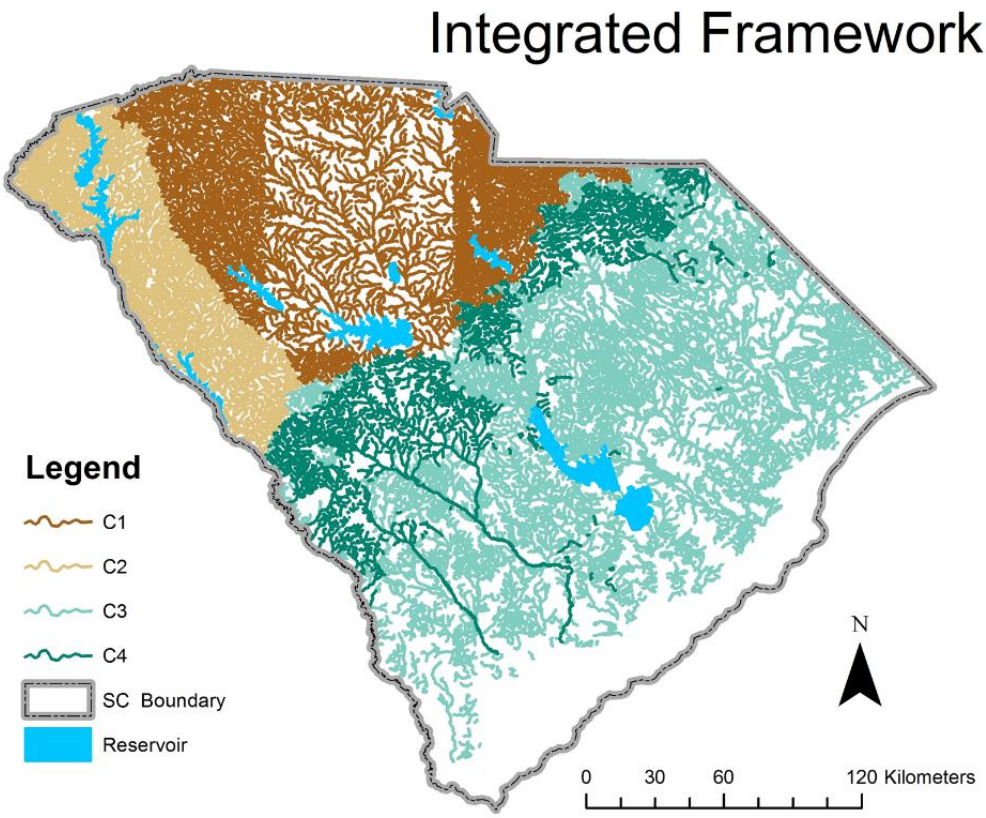

FIGURE 3-2: Freshwater fish bioassessment classes of South Carolina (Denison et al. 2021). Class 1 = Uplands-Santee/Pee Dee basins; Class 2 = Uplands-Savannah basin; Class 3 = Coastal Plain-Perennial/Intermittent; Class 4 = Coastal Plain-Stable Baseflow.

Piedmont Ecoregion

Piedmont Rock Outcrops and Glades

This concept includes Piedmont examples of "Granitic Dome" and "Granitic Flatrock" communities of Nelson (1986), and "Granitic Domes" and "Granitic Flatrocks" of McMillan et al. (2022), and "Flat Rock Communities" of Barry (1980). Schafale (2024) includes these communities in a broad "Low Elevation Cliffs and Rock Outcrops" theme as well as a "Granitic Flatrocks" theme. The USNVC classification is "Piedmont-Blue Ridge Dome and Flatrock". Rock outcrops of widely varying sizes and slopes occur throughout the region and are composed of granite or gneiss. These are often associated with monadnocks which are isolated hills rising from the surrounding terrain. Slopes range from nearly horizontal to nearly vertical. As classified here, Rock Outcrops that have 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 sparse tree tree-dominated communities. Successional trees, such as Eastern Red Cedar (*Juniperus virginiana*) and Virginia Pine (*Pinus virginiana*), are common on these sites. Other rocky communities can occur embedded in various Piedmont ecosystems, and those microhabitats themselves can be important for wildlife. Crevices and

ledges can only provide habitats for larger plants once sufficient soil has accumulated. A cliff or dome may also have small areas of wet seepage zones, with a mosaic of xeric to wet microhabitats in a small area. Some rock outcrops have small vernal pools with shallow soils. These pools are fed by later winter and spring rains and dry out when temperatures rise. These habitats are critical for several rare plant species, such as the federally threatened Pool-Sprite (*Gratiola amphiantha*) which can complete their life cycles during the brief wet period. These pools are also important breeding sites for amphibians.

Piedmont Monadnock Forest

This community is new to this revision. Isolated hills in the Piedmont often have a unique flora and topography in many ways more similar to the mountains than to the surrounding flatter areas of the Piedmont. This concept follows the "Piedmont Monadnock Forest" of Schafale (2024) and corresponds to the "Chestnut Oak-Heath Forests" of Barry (1980). The USNVC classification is "Piedmont-Coastal Plain Oak Forest and Woodland Group". Acidic monadnocks are often dominated by Chestnut Oak (*Quercus montana*) sometimes mixed with Shortleaf Pine (*Pinus echinata*) on drier ridges. Hardwoods are usually present and include xeric-adapted oaks such as Post Oak (*Q. stellata*) and Blackjack Oak (*Q. marilandica*), and others including Sourwood (*Oxydendrum arboreum*), Sassafras (*Sassafras albidum*), and Sour Gum (*Nyssa sylvatica*). The shrub layer is often dominated by Mountain Laurel (*Kalmia latifolia*) or Sparkleberry (*Vaccinium arboreum*). Sites maintained with fire can have diverse and dense graminoids and forbs. Common species are Little Bluestem (*Schizachyrium scoparium*), Poverty-Oat Grass (*Danthonia spicata*), and Woodland Coreopsis (*Coreopsis major*). A striking example is seen at Glassy Mountain in Pickens County, where the underlying geology is more mafic, so there are species more commonly found in dry but nutrient-rich areas such as White Oak (*Q. alba*), Northern Red Oak (*Q. rubra*), and Southern Black Haw (*Viburnum rufidulum*).

Oak-Hickory Forest

This concept includes the "Oak-Hickory Forest" of Nelson (1986) and McMillan et al. (2022), and "Ridgetop Forests", "Midslope Forests" and "Chestnut Oak-Heath Forests" in Barry (1980). Schafale (2024) includes several communities here under the "Piedmont and Coastal Plain Oak Forests" theme. The USNVC classification is "Piedmont-Coastal Plain Oak Forest and Woodland Group". Oak-Hickory Forest is a widely distributed community that varies from site to site and, as noted by McMillan et al. (2022), is complex and difficult to characterize. It is associated with acidic soils characteristic of rolling uplands in the Piedmont. It is made up of a diverse assemblage of hardwoods, primarily oaks and hickories, including Mockernut Hickory (*Carya tomentosa*), Pignut Hickory (*C. glabra*), Spanish Oak (*Quercus falcata*), Tulip-Tree (*Liriodendron tulipifera*), and Sour Gum (*Nyssa sylvatica*), and sometimes with mixed pines (*Pinus* spp.). Shrub and herbaceous layers are highly variable dependent on the canopy species present, their abundance, and other geomorphological factors.

Mesic Mixed Hardwood Forest

This concept includes the mesic Mixed Hardwood Forest of Nelson (1986) and the Beech Forest of McMillan et al. (2022) while Schafale (2024) classifies it as "Mesic Mixed Hardwood Forests (Piedmont Subtype)". The USNVC classification is "Southern Appalachian-Interior Mesic Forest Group". Mesic forests occur on mesic slopes, ravines, and sometimes flats. This habitat is typically characterized by closed canopy hardwood forests with White Beech (*Fagus grandifolia*

var. *caroliniana*), Tulip-Tree (*Liriodendron tulipifera*), Sour Gum (*Nyssa sylvatica*), Red Maple (*Acer rubrum*), and Sweet Gum (*Liquidambar styraciflua*). The understory is variable and typically composed of smaller tree species and shrubs. Where the understory is sparse to absent, a herbaceous layer of moderate density and diversity may develop.

Basic Mesic Forest

This concept includes the "Basic Forest" of Nelson (1986), Mixed-Mesophytic-Cove Hardwood Forest" of Barry (1980), and the "Basic Mesic Forest" of McMillan et al. (2022). Schafale (2024) classifies it as "Basic Mesic Forest (Piedmont Subtype)" while the USNVC classification is "Southern Appalachian-Interior Mesic Forest Group". Basic mesic forests form on high pH (circumneutral), mesic soils in sheltered locations such as north-facing slopes and ravines. They are among the most botanically diverse of Piedmont forests. Sites are widely scattered and often small. The canopy and understory are composed of hardwoods including White Beech (*Fagus grandifolia* var. *caroliniana*), Tulip-Tree (*Liriodendron tulipifera*), Sour Gum (*Nyssa sylvatica*), Sourwood (*Oxydendrum arboreum*), White Oak (*Quercus alba*), Northern Red Oak (*Q. rubra*), Black Oak (*Q. velutina*), Sweet Gum (*Liquidambar styraciflua*), Red Maple (*Acer rubrum*), Mountain Basswood (*Tilia americana* var. *heterophylla*), American Hornbeam (*Carpinus caroliniana*), Flowering Dogwood (*Benthamidia florida*), American Holly (*Ilex opaca*), Northern Witch-Hazel (*Hamamelis virginiana*) and American Hop-Hornbeam (*Ostrya virginiana*). Shrub species are usually numerous, and the herbaceous flora is fairly rich, including many spring ephemerals.

Piedmont Seepage Forest

This concept includes the "Piedmont Seepage Forest" of Nelson (1986), "Piedmont Springhead Seepage Forest" of McMillan et al. (2022), and subtypes of Schafale's (2024) "Low Elevation Seep" occurring in the Piedmont. The USNVC classifies these in part as "Central Hardwood Swamp Forest" and in part as "Eastern North American Seep and Rock Pool". Piedmont Seepage Forests are distinguished from forest alluvial communities along rivers and streams because they arise as seepage swamps, and soils and water have high mineral content. The canopy is mixed with Red Maple (*Acer rubrum*), Sweet Gum (*Liquidambar styraciflua*), Tulip-Tree (*Liriodendron tulipifera*), and often Swamp Tupelo (*Nyssa biflora*). Understory shrubs include Southern Wild Raisin (*Viburnum nudum*), Tag Alder (*Alnus serrulata*), Red Chokeberry (*Aronia arbutifolia*), and Southern Arrow-Wood (*V. dentatum*). Vines including Eastern Poison Ivy (*Toxicodendron radicans*), Virginia-Creeper (*Parthenocissus quinquefolia*), Climbing Hydrangea (*Hydrangea barbara*), and greenbriers (*Smilax* spp.) are often abundant, with a variable herb layer that often includes several species of sedges (*Carex* spp.), Common Jack-In-The-Pulpit (*Arisaema triphyllum*), Cinnamon Fern (*Osmundastrum cinnamomeum*), and Netted Chain Fern (*Lorinseria areolata*). The finest examples of this community are found in Greenville County near Travelers Rest, where the seepages support many rare herbs such as the federally endangered Bunched Arrowhead (*Sagittaria fasciculata*) and the federally threatened Dwarf-Flowered Heartleaf (*Hexastylis naniflora*).

Piedmont Alluvial Communities

This concept includes wetlands along rivers and creeks, following "Bottomland Hardwoods", "Small Stream Forest", "Shoal and Stream Bar" of Nelson (1986), and "Rocky Shoals" of McMillan et al. (2022). Schafale (2024) treats this in a broad "Piedmont and Mountain

Floodplains" theme, including "Piedmont Alluvial Forest", Piedmont Headwater Stream Forest", Piedmont Levee Forest", Piedmont Bottomland Forest", "Piedmont Swamp Forest", and Rocky Bar and Shore". The USNVC classifies these as mainly "Oak-Sweet Gum Floodplain Forest Group" but also as "Eastern North American Riverine Sand-Gravel Bar Group". Piedmont Alluvial Communities consist of usually hardwood-dominated woodlands, but also shrub-dominated or herbaceous wetlands, with moist soils that are associated with river and creek floodplains. Compared to the Coastal Plain, the floodplains of major rivers in the Piedmont are confined by topography and geology to relatively narrow corridors. Vegetation can be extremely variable depending on hydrology, soils, geology, and canopy. Characteristic tree species include Sweet Gum (*Liquidambar styraciflua*), Loblolly Pine (*Pinus taeda*), Water Oak (*Quercus nigra*), Willow Oak (*Q. phellos*), Laurel Oak (*Q. laurifolia*), Cherrybark Oak (*Q. pagoda*), and American Holly (*Ilex opaca*). Sunny edges along open water can be dominated by hardwood species that are adapted to wetter conditions such as Black Willow (*Salix nigra*), American Sycamore (*Platanus occidentalis*), River Birch (*Betula nigra*), and Tag Alder (*Alnus serrulata*). Emergent aquatic herbs may be present in shallow sunny areas, such as the edges of stream or river channels and along backwaters and oxbows. Rocky shoals at Fall Line sites can support populations of emergent and submerged aquatics such as American Water-Willow (*Justicia americana*), Shoals Spiderlily (*Hymenocallis coronaria*), and Threadfoot (*Podostemum ceratophyllum*). Canebrakes were once vast stands of River Cane (*Arundinaria gigantea*) along floodplains, thought to be fire-maintained and associated with settlement patterns of Native Americans (Platt & Brantley 1997). They are now largely gone from floodplains, though smaller patches of River Cane are often seen in broader floodplain communities.

Montmorillonite Forest

This community is new to this revision. This includes the "Montmorillonite Forest" of Nelson (1986), and "Piedmont Xeric Hardpan Forest" of McMillan et al. (2022). Schafale (2024) classifies this as "Xeric Hardpan Forest", with several subtypes, and also as "Mixed Moisture Hardpan Forest". The USNVC classification is "Piedmont-Coastal Plain Oak Forest and Woodland". This ecosystem is restricted to a small number of Piedmont counties and is best represented in York County. It forms on circumneutral pH "shrink-swell" clay soils, often over a rock hardpan. These soils and hardpan (when present) limit infiltration of water and roots. Sites flood after rainfall but can be extremely dry during drought. The canopy consists of stunted trees including Post Oak (*Quercus stellata*), Black Oak (*Q. velutina*), Willow Oak (*Q. phellos*), Carolina Shagbark Hickory (*Carya carolinae-septentrionalis*), Eastern Red Cedar (*Juniperus virginiana*), and sometimes Shortleaf Pine (*Pinus echinata*) and/or Virginia Pine (*P. virginiana*). The herbaceous layer is sometimes diverse, with rare plant species that are more characteristic of midwestern prairies such as Wild Hyacinth (*Camassia scilloides*). Montmorillonite Forests form on soils that can also support a subtype of Piedmont Prairie, but more work needs to be done to understand the long-term history and ecological processes of these two differently structured ecosystems.

Piedmont Prairies and Woodlands

This community is new to this revision, treated only generally in 2015 under a broad "Grasslands and Early Successional Habitats" classification. This includes the "Piedmont Prairie" and "Oak Savanna" of McMillan et al. (2022) but is not described by either Barry (1980) or Nelson (1986).

Schafale (2024) classifies this in his "Piedmont and Mountain Glades and Barrens" theme, with communities and their subtypes delineated by soil (type, pH, depth, slope) and vegetation structure (open, or with a sparse canopy). The growing literature indicates that open prairie and savanna ecosystems were once a prominent feature in the Piedmont and the restoration of these habitats are a high conservation priority, thus the need to separate them from modern early-successional habitats. The two difficulties in describing this community are that 1) it was likely many community types, and 2) examples have either been eliminated from the State or completely altered and only historical accounts or theories remain. Only fragments of what were likely widespread prairies and woodlands remain today. The best examples are in York County (Rock Hill Blackjacks Heritage Preserve), and the Post Oak Savanna natural area in Sumter National Forest in Saluda County. Otherwise, most remnants are along road shoulders and utility rights-of-ways with plant species that indicate the former presence of prairies or woodlands. These communities likely had scattered trees (i.e. woodland ecosystems), but it is possible that some were treeless (prairies). Open conditions would have been influenced by period fires, both from lightning and by Native Americans. Canopy species likely included Post Oak (*Quercus stellata*), Blackjack Oak (*Q. marilandica*), and pines such as Shortleaf Pine (*Pinus echinata*). The groundcover was likely rich in graminoids and forbs with widespread species including Little Bluestem (*Schizachyrium scoparium*), Big Bluestem (*Andropogon gerardi*), and Yellow Indiangrass (*Sorghastrum nutans*). Soil type would have strongly influenced species composition. Prairies on wet "shrink-swell" soils have an unusual set of species with midwestern prairie affinities.

Even roadsides that harbor native plant species can provide habitat for insect species such as this Monarch Butterfly in Charleston County, SC. Photo by Anna Smith, SCDNR

Piedmont Pools, Depressions, and Impoundments

This heterogeneous concept includes any wetland with standing water at least part of the year not covered in "Piedmont Alluvial Communities" or "Piedmont Small Stream Seepage Forest" or "Piedmont Rock Outcrops and Glades" above, such as pools, depressions, and man-made impoundments. Included here are Nelson's (1986) concept of "Upland Depression Swamp Forest" and Schafale's "Piedmont and Mountains Upland Pools and Depressions" theme as well as his concepts of "Floodplain Pool" and "Piedmont/Mountain Semipermanent Impoundment" of USNVC. In many areas, small, often ephemeral, wetlands may form from rainwater or local sources and hold standing water. Vegetation may range from small pools or open marshes to dense forests. Beaver activity may contribute to semipermanent impoundments, but man-made impoundments are also important wildlife habitat so are therefore included here.

Pine Plantation

This community is new to this revision. In the 2015 SWAP it was treated as part of the broad "Upland Pine" community of this Piedmont Ecoregion, and "Pine Woodland" of the Coastal Plain and Coastal Zone Ecoregions, and absent from the Blue Ridge Ecoregion. Those classifications, however, also included natural pine-dominated ecosystems. The USNVC classification for these timber production areas is "Temperate and Boreal Plantation". Planted pine plantations are the dominant vegetation type in the Piedmont's landscape. Loblolly Pine (*Pinus taeda*) is the most planted species, although Eastern White Pine (*P. strobus*) plantations are also present. Loblolly Pine is often co-dominant with dense Sweet Gum (*Liquidambar styraciflua*). Pine plantations are generally poor wildlife habitat, lacking in both the food and cover needed by native wildlife.

Early-Successional Habitats

Early-successional habitats are important habitats for wildlife species that depend on these open areas. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual and perennial forbs and graminoids with variable coverage of shrubs, vines, and small trees. A variety of open landcover types represent this category and can include old field sites, open canopy gaps, shrub thickets, recently cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early successional habitat is usually accomplished through timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of a variety of successional, or seral, stages.

Freshwater Streams, Lakes, and Ponds

The Piedmont Ecoregion extends south of the 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 27,941 km² (10,788 mi^2), 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 114 to 305 m (375 to 1,000 ft.). Freshwaters in the Piedmont Ecoregion total approximately 17,703 km (11,000 mi.) of streams and rivers with over 777 km² (300 mi^2) of major impoundments. By length, first- through fourth-order (wadeable) streams comprise the primary aquatic habitat type. At higher elevations, Piedmont streams may exhibit moderate gradient with coarse substrates including cobble, gravel, and bedrock. Lower elevation Piedmont streams generally have less gradient with substrates primarily consisting of sand, gravel, and silt. Piedmont streams are typified by long runs of intermediate depth separated by shallow riffles and deeper pools. The Piedmont Ecoregion cuts across the top of 3 major South Carolina drainages, the Savannah, the Santee, and the Pee Dee, forming 3 ecobasins: the **Savannah-Piedmont, Santee-Piedmont** and **Pee Dee-Piedmont**.

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 211 km (131 mi.) 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 7,457 km^2 (2,879 mi^2) and contains 5,356 km (3,328 mi.) of lotic habitat with 370 km^2 (143 mi^2) of impoundments.

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 increasing human population. Impacts to the watershed from point- and non-point sources can have a degrading effect on the aquatic community downstream.

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 from the Santee River.

The **Santee-Piedmont Ecobasin** is the largest in the State, containing part or all of 84 watersheds and encompassing 19,694 km^2 (7,604 $mi.^2$). The Ecobasin contains approximately 18,547 km^2 (7,161 mi.) of stream habitat and nearly 414 km^2 (160 $mi.^2$) of impoundments. The Santee-Piedmont Ecobasin contains several areas of conservation priority (Smith et al. 2002). 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 region in Saluda County; the main stem 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 area in Cherokee and York Counties; the Six Mile Creek and Waxhaw Creek systems in the Twelve Mile 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 priority fish species including Turquoise Darter and Carolina Fantail Darter. The Clouds Creek watershed contains populations of the priority fish species the Carolina Darter (formerly Saluda Darter) as well as at least one priority mussel

species, the Savannah Lilliput. The main stem of the Broad River contains priority fish species including several catostomids (Notchlip Redhorse, V-lip Redhorse, Quillback, and Highfin Carpsucker) and percids (Seagreen Darter, Carolina Fantail Darter, and Piedmont Darter). The Kings Creek watershed and Clarks Fork system contain several priority fish species including the Carolina Fantail Darter, the Seagreen Darter, and the Piedmont Darter. The Six Mile 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, Piedmont Darter, and Seagreen Darter.

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 715 km^2 (276 $mi.^2$). Tributaries to the Pee Dee River included in the Ecobasin are the Lynches River and Thompson Creek. There are approximately 753 km (468 mi.) of stream habitat within the Ecobasin and only 136 ha (337 ac.) of impounded water. 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. Also, the Thompson Creek system in the upper Pee Dee basin in Chesterfield County is a high priority. 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 the federally endangered Carolina Heelsplitter. The Thompson Creek system contains several priority fish species—"Thinlip" Chub, Sandhills Chub, Fantail Darter, and Piedmont Darter—as well as several species whose populations in South Carolina are entirely restricted to that system such as the Satinfin Shiner, Redlip Shiner, and Comely Shiner.

In the Piedmont, aquatic habitats change physically, chemically, and biologically as water flows from the headwaters to streams, larger streams, and ultimately rivers while being influenced by the surrounding watershed and landscape (Hynes 1975, Vannote et al. 1980). In the higher elevation sections of the Piedmont, gradients average 5-10 m/km and substrates remain generally course. In lower elevations, broader alluvial valley characteristics prevail, with riffle-run-pool sequences the dominant habitat type. Water pH is relatively neutral, with a range of 6.4 to 7.4, with relatively low dissolved solids and hardness (Jennings et al. 2023). Habitat complexity and species diversity increase with stream size, producing a continuum of aquatic species assemblages from headwaters to the largest rivers. Whereas certain species are generalists and occur along the entire continuum in varying abundance, others are highly specialized for the precise set of physical and chemical characteristics produced by the underlying geology and surrounding landscape and only occur in certain stream sizes or habitat types within the Ecoregion.

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 comfortably wadeable 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 coble 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 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.

In an aquatic bioassessment framework developed by Denison et al. (2021) utilizing fish assemblage data, streams of the Piedmont Ecoregion responded similarly to those of the Blue Ridge Ecoregion to change in environmental and watershed characteristics (i.e. upland physical and chemical characteristics, disturbance). Across this Ecoregion, differences in fish assemblage composition and response to disturbance are primarily attributable to taxonomic differences between the Savannah and Santee River basins due largely to the presence of "sister species" (i.e. taxonomically distinct but ecologically equivalent species) (Figure 3-2). The response of Piedmont streams to changes in environmental disturbance would therefore be expected to be most similar among streams within river basins.

Sandhills Ecoregion

Longleaf Pine Sandhill

This ecosystem is defined extremely broadly here and includes any Longleaf Pine- (*Pinus palustris*) dominated ecosystem in the Ecoregion. This includes the "Pine-Scrub Oak Sandhill", "Xeric Sandhill Scrub" of Nelson (1986), "Turkey Oak Barrens", "Scrub Oak Barrens", and in part the "Xeric Pine-mixed Hardwoods" of Barry (1980), and the "Longleaf Pine-scrub Oak Sandhills" and "Longleaf Pine-Turkey Oak Sandhills" of McMillan et al. (2022). Schafale (2024), under the "Dry Longleaf Pine Communities" theme, divides this vegetation type into a variety of Longleaf Pine-dominated forest, barren, scrub, and Sandhill types. The USNVC classification is "Xeric Longleaf Pine Woodland Group". On the well-drained sands of the Ecoregion, frequent fires have formed Longleaf Pine- (*Pinus palustris*) dominated communities. The Longleaf Pine-Wiregrass subtype is dependent on fire for maintenance. Wiregrass and leaf litter generally carry fire well and Longleaf Pine is well-adapted to fire due to its specialized

juvenile stage and thick bark. Where fire is excluded, Turkey Oak (*Quercus laevis*) and other scrub oak species gradually increase in abundance. Sandhill communities are variable in structure and species composition correlated with soils, fire frequency, and geography. Most typically, there is a relatively open canopy, an understory of xeric-adapted oak species, and a diverse groundcover of graminoids and forbs. In the most xeric sands "Sand Barren" subtypes may form, with large areas of open sand with little herbaceous cover. Sandhill habitats with loamier soils can have much more diverse herb and graminoid communities, supporting rare species and abundant members of the bean family (*Fabaceae*), though the dominant species is still usually wiregrass, with Southern Wiregrass (*Aristida beyrichiana*) occurring in the southern part of the region, and Carolina Wiregrass (*A. stricta*) in the northern part.

Oak-Hickory Forest

This concept includes the "Oak-Hickory Forest" of Nelson (1986) and McMillan et al. (2022), and "Xeric Pine-Mixed Hardwoods" of Barry (1980). Schafale (2024) calls it "Dry Oak–Hickory Forest (Coastal Plain Subtype)". USNVC classifies it as "Piedmont-Coastal Plain Oak Forest and Woodland Group". Oak-Hickory Forest is a widely distributed and variable community. 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, sometimes 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. Characteristic canopy species include White Oak (*Quercus alba*), Spanish Oak (*Q. falcata*), and often Post Oak (*Q. stellata*), Mockernut Hickory (*Carya tomentosa*), and Loblolly Pine (*Pinus taeda*), and sometimes Shortleaf Pine (*Pinus echinata*). The understory usually contains Sourwood (*Oxydendrum arboreum*), Flowering Dogwood (*Benthamidia florida*), and American Holly (*Ilex opaca*). The herbaceous layer is often sparse but can include dense Slender Spikegrass (*Chasmanthium laxum*).

Mesic Mixed Hardwood Forest

This concept includes the "Mesic Mixed Hardwood Forest" of Nelson (1986), and "Beech Forest" of McMillan et al. (2022). Schafale (2024) calls this "Mesic Mixed Hardwood Forest (Coastal Plain Subtype). The USNVC classification is "Southern Mesic Beech-Oak-Mixed Deciduous Forest Group". Mesic forests are scattered throughout the region, often associated with river bluffs and other sites where fire shadows form. Soils are moist, intermediate between the dryer soils of Oak-Hickory Forest and wet soils of alluvial forests, and have a lower pH than Basic Mesic Forest. These forest communities may consist of a mixed hardwood canopy. Common canopy species include White Beech (*Fagus grandifolia* var. *caroliniana*), Tulip-Tree (*Liriodendron tulipifera*), Water Oak (*Quercus nigra*), White Oak (*Q. alba*), Sweet Gum (*Liquidambar styraciflua*), and often Loblolly Pine (*Pinus taeda*), although a wide variety of tree species can occur. The shrub layer often includes American Beautyberry (*Callicarpa americana*), Sweetleaf (*Symplocos tinctoria*), Dangleberry (*Gaylussacia frondosa*), and Switch Cane (*Arundinaria tecta*). Herbs and graminoids may be sparse to dense.

Basic Mesic Forest
Forests with high pH have not been well-described for the Sandhills Ecoregion. This concept somewhat follows the "Basic Forest" of Nelson (1986). He restricted that community to the Piedmont Ecoregion, but Sandhill Ecoregion examples have similarities. Schafale includes this as Basic Mesic Forest (Coastal Plain Subtype). The USNVC calls this "Southern Mesic Beech - Oak - Mixed Deciduous Forest Group". Basic Mesic Forests are found on high pH soils and are dominated by a mixed canopy of hardwoods. This is a rare ecosystem in the Sandhills Ecoregion, and examples are mainly found associated with bluffs along large rivers such as the Congaree, Savannah, and Wateree, close to the Fall Line where high pH substrates are exposed beneath well-drained sands. Canopy composition varies with soil moisture, but species include Live Oak (*Quercus virginiana*), Basket Oak (*Q. michauxii*), American Hop-Hornbeam (*Ostrya virginiana*), and White Beech (*Fagus grandifolia* var. *caroliniana*). There may be an understory of shrubs or palms including Common Wax-Myrtle (*Morella cerifera*) and Dwarf Palmetto (*Sabal minor*). There will be plant species that are indicators of calcareous or circumneutral soils including Silverbells (*Halesia* spp.), American Hop Hornbeam (*O. virginiana*), Silky Camellia (*Stewartia malacodendron*), Richweed (*Collinsonia canadensis*), or Mellichamp's Skullcap (*Scutellaria mellichampii*).

Streamhead Pocosin
This community is new to this revision. It includes the "Seepage Pocosin" and "Streamhead Pocosin" of Nelson (1986) and "Streamhead Pocosin" of McMillan et al. 2022. Schafale includes it as a "Streamhead Pocosin" theme and all four community types under it are included here, including "Streamhead Pocosin", "Sandhill Streamhead Swamp", "Streamhead Canebrake", and "Streamhead Atlantic White Cedar Forest". The USNVC includes these as "Southern Coastal Plain Mixed Evergreen Swamp Group" and for canebrakes "Southeastern Coastal Pocosin and Shrub Bog Group". These pocosin ecosystems are frequent in the Sandhills, arising at streamheads in Longleaf Pine communities. All are characterized by permanently saturated soils in seepage-fed Sandhill drainages. Vegetation structure is variable, as reflected in Schafale's classification, but is usually a suite of evergreen shrubs and sometimes with a canopy of Pocosin Pine (*Pinus serotina*) or much more rarely Atlantic White Cedar (*Chamaecyparis thyoides*). Variation is due to fire history and fire regime, slope, hydrology, and physiography. A tree canopy is often more abundant downslope where fires penetrate less frequently, grading into Blackwater Floodplains. Common tree species include Pocosin Pine, Tulip-Tree (*Liriodendron tulipifera*), Swamp Bay (*Tamala palustris*), and Sweet Bay (*Magnolia virginiana*). Shrub species include Little Gallberry (*Ilex glabra*), Big Gallberry (*Ilex coriacea*), Shining Fetterbush (*Lyonia lucida*), and Poison Sumac (*Toxicodendron vernix*). The graminoid and forb layer is usually sparse unless fires are very frequent.

Sandhill Seep
This includes the "Hillside Herb Bog" of Nelson (1986), "Hillside Bogs" of Barry (1980), and Herbaceous Seepage Slopes" of McMillan et al. (2022). Schafale (2024) calls this "Sandhill Seep". The USNVC classification is "Wet-Mesic Longleaf Pine Open Woodland Group". Sandhill seeps 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. This ecosystem is related

to Streamhead Pocosins because they can form on similar sites, but Sandhill Seeps are characterized by a dense graminoid and forb groundcover, often with shrubs. Vegetation is variable, depending on position on the slope, the amount of peat accumulation, and fire history, but is here defined as having a sparse tree canopy and low shrub density. Lacking fire, woody plant density may become dense causing succession to Streamhead Pocosin. An open canopy of Pocosin Pine (*Pinus serotina*) is typical, but sometimes with sparse hardwoods such as Tulip-Tree (*Liriodendron tulipifera*). Shrubs include Pocosin Bayberry (*Morella caroliniensis*), blueberries (*Vaccinium* spp.), Pocosin Witch-Alder (*Fothergilla gardenii*), St. John's-worts (*Hypericum* spp.), Little Gallberry (*Ilex glabra*), Big Gallberry (*Ilex coriacea*), Shining Fetterbush (*Lyonia lucida*), and Poison Sumac (*Toxicodendron vernix*). This is now a rare ecosystem in South Carolina because of fire suppression. Some of the best examples remaining occur in utility rights-of-ways where woody plants are controlled through prescribed fire or periodic mowing. Those managed with herbicide application are generally of lower floristic quality and have fewer conservative species.

Depression Wetlands; Carolina Bays

This community is very broadly defined here and includes depression wetlands representing many distinctive habitats within this broad category. This includes Carolina Bays, High Ponds, vernal pools, flatwoods pond, wet weather pond, and broad swales that aren't connected to alluvial systems. This concept includes the "Pocosin" and "Pond Cypress Pond" or Nelson (1986), and "Pocosins" and possibly "Depression Meadows" of McMillan et al. (2022). Schafale (2024) treats these in a broad "Coastal Plain Depression Communities" theme that encompasses the Sandhills and Coastal Plain. This includes depression pocosin, depression swamp, vernal pool, cypress savanna, draw-down meadow, and depression pond. USNVS communities include "Southern Atlantic Coastal Plain Depression Pond" and "Atlantic Coastal Plain Clay-Based Carolina Bay Wetland".

Depression wetlands in the Sandhills formed due to many reasons, such as the collapse of a friable subterranean layer such as sandstone, or due to natural concavities, bowls, or slumps on the surface topography. These depressions will hold water given the presence of an impermeable soil layer such as clay, rock, or humate-impregnated sand. Depression wetlands are often referred to as "perched" water tables because they hold water perched above the normal sub-surface water table. They are also referred to as isolated, temporary wetlands due to the general lack of connection to surface streams and the pulsed nature of their hydrology, typically filling and drying with rainfall cycles.

Some of these wetlands display unique geomorphologies, such as Carolina Bays and High Ponds. The latter are poorly understood and are restricted to an area of Atlantic Southern Loam Plain that's inland of the true Sandhills Ecoregion, around the intersection of Aiken, Edgefield, and Saluda counties. Carolina Bays, and likely also High Ponds, are a class of depression wetland that display both a unique shape and orientation. Carolina Bays are either oval or elliptical in shape with the long axis of the ellipse, or oval lying along a northwest to southeast alignment. There are several hypotheses about the origin of these features, but no conclusive data supports any one of them to date.

Depression wetlands in the Coastal Plain can support a variety of vegetative community types ranging from Pond-Cypress- (*Taxodium ascendens*) or Swamp Tupelo- (*Nyssa biflora*) dominated ponds, to Pond Cypress savannas and wet meadow communities, and/or to pocosin and Pocosin Pine (*Pinus serotina*) woodlands. Open water ponds, hardwood ponds, and sedge-dominated ponds may occur in other parts of the State as well.

Despite the differences in origin, geomorphology, and vegetative structure, these habitats are similar in ecological function. With a few notable exceptions, these habitats are primarily linked to rainfall cycles, relying on rain to fill their basins and subsequently drying out during periods of low rainfall. The frequency of inundation may vary both in time and in location, such that most of these wetlands do not fill and dry on an annual basis.

Depression wetland habitats are detritus-based systems. When they dry, herbaceous plants and grasses die back and desiccate, forming a detrital layer. When the basins are inundated again, this detritus forms the base of a food web that can support a variety of invertebrate and vertebrate species. Many native plant and animal species, including numerous rare species, rely on depression wetlands as a primary habitat or for some life history stage such as breeding habitat. Because these habitats fill and dry cyclically, they typically do not support large predatory fish populations. Numerous amphibian species in South Carolina breed preferentially or exclusively in depression wetland habitats. Avoidance of larval predators, such as fish, is a critical adaptive mechanism for amphibians, and one solution is to breed in fish-free habitats such as depression wetlands. As such, depression wetlands are critically important habitats for several amphibian species in South Carolina.

Blackwater Floodplains

This concept includes the variety of alluvial ecosystems that occur along blackwater waterways including rivers and streams. Because of the variation, a crosswalk to other sources is difficult, but it does include blackwater examples of Nelson's (1986) "Atlantic White Cedar Swamp", "Bald-Cypress-Tupelo Gum Swamp, "Bay Forest" (likely in part), "Bottomland Hardwoods", "Levee", "Shoal & Stream Bar", and "Small Stream Forest". McMillan et al. (2024) includes "Atlantic White Cedar Forests" and different kinds of "Bottomland Forest Communities" including blackwater types of "Bald-Cypress-Tupelo Gum Swamp Forests", "Hardwood Bottom Forests", and "Levee Forests". Schafale (2024) has a broad treatment of a "Coastal Plain Floodplains" theme, and his blackwater communities are included here, including "Levee/Bar Forest", "Bottomland Hardwoods", "Cypress-Gum Swamp", "Oxbow Lake", "Sand and Mud Bar", "Riverine Floating Mat", and "Semipermanent Impoundment". The USNVC classification includes "Oak-Sweetgum Floodplain Forest Group", "Oak-Sweetgum Floodplain Forest Group", "Bald-cypress-Tupelo Floodplain Forest", Eastern North American Riverine Sand-Gravel Bar Group", "South Atlantic and Gulf Coastal Plain River and Basin Freshwater Marsh and Wet Meadow Group", and "Eastern North American Freshwater Aquatic Vegetation Group". Streams and rivers arising in the Sandhills and Coastal Plain are commonly known as "blackwater" for the color of tannins that leach from decaying vegetation. They are more acidic than "brownwater" rivers with lower ion concentrations. Forests on the floodplains formed by these waterways 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-Tree (*Liriodendron tulipifera*), Sweet Gum (*Liquidambar*

styraciflua), Pocosin Pine (*Pinus serotina*), Loblolly Pine (*Pinus taeda*) and Laurel Oak (*Quercus laurifolia*) are important associates. The shrub layer is open in areas subject to the most flooding, or it can be 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 (*Chamaecyparis thyoides*). Sunny areas along the waterways can support marsh vegetation. Draw-down zones during low water can support an assemblage of herbaceous annual plant species.

Brownwater Floodplains

This concept includes the variety of alluvial ecosystems that occur along brownwater waterways including rivers and streams. Because of the variation, a crosswalk to other sources is difficult, but it does include brownwater examples of Nelson's (1986) "Bald-Cypress-Tupelo Gum Swamp, "Bottomland Hardwoods", "Levee", "Shoal and Stream Bar", and "Small Stream Forest". McMillan et al. (2024) includes different kinds of "Bottomland Forest Communities" including brownwater types of "Bald-Cypress-Tupelo Gum Swamp Forests", "Hardwood Bottom Forests", and "Levee Forests". Schafale (2024) has a broad treatment of a "Coastal Plain Floodplains" theme, and his brownwater communities are included here, including "Levee/Bar Forest", "Bottomland Hardwoods", "Cypress-Gum Swamp", "Oxbow Lake", "Sand and Mud Bar", "Riverine Floating Mat", and "Semipermanent Impoundment". The USNVC classification includes "Southern Ash-Elm-Willow Floodplain Forest Group", "South Central-Appalachian-Northeast Floodplain Forest Group", "Oak-Sweetgum Floodplain Forest Group", "Bald-cypress-Tupelo Floodplain Forest", "Bald-Cypress-Tupelo Floodplain Forest", "Eastern North American Riverine Sand-Gravel Bar Group", and "Eastern North American Freshwater Aquatic Vegetation Group".

Streams and rivers arising or cutting through the Piedmont and Blue Ridge are commonly known as "brownwater" for the dark brownish color due to high amounts of silt and clay particles suspended in the water. Forests on the floodplains formed by these waterways typically have a canopy dominated by Sweet Gum (*Liquidambar styraciflua*), Loblolly Pine (*Pinus taeda*), Water Oak (*Q. nigra*), Willow Oak (*Q. phellos*), Laurel Oak (*Q. laurifolia*), Cherrybark Oak (*Q. pagoda*) and American Holly (*Ilex opaca*). The Cypress-Tupelo Swamp subtype occurs on lower elevation sites as seasonally flooded swamps. Dominant trees are Bald-Cypress (*Taxodium distichum*), Water Tupelo (*Nyssa aquatica*), Planer-Tree (*Planera aquatica*) and Red Maple (*Acer rubrum*). Sunny areas along the waterways can support marsh vegetation or floating mats, or occasionally canebrakes. Draw-down zones during low water can support an assemblage of herbaceous annual plant species.

Pine Plantation

This community is new to this revision. In the 2015 SWAP, it was treated as part of the broad "Upland Pine" community of the Piedmont Ecoregion and "Pine Woodland" of the Coastal Plain and Coastal Zone Ecoregions. Those classifications, however, also included natural pine-dominated woodlands. The USNVC classification for these timber production areas is "Temperate and Boreal Plantation". Planted pine plantations are very abundant in the Sandhills Ecoregion, comprising much of the area formerly occupied by the various communities making up the greater Southeastern Longleaf Pine ecosystem. Like the rest of the State, Loblolly Pine

(*Pinus taeda*) is the typical species. Pine plantations are generally poor wildlife habitat, however, lacking in both the food and cover needed by native wildlife.

Early-Successional Habitats

Early-successional habitats in the Sandhills Ecoregion are important habitats for wildlife species that depend upon these open areas. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual and perennial forbs and graminoids and a variable coverage of shrubs, vines, and small trees. A variety of open landcover types represent this category and can include old field sites, open canopy gaps, shrub thickets, recently reforested areas, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports, and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high-quality, early-successional habitat. Maintenance of early-successional habitat requires periodic disturbance or disruption of the existing vegetative community. Purposeful management of Early -Successional Habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of a variety of successional, or seral, stages.

Freshwater Streams, Rivers, Lakes, and Ponds

[The aquatic habitats in this ecoregion are discussed in the framework of the larger Southeastern Plains instead of just the Sandhills.]

Streams and rivers originating in the Sandhills Ecoregion are generally low to moderate gradient and often possess tannin-stained waters imparted by the surrounding vegetation. The classic Sandhills stream exhibits steady, moderate flow over a predominantly sand substrate with patches of rooted aquatic vegetation and scattered woody debris. Streams in this region may also transition into swamps and wetlands in areas of lower gradient. First- through fourth-order streams make up the majority of freshwater habitats on the landscape.

Portions of all of South Carolina's major river basins occur in the Sandhills Ecoregion. The region denoted the Southeastern Plains encompasses the Sandhills and Upper Coastal Plain and is sandwiched between the Piedmont to the north and the Lower Coastal Plain to the south. (This follows the Griffith et al. 2002 ecoregion map before its modification for the SWAP in Figures 2-1 and 3-1.) It extends northwest from the Savannah River to the Pee Dee River. The Southeastern Plains encompasses portions of 24 counties and 23,584 km² (9,106 mi²). Just below the Fall Line, the region is dominated by sandy soils with scrub vegetation on moderately sloping lands. This portion is known as the Sandhills and varies in elevation from 76-137 m (250-450 ft.) above mean sea level. Moving toward the coast, the topography is reduced to gentle sloping and then to nearly level lands with elevations of 130-137m (25-450 ft.).

The **Savannah-Southeastern Plains Ecobasin** extends from the southern portions of Edgefield County south to the southern portion of Allendale County. It includes about 137 km (85 mi.) 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 6 watersheds and parts of 10 others in its 2,538 km^2 (980 $mi.^2$). The Ecobasin contains 1,576 km (979 mi.) of lotic habitat and 2,600 ha (6,425 ac.) of lentic habitat, primarily impoundments. A small portion of the lentic habitat is comprised of Carolina Bays.

Primary conservation targets in the Ecobasin include the main stem Savannah River in Aiken and Allendale Counties, Upper Three Runs Creek and its tributaries in Aiken and Barnwell Counties, and the Brier Creek system in Allendale County (Smith et al. 2002). The main stem of the Savannah River within the Ecobasin contains several aquatic animals on South Carolina's Species of Greatest Conservation Need (SGCN) List including Shortnose Sturgeon and Robust Redhorse, as well as several mussel species (e.g. 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.

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 5,747 km^2 (2,219 $mi.^2$). The Ecobasin contains approximately 2,239 km (2,117 mi.) 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 730 ha or 5 ac.) 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 main stem 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. 2002). 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.

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 3 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 5,346 km^2 (2,064 $mi.^2$). The Ecobasin contains approximately 3,589 km (2,230 mi.) of lotic habitat and 379 km^2 (146 $mi.^2$) of lentic habitat, most of which is contained in Lake Marion (352 km^2 or 136

mi.^{2}). 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.

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 3 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 34 km 114 km (21 mi.) through the South Carolina Piedmont before entering the Pee Dee-Southeastern Plains Ecobasin, then flows another 114 km (71 mi.) until it enters the Coastal Plain, picking up inputs from 2 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 148 km (92 mi.) 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 119 km (74 mi.) through the Pee Dee-Southeastern Plains Ecobasin before entering the Coastal Plain of South Carolina. The primary tributary is Buck Swamp. Pocataligo 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 9,920 km^2 (3,830 mi.^{2}). There are about 7,388 km (4,591 mi.) of lotic habitat and 96 km^2 (37 mi.^{2}) of lentic habitat; the largest lentic area is Big Bay (1,002 ha or 2,476 ac.) which is a Carolina Bay.

Areas of primary conservation concern include the upper Lynches River and its Sandhills tributaries in Chesterfield, Kershaw, Lee, and Darlington Counties; the 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. 2002). The upper Lynches River is home to several aquatic priority fish (Sandhills Chub, "Thinlip" Chub, and "Broadtail" Madtom) and mussels (Brook Floater, Creeper, Notched Rainbow, and the federally endangered Carolina Heelsplitter). The main stem 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.

Aquatic habitats in the Sandhills change physically, chemically, and biologically as water flows from the headwaters to streams, larger streams, and ultimately rivers while being influenced by the surrounding watershed and landscape (Hynes 1975, Vannote et al. 1980). Habitat complexity and species diversity increase with stream size, producing a continuum of aquatic species assemblages from headwaters to the largest rivers. Whereas certain species are generalists and occur along the entire continuum in varying abundance, others are highly specialized for the precise set of physical and chemical characteristics produced by the underlying geology and

surrounding landscape and only occur in certain stream sizes or habitat types within the Ecoregion.

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 SGCN list. Wadeable streams are those with Strahler stream orders of 0 to 3; generally, these are 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; these streams commonly overflow their banks, bringing in organic material from the floodplain. Bacterial decomposition releases both tannic and fulvic acids, decreasing the pH to low levels; the average pH in the North and South forks of the Edisto River, for example, average 5.4 (Jennings et al. 2023).

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.

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.

In an aquatic bioassessment framework developed by Denison et al. (2021) utilizing fish assemblage data, streams of the Sandhills were characterized predominantly by a Stable Baseflow hydrology with associated fish assemblages that are more oriented to greater water current velocities (Figure 3-2). The fish assemblage characteristics and expected response of Sandhills streams to changes in environmental or landscape factors (i.e. disturbance) would therefore be expected to be most similar among streams with this type of hydrology.

Coastal Plain Ecoregion

Pine Savannas and Flatwoods

This highly variable concept includes pine-dominated communities that are mesic to wet. This excludes drier Sandhill communities (see "Longleaf Pine Sandhill"), and it also excludes wet pine communities in Carolina Bays (see "Depression Wetlands/Carolina Bays" treatment). This concept follows the "Wet Pine Savannas" theme, and "Mesic Pine Savanna" communities of Schafale (2024). Similarly, it includes the "Pine/Saw Palmetto Flatwoods" and "Longleaf Pine Savannas" of McMillan et al. (2022) as well as the "Pine Flatwoods", "Pine Savannah", "Pine-Saw Palmetto Flatwoods" and "Pond Pine Woodland" of Nelson (1986). The USNVC classifications are "Dry-Mesic Loamy Longleaf Pine Woodland Group" and "Mesic Longleaf Pine Flatwoods-Spodosol Woodland Group". The canopy in these communities is dominated by one or several species of pine, generally Longleaf Pine (*Pinus palustris*) or Pocosin Pine (*Pinus serotina*), depending on soil moisture. Canopy closure ranges from very open, to dense on fire suppressed sites. When burning is frequent, graminoid and herb density and diversity can be very high, but in the absence of fire, shrubs can become predominant, including Dangleberry (*Gaylussacia frondosa*), Common Wax-Myrtle (*Morella cerifera*), and Little Gallberry (*Ilex glabra*). Optimal habitat for priority species consists of open stands of pine, sparse understory and shrub layers, and a dense groundcover. The community, as circumscribed here, is variable and could be broken down further. As detailed by Schafale (2024), mesic soils support "Mesic Pine Savanna" communities that are usually dominated by Longleaf Pine. Seasonally saturated sites support "Wet Pine Flatwoods" that are usually dominated by Pocosin Pine.

Dry Longleaf Pine

This concept is for pine communities on dry soil. It includes the "Pine-Scrub Oak Sandhill" and "Xeric Sandhill Scrub" of Nelson (1986), "Turkey Oak and Scrub Oak Barrens" of Barry (1980), and "Longleaf Pine-Scrub Oak Sandhills", "Longleaf Pine-Turkey Oak Sandhills" of McMillan et al. (2022). Schafale included this in a "Dry Longleaf Pine" communities theme, excluding savannas (see "Pine Savannas and Flatwoods" community). The USNVC classification is "Xeric Longleaf Pine Woodland Group" and "Dry-Mesic Loamy Longleaf Pine Woodland Group". Dry Longleaf Pine is a variation of "Pine Savannas and Flatwoods" composed of species adapted to xeric, sandy soils. This community type occurs along dry sand ridges including riverine sand ridges and Carolina Bay rims. It is characterized by an absence of frequent fire, a canopy of Longleaf Pine, and a subcanopy of Turkey Oak interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to the development of a diverse graminoid- and forb-dominated groundcover. Where sand ridges form in fluvial versus alluvial environments, the plant species composition may be dramatically different because of differences in soil composition. Regular flood events, that shift sand ridges along the Waccamaw or Little Pee Dee Rivers, may hinder the development of a more diverse suite of plant species. The sole canopy species is Longleaf Pine (*Pinus palustris*) when frequently burned. Shrub species can be diverse and abundant and include Turkey Oak (*Quercus laevis*), Blackjack Oak (*Quercus marilandica*), Bluejack Oak (*Quercus incana*), and Farkleberry (*Vaccinium arboreum*). Groundcover can vary considerably with soil conditions but often includes Carolina Wiregrass (*Aristida stricta*), Southern Wiregrass (*Aristida beyrichiana*), Common Little Bluestem (*Schizachyrium scoparium*), and a wide variety of herbaceous species.

Mesic Mixed Hardwood Forest

This concept combines the "Mesic Forest" and "Hardwood Slopes and Bottoms" of the 2015 SWAP. It also includes the "Mesic Mixed Hardwood Forest" of Nelson (1986) and the "Beech Forest" of McMillan et al. (2022). Schafale (2024) describes it as "Mesic Mixed Hardwood Forest (Coastal Plain Subtype)". The USNVC classification is "Southern Mesic Beech-Oak-Mixed Deciduous Forest Group". As Schafale (2024) describes, this community varies widely with hydrology, slope, soils, and fire frequency. The community forms on soils that are protected from fire, and with mesic to dry, low pH soils. It can occur on bluffs, swamp islands (often with abundant Loblolly Pine (*Pinus taeda*)), or on upland flats. Common hardwood canopy species include White Beech (*Fagus grandifolia* var. *caroliniana*), Water Oak (*Quercus nigra*), Black Oak (*Q. velutina*), White Oak (*Q. alba*), Pignut Hickory (*Carya glabra*), Mockernut Hickory (*C. tomentosa*), American Hornbeam (*Carpinus caroliniana*), Sour Gum (*Nyssa sylvatica*), Red Maple (*Acer rubrum*), and American Holly (*Ilex opaca*). The understory may be dense to open. Groundcover can be sparse or with dense Slender Spikegrass (*Chasmanthium laxum*) and sometimes other forbs and graminoids. These sites lack plant species that are indicators of calcareous soils that would be found in "Basic Mesic Forest".

Basic Mesic Forest

This concept follows the "Marl Forest", "Calcareous Cliff" (which is usually in association with this community type), and "Beech-Magnolia Hammock" (at least in part) of Nelson (1986), the "Magnolia Forest" of Barry (1980), and "Calcareous Forest" of McMillan et al. (2022). Schafale includes this as Basic Mesic Forest (Coastal Plain Subtype). Schafale (2024) calls this "Basic Mesic Forest (Coastal Plain Subtype)". Also included here are alluvial islands in some major rivers, such as the Savannah River, that are calcareous which Schafale calls "Swamp Island Evergreen Forest". The USNVC classification is "Southern Mesic Beech-Oak-Mixed Deciduous Forest Group" and "Southeastern Evergreen Oak Forest Group". Basic Mesic Forests are found on high pH soils and are dominated by a mixed canopy of hardwoods, but also frequently have Spruce Pine (*Pinus glabra*). Canopy composition varies with soil moisture, but species include Live Oak (*Quercus virginiana*), Swamp Chestnut Oak (*Q. michauxii*), Bluff Oak (*Q. austrina*), American Hop Hornbeam (*Ostrya virginiana*), and Southern Magnolia (*Magnolia grandiflora*). There may be an understory of shrubs or palms including Common Wax-Myrtle (*Morella cerifera*), Dwarf Palmetto (*Sabal minor*), and rarely Needle Palm (*Rhapidophyllum hystrix*). Many of the plant species are indicators of calcareous or circumneutral soils including Bluff Oak, Needle Palm, Spruce Pine, Southern Basswood (*Tilia americana* var. *caroliniana*), Silverbells (*Halesia* spp.), American Hop Hornbeam (*O. virginiana*), and Mottled Trillium (*Trillium maculatum*).

Oak-Hickory Forest

This concept includes a variety of hardwood-dominated forests on dry soils, including the "Oak-Hicky Forest" of Nelson (1986) and McMillan et al. (2022). Schafale (2024) includes this in a broad "Piedmont and Coastal Plain Oak Forests" theme as several types of dry oak-hickory forest, dependent on species composition and soil moisture. The USNVC classification is "Piedmont-Coastal Plain Oak Forest & Woodland Group". The composition of the vegetation in the upland forest landcover type is similar to that of Oak-Hickory Forest in the Piedmont, where

it is a major vegetation type. In contrast, upland forest is rare in the Coastal Plain, typically occurring on fire-protected upland slopes near river floodplains or between rivers and tributaries, intergrading with other communities. Representative canopy trees include White Oak (*Quercus alba*), Black Oak (*Q. velutina*), Post Oak (*Q. stellata*), Mockernut Hickory (*Carya tomentosa*), Pignut Hickory (*C. glabra*), Loblolly Pine (*Pinus taeda*), Flowering Dogwood (*Benthamidia florida*) and Sour Gum (*Nyssa sylvatica*), with sometimes pines as a minor component including Shortleaf Pine (*P. echinata*). Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species.

Blackwater Floodplains

This concept includes the variety of alluvial ecosystems that occur along blackwater waterways including rivers and streams. Because of the variation, a crosswalk to other sources is difficult, but it does include blackwater examples of Nelson's (1986) "Atlantic White Cedar Swamp", "Bald-Cypress-Tupelo Gum Swamp", "Bay Forest" (likely in part), "Bottomland Hardwoods", "Levee", "Shoal and Stream Bar", and "Small Stream Forest". McMillan et al. (2024) includes "Atlantic White Cedar Forests" and different kinds of "Bottomland Forest Communities" including blackwater types of "Bald-Cypress-Tupelo Gum Swamp Forests", "Hardwood Bottom Forests", and "Levee Forests". Schafale (2024) has a broad treatment of a "Coastal Plain Floodplains" theme, and his blackwater communities are included here, including "Levee/Bar Forest", "Bottomland Hardwoods", "Cypress-Gum Swamp", "Oxbow Lake", "Sand and Mud Bar", "Riverine Floating Mat", and "Semipermanent Impoundment". The USNVC classification includes "Oak-Sweetgum Floodplain Forest Group", "Oak-Sweetgum Floodplain Forest Group", "Bald-Cypress-Tupelo Floodplain Forest", "Eastern North American Riverine Sand-Gravel Bar Group", "South Atlantic and Gulf Coastal Plain River and Basin Freshwater Marsh and Wet Meadow Group", and "Eastern North American Freshwater Aquatic Vegetation Group". Streams and rivers rising in the Sandhills and Coastal Plain are commonly known as "blackwater" for the color of tannins that leach from decaying vegetation. They are more acidic than South Carolina's "brownwater" rivers with lower ion concentrations. Forests on the floodplains formed by these waterways 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-Tree (*Liriodendron tulipifera*), Sweet Gum (*Liquidambar styraciflua*), Pocosin Pine (*Pinus serotina*), Loblolly Pine (*P. taeda*) and Laurel Oak (*Quercus laurifolia*) are important associates. The shrub layer is open in areas subject to the most flooding, or it can be 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 (*Chamaecyparis thyoides*). Sunny areas along the waterways can support marsh vegetation. Draw-down zones during low water can support an assemblage of herbaceous annual plant species.

Brownwater Floodplains

This concept includes the variety of alluvial ecosystems that occur along brownwater waterways including rivers and streams. Because of the variation, a crosswalk to other sources is difficult, but it does include brownwater examples of Nelson's (1986) "Bald-Cypress-Tupelo Gum Swamp", "Bottomland Hardwoods", "Levee", "Shoal and Stream Bar", and "Small Stream

Forest". Barry (1980) includes it in a broad "Major River Bottoms" theme. McMillan et al. (2024) includes different kinds of "Bottomland Forest Communities" including brownwater types of "Bald-Cypress-Tupelo Gum Swamp Forests", "Hardwood Bottom Forests", and "Levee Forests". Schafale (2024) has a broad treatment of a "Coastal Plain Floodplains" theme, and his brownwater communities are included here, including "Levee/Bar Forest", "Bottomland Hardwoods", "Cypress-Gum Swamp", "Oxbow Lake", "Sand and Mud Bar", "Riverine Floating Mat", and "Semipermanent Impoundment". The USNVC classification includes "Southern Ash-Elm-Willow Floodplain Forest Group", "South Central-Appalachian-Northeast Floodplain Forest Group", "Oak-Sweetgum Floodplain Forest Group", "Bald-Cypress-Tupelo Floodplain Forest", "Eastern North American Riverine Sand-Gravel Bar Group", and "Eastern North American Freshwater Aquatic Vegetation Group".

Streams and rivers rising or cutting through in the Piedmont and Blue Ridge are commonly known as "brownwater" for the dark brownish color due to high amounts of silt and clay particles suspended in the water. Forests on the floodplains formed by these waterways typically have a canopy dominated by Sweet Gum (*Liquidambar styraciflua*), Loblolly Pine (*Pinus taeda*), Water Oak (*Quercus nigra*), Willow Oak (*Q. phellos*), Laurel Oak (*Q. laurifolia*), Cherrybark Oak (*Q. pagoda*) and American Holly (*Ilex opaca*). The Cypress-Tupelo Swamp subtype occurs on lower elevation sites as seasonally flooded swamps. Dominant trees are Bald-Cypress (*Taxodium distichum*), Water Tupelo (*Nyssa aquatica*), Planer-Tree (*Planera aquatica*), and Red Maple (*Acer rubrum*). Sunny areas along the waterways can support marsh vegetation or floating mats, or occasionally canebrakes. Draw-down zones during low water can support an assemblage of herbaceous annual plant species.

Depression Wetlands; Carolina Bays

This habitat is very broadly defined here and includes depression wetlands representing many distinctive habitats within this broad category. This includes Carolina Bays, vernal pools, flatwoods pond, limesink, wet weather pond, and broad swales that aren't connected to alluvial systems. Nelson (1986) includes "Depression Meadows", "Pond Cypress Pond" and "Swamp Tupelo Pond". McMillan et al. (2022) treats it as "Pond Cypress Savannas", Pond Cypress-Swamp Gum Upland Swamps", "Depression Meadows", and "Pocosins". Schafale (2024) includes these in a broad "Coastal Plain Depression Communities" theme, and a "Peatland Pocosins" theme. USNVC communities include "Southern Atlantic Coastal Plain Depression Pond Ecological System", "Atlantic Coastal Plain Clay-Based Carolina Bay Wetland Ecological System", and "Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System". Depression wetlands in the Coastal Plain formed due to many reasons, such as the collapse of a friable subterranean layer such as limestone or sandstone, or due to natural concavities, bowls, or slumps on the surface topography. These depressions will hold water given the presence of an impermeable soil layer such as clay, rock, or humate-impregnated sand. Depression wetlands are often referred to as "perched" water tables because they hold water perched above the normal sub-surface water table. They are also referred to as isolated, temporary wetlands due to the general lack of connection to surface streams and the pulsed nature of their hydrology, typically filling and drying with rainfall cycles.

Some of these wetlands display unique geomorphologies, such as Carolina Bays and limesinks. Carolina Bays are a class of depression wetland that display both a unique shape and orientation.

Carolina Bays are either oval or elliptical in shape with the long axis of the ellipse or oval lying along a northwest to southeast alignment. There are several hypotheses about the origin of these features, but no conclusive data supports any one of them to date. Limesinks are typically circular on the surface with steep sides that are conical in form.

Depression wetlands in the Coastal Plain can support a variety of vegetative community types ranging from Pond-Cypress- (*Taxodium ascendens*) or Swamp Tupelo- (*Nyssa* biflora) dominated ponds, to Pond Cypress savannas and wet meadow communities, and/or to pocosin and Pocosin Pine (*Pinus serotina*) woodlands. Open water ponds, hardwood ponds, and sedge-dominated ponds may occur in other parts of the State as well.

Despite the differences in origin, geomorphology, and vegetative structure, these habitats are similar in ecological function. With a few notable exceptions, these habitats are primarily linked to rainfall cycles, relying on rain to fill their basins and subsequently drying out during periods of low rainfall. The frequency of inundation may vary both in time and in location, such that most of these wetlands do not fill and dry on an annual basis.

Depression wetland habitats are detritus-based systems. When they dry, herbaceous plants and grasses die back and desiccate, forming a detrital layer. When the basins are inundated again, this detritus forms the base of a food web that can support a variety of invertebrate and vertebrate species. Several native plant and animal species, including numerous rare species, rely on depression wetlands as a primary habitat or for some life history stage such as breeding habitat. Because these habitats fill and dry cyclically, they typically do not support large predatory fish populations. Numerous amphibian species in South Carolina breed preferentially or exclusively in depression wetland habitats. Avoidance of larval predators, such as fish, is a critical adaptive mechanism for amphibians, and one solution is to breed in fish-free habitats such as depression wetlands. As such, depression wetlands are critically important habitats for several amphibian species in South Carolina.

Pine Plantation

This community is new to this revision. In the 2015 SWAP it was treated as part of the broad "Upland Pine" community of the Piedmont Ecoregion and "Pine Woodland" of the Coastal Plain and Coastal Zone Ecoregions. The USNVC classification for these timber production areas is "Temperate and Boreal Plantation". Those classifications, however, also included natural pine-dominated woodlands. Planted pine plantations are abundant and widespread in the Coastal Plain and are an important part of the region's landscape. Like the rest of the state, Loblolly Pine (*Pinus taeda*) is the typical species, although Slash Pine (*P. elliottii*) plantations are also frequent. Pine plantations are generally poor wildlife habitat, however, lacking in both the food and cover needed by native wildlife.

Early-Successional Habitats

Early-successional habitats in the Coastal Plain Ecoregion are important habitats for wildlife species that depend on these open areas. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual and perennial forbs and graminoids, and variable coverage of shrubs, vines, and small trees. A variety of open landcover types represent this category and can include old field sites, open

canopy gaps, shrub thickets, recently reforested areas, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports, and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat. Maintenance of early-successional habitat requires periodic disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of a variety of successional, or seral, stages.

Freshwater Streams, Rivers, Lakes, and Ponds

Freshwater habitats in the Coastal Plain exhibit a wide range of characteristics depending on elevation and gradient, with first- through fourth-order streams comprising the majority of aquatic habitats by length. Streams at higher elevations in this ecoregion may possess moderate flow and primarily sand substrate with patchy aquatic vegetation, often slowing and widening into densely vegetated swamps in areas of lower gradient. In the lower elevations of the region, streams generally are sluggish, strongly meandering blackwater channels with primarily organic substrates including detritus and woody debris. Streams in the Coastal Plain are often strongly associated with adjacent floodplain swamps and wetlands in which the exchange of water, nutrients, and biota is critical to ecosystem function. The Coastal Plain contains portions of all of South Carolina's major river basins.

The Lower Coastal Plain is situated directly below the Southeastern Plains and terminates at the Coastal Zone marsh. In South Carolina, it extends northwest from the Savannah River to the North Carolina State line. The Lower Coastal Plain intersects 19 counties and covers approximately 22,157 km^2 (8,555 $mi.^2$). The Coastal Plain is nearly level with elevations ranging from 8-38 m (25-125 ft.). The major aquatic habitats within the Ecoregion include lazy meandering streams, swamps, marshes, and estuaries. Pocosins and Carolina Bays are abundant in some areas. These unique aquatic habitats are discussed in more detail in the Coastal Zone Ecoregion.

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 72 km (45 mi.) 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 906 km^2 (350 $mi.^2$). The Ecobasin contains approximately 446 km (277 mi.) of lotic habitat and 251 ha (620 ac.) of lentic habitat.

Primary conservation targets within the Ecobasin include the main stem of the Savannah River throughout the Ecobasin and the Brier Creek/Boggy Gut Creek system in Allendale County (Smith et al. 2002). The main stem of the Savannah River contains several aquatic animals that are on South Carolina's SGCN 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.

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 (10 km or 6 mi.) of the Coastal Plain in the Southeastern Plains and flows for about 76 km (47 mi.) through the Coastal Plain before merging with the 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 43 km (27 mi.) through the Coastal Plain before merging with the Little Salkehatchie River to form the Combahee River, which flows for 82 km (51 mi.) 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 92 km (57 mi.), 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 31 km (19 mi.) through the Coastal Plain before merging and forming the Edisto River. The Edisto River flows for about 196 km (122 mi.) 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 40 km (25 mi.) until it merges with Captains Creek to form the Ashley River. The Ashley River flows for about 64 km (40 mi.) 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 29 km (18 mi.) before merging with the East Branch Cooper River to form the Cooper River. The Cooper River flows through the Coastal Plain for about 48 km (30 mi.), picking up inputs from the Back River, Goose Creek, and Filbin Creek along its western shore; further, Flag Creek and Yellow House Creek are picked up along its eastern shore before being deposited in Charleston Harbor and the Atlantic Ocean.

The Ecobasin intersects 72 watersheds and encompasses 10,601 km^2 (4,093 $mi.^2$). There are approximately 5,919 km (3,678 mi.) of lotic habitat and 280 km^2 (108 $mi.^2$) of lentic habitat within the Ecobasin. The majority (231 km^2 or 89 $mi.^2$) of lentic habitat is represented by Lakes Moultrie and Marion, the only major reservoirs 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 main stem 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 SGCN list. The North Fork and main stem 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.

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 130 km (81 mi.) 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 1,606 km^2 (620 $mi.^2$). There are 921 km (572 mi.) of lotic habitat and 11 km^2 (4.4 $mi.^2$) of lentic habitats.

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 198 km (123 mi.) 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 124 km (77 mi.) of the Coastal Plain before merging with the Pee Dee River near Gilbert Crossroads, SC. 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 143 km (89 mi.) 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 119 km (74 mi.) of the South Carolina's Southeastern Plains before entering the Coastal Plain. Within the Coastal Plain, the Little Pee Dee River flows for about 105 km (65 mi.), 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 167 km (104 mi.) 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 9,044 km^2 (3,492 $mi.^2$). Within the Ecobasin, there are approximately 6,027 km (3,745 mi.) of lotic habitat and 47.4 km^2 (18.3 $mi.^2$) of lentic habitats. There are no major impoundments (lakes) 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 SGCN 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 the 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 as well as mussel species (Waccamaw Spike and Yellow Lampmussel).

In the Coastal Plains, aquatic habitats continually change physically, chemically, and biologically as water flows from the headwaters to streams, larger streams, and downstream to rivers while being influenced by the surrounding watershed and landscape (Hynes 1975, Vannote et al. 1980). Slow moving, low velocity, and low topographic channels are common and contribute to "blackwater" habitats in which tannic and fulvic acids are leached out of decomposing organic material in the water. These channel systems often flow through old, utisol soils that are low in cation-exchange capacity, leading to low water hardness and low pH. In the Santee Basin, pH readings of 4 to 6 are common; the Edisto River averages 5.4 in its upper reaches but is a more moderate 6.8 lower in the system (Jennings et al. 2023). Habitat complexity and species diversity increase with stream size, producing a continuum of aquatic species assemblages from headwaters to the largest rivers. Whereas certain species are generalists and occur along the entire continuum in varying abundance, others are highly specialized for the precise set of physical and chemical characteristics produced by the underlying geology and surrounding landscape and only occur in certain stream sizes or habitat types within the Ecoregion.

In an aquatic bioassessment framework developed by Denison et al. (2021) utilizing fish assemblage data, streams of the Coastal Plain were characterized predominantly by a perennial/intermittent (i.e. slow current, swamp-like) hydrology with associated fish assemblages (Figure 3-2). The fish assemblage characteristics and expected response of Coastal Plain streams to changes in environmental or landscape factors (i.e. disturbance) would therefore be expected to be most similar among streams with this type of hydrology.

Coastal Zone Ecoregion

Pine Savannas and Flatwoods

This concept includes pine-dominated communities that are mesic to wet. This excludes drier sandhill communities (see "Dry Longleaf Pine" in the Coastal Plain Ecoregion), and it also excludes wet pine communities in Carolina Bays (see "Depression Wetlands, Carolina Bays" treatment in the Coastal Plain Ecoregion). There are significant areas of this habitat in the Ecoregion in northern Charleston County. This concept follows the "Wet Pine Savannas" theme, and "Mesic Pine Savanna" communities of Schafale (2024). Similarly, it includes the "Pine/Saw Palmetto Flatwoods" and "Longleaf Pine Savannas" of McMillan et al. (2022), the "Pine Flatwoods", "Pine Savannah", "Pine-Saw Palmetto Flatwoods" and "Pond Pine Woodland" of

Nelson (1986), and "Savannas" of Barry (1980). The USNVC classifications are "Dry-Mesic Loamy Longleaf Pine Woodland Group" and "Mesic Longleaf Pine Flatwoods-Spodosol Woodland Group". The canopy in these communities is dominated by one or several species of pine, generally Longleaf Pine (*Pinus palustris*), or Pocosin Pine (*P. serotina*) depending on elevation and soil type. Canopy closure ranges from very open, to dense on fire-suppressed sites. When burning is frequent, graminoid and herb density and diversity can be very high, but in the absence of fire, shrubs can become predominant, including Common Wax-Myrtle (*Morella cerifera*) and Little Gallberry (*Ilex glabra*). Optimal habitat for priority species consists of open stands of pine, sparse understory and shrub layers, and a dense groundcover. The community as circumscribed here is variable and could be broken down further. As detailed by Schafale (2024), mesic soils support "Mesic Pine Savanna" communities that are usually dominated by Longleaf Pine. Seasonally saturated sites support "Wet Pine Flatwoods" that are usually dominated by Pocosin Pine.

Coastal Fringe Evergreen Forest

The concept of this community follows Schafale's several kinds of "Coastal Fringe Forest" types (2024) and is also treated by Nelson (1986) as "Beech-Magnolia Hammock" and "Middens", and a broad "Maritime Forest" by Barry (1980) and McMillan et al. (2022). The USNVC classification is "Coastal Live Oak-Hickory-Palmetto Forest". The concept here is variable and includes hardwood forests in mainland coastal areas that are protected from salt spray, including on Native American shell middens and shell rings. (There are 25 known shell rings in South Carolina.) Soils can be dry to moist and can be deep sands or shell. Vegetation is a dense to partially copen canopy of hardwoods, often with Southern Red Cedar (*Juniperus silicicola*) and Cabbage Palmetto (*Sabal palmetto*). Common canopy trees include Live Oak (*Quercus virginiana*), Southern Magnolia (*Magnolia grandiflora*), Sand Laurel Oak (*Q. hemisphaerica*), Pignut Hickory (*Carya glabra*), Southern Hackberry (*Celtis laevigata*), and Southern Basswood (*Tilia americana* var. *caroliniana*). The subcanopy may be dense to open, with species such as Yaupon (*Ilex vomitoria*), and Red Buckeye (*Aesculus pavia*). Examples on Native American shell middens and shell rings have a flora influence by the calcareous soils and often have several rare plant species, some of which were probably culturally important.

Maritime Forest

This concept follows Schafale's (2024) "Maritime Evergreen Forest" (several kinds), "Maritime Shrub". Barry (1980), Nelson (1986), and McMillan et al. (2022) treat it as "Maritime Forest", with fairly broad definitions. The USNVC classification is "Central Atlantic Coastal Plain Maritime Forest". This is the typical forested plant community in the Coastal Zone on barrier islands, salt marsh islands (including hammock islands) and mainland areas that are influenced by salt spray, usually just inland of an Ocean Beach. Maritime forests are typically dominated by Live Oak (*Quercus virginiana*), Southern Magnolia (*Magnolia grandiflora*), and one or more species of pine, including Slash Pine (*Pinus elliottii*) and Loblolly Pine (*P. taeda*). Typical shrubs and small trees include Southern Red Cedar (*Juniperus silicicola*), Cabbage Palmetto (*Sabal palmetto*), American Holly (*Ilex opaca*), Red Bay (*Tamala borbonia*), Common Wax-Myrtle (*Morella cerifera*), and Yaupon (*Ilex vomitoria*). The herbaceous layer is usually sparse due to the dense canopy cover.

Marsh Hammock Island

This concept mainly follows the "Marsh Hammock" of Schafale (2024), and some aspects of Nelson's (1986) and Barry's (1980) broad "Maritime Forest". The USNVC classification is "Coastal Live Oak-Hickory-Palmetto Forest". This ecosystem forms on uplands and occurs in small patches embedded in marshes, or on their edges, either on islands or on the mainland, and usually contain some marsh species. Soils range from dry to slightly wet. Approximately 3,500 hammock (or hummock) islands are distributed throughout the coastal tidelands of South Carolina. Marsh hammock islands are most abundant (90%) within the expansive estuarine and brackish marshlands and tidal waterways of Charleston, Colleton, and Beaufort Counties. Marsh hammock islands range in size from 0.04 to 404.5 ha (0.1-1,000 ac.) and are surrounded by tidal wetlands. Most were naturally formed, although in this concept uplands are included along the Intracoastal Waterway that have similar vegetation. These were originally created by the disposal of dredged materials. Typical canopy species include Live Oak (*Quercus virginiana*), Cabbage Palmetto (*Sabal palmetto*), Southern Red Cedar (*Juniperus silicicola*), Loblolly Pine (*Pinus taeda*), and—where better developed—other hardwoods such as Hickories (*Carya* spp.) and Oaks (*Quercus* spp.).

Tidal Freshwater Marsh

This is a new community for this revision. This ecosystem is best described under "Tidal Freshwater Marsh" by Schafale (2024) who also subdivides North Carolina examples into 12 subtypes. This was also called "Tidal Freshwater Marsh" by Nelson (1986) and McMillan et al. (2022). The USNVC classification is "South Atlantic and Gulf Coastal Tidal Freshwater Marsh Group". Tidal freshwater wetlands include marshes and swamps that are regularly inundated by tidal flooding along a range from fresh to oligohaline salinity. Saltier water may intrude periodically, especially during storm events. Tidal freshwater marshes grade into tidal freshwater swamps upstream, and brackish marsh downstream, and distinguishing the communities in these gradients may be difficult. Tidal freshwater marshes are graminoid and herb-dominated ecosystems but are extremely variable. Part of this variation is complicated by the conversion of vast areas of the ecosystem that was converted to rice impoundments in the 18th and 19th centuries. Common species include Southern Wild-Rice (*Zizaniopsis miliacea*), Sawgrass (*Cladium jamaicense*), Giant Cordgrass (*Spartina cynosuroides*), and cattails (*Typha* spp.). In some areas, shrubs can also become common including Common Wax-Myrtle (*Morella cerifera*) and Swamp Rose (*Rosa palustris*) as well as young trees such as Red Maple (*Acer rubrum*), Loblolly Pine (*Pinus taeda*), and Bald-Cypress (*Taxodium distichum*). Waterways along the edges of this community may have extensive stands of Narrowleaf Pondlily (*Nuphar sagittifolia*).

Tidal Freshwater Swamp

This is a new community for this revision. This ecosystem is best described under "Tidal Freshwater Swamp" by Schafale (2024) who also subdivides North Carolina examples into 2 subtypes. This includes the "Tidal Bald-Cypress-Tupelo Gum Swamp" of Nelson (1986). The USNVC classification is "Bald-Cypress-Tupelo Floodplain Forest Group". Freshwater tidal wetlands include marshes and swamps that are regularly inundated by tidal flooding along a range from fresh to oligohaline salinity. Saltier water may intrude periodically, especially during storm events, although to less of an extent than Tidal Freshwater Marsh. Tidal Freshwater

Swamps grade into Tidal Freshwater Marshes downstream, and distinguishing the communities where they grade together may be difficult to differentiate. Tidal Freshwater Swamps are ecosystems with closed to open canopies usually represented by gum-cypress, but other species combinations may be present, such as ash- or elm-dominated areas. Common canopy species include Bald-Cypress (*Taxodium distichum*), Water Tupelo (*Nyssa aquatica*), Ash (*Fraxinus* spp.), Red Maple (*Acer rubrum*), and American Elm (*Ulmus americana*). The understory is also variable, sometimes with dense shrub cover, such as Common Wax-Myrtle (*Morella cerifera*), or open with dense herbs and graminoids. Waterways along the edges of this community may have extensive stands of Narrowleaf Pondlily (*Nuphar sagittifolia*).

Freshwater Streams, Rivers, Lakes, and Ponds
Fresh waters in the Coastal Zone are limited and primarily confined to the interior portion of this ecoregion where large volumes of fresh water enter via major rivers. These areas include portions of the Waccamaw, Santee, Cooper, Ashley, Edisto, and Combahee rivers. These habitats usually support a mixture of brackish water species and freshwater species tolerant of higher salinity.

Isolated Maritime Wetlands
Depressions, including pools and isolated wetlands, occur throughout the Coastal Zone and are usually embedded within larger habitats such as forests, hammocks, pine savannas, early successional habitats, and diked spoil islands. Four kinds are delineated below.

- ***Vernal Pools***
  These are small, seasonally flooded depressions with gradually sloping margins that occur in sandy uplands on barrier islands and within other landforms of recent origin such as spoil islands. These pools may be embedded within the interior of uplands, or they 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 non-native invasive Chinese Tallowtree (*Triadica sebifera*). Vernal pools may be a primary source of low salinity water for birds and mammals and may serve 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. Some examples of this habitat include Schafale's (2024) "Freshwater Marsh Pool". Vegetation is extremely variable and varies from open marsh to swamp forest structures. This is classified in the USNVC as "Eastern North American Freshwater Aquatic Vegetation Group".

- ***Small Depression Ponds***
  These may intergrade with vernal pools but are permanently flooded, except possibly during severe droughts. Obligate aquatic plants, like White Waterlily (*Nymphaea odorata*) or Broadleaf Pondlily (*Nuphar advena*), may inhabit submerged areas, and a variety of emergent and wetland species, including sedges and grasses, generally colonize shallow and intermittently exposed borders. Small depression ponds are generally not affected by tidal activities and can represent a variety of types such as Carolina Bays which are very poorly represented in this ecoregion.

- ***Interdune Ponds and Swales***
  This concept includes Schafale's (2024) "Interdune Pond", both types of "Maritime Wet Grassland", and "Interdune Marsh". Nelson (1986) treats this as "Interdune Pond". The USNVC classification is "Southern Atlantic Coastal Plain Dune and Maritime Grassland". These are depressions located in swales between beach secondary dunes or ridges that contain permanent or vernal pools. Both vegetation and animal life in pools are 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.

- ***Man-made Ponds***
  These are constructed for recreational, water supply, or stormwater retention, and are highly variable with regard to their physical features, water chemistry, and connection to open tidal systems. These factors, as well as land use and other human activities near such constructed features, primarily control both floral and faunal features. Though such habitats are not generally considered high quality wildlife habitat, some provide suitable foraging, nesting, roosting and resting habitat for priority species of wading birds.

Managed Impoundments
The coastal wetland impoundments of South Carolina comprise managed and formerly managed tidal wetlands that were primarily created for rice production in the 18ths and 19th centuries. The USNVC classification is "Southeastern Ruderal Marsh, Wet Meadow and Shrubland". Many of these are managed for migratory waterfowl. These impoundments generally occur from Georgetown County southward, coincident with the State's most extensive tidal freshwater marshlands. Salinity regimes range from fresh to brackish, depending on their water sources and management practices. Depending on management regimes and hydrology, a diverse assemblage of rooted floating aquatics, such as White Waterlily (*Nymphaea odorata*), American Lotus (*Nelumbo lutea*), and Pondweeds (*Potamogeton* spp.), occupies managed freshwater impoundments. Emergent plants such as cattails (*Typha* spp.), Southern Wild-Rice (*Zizania aquatica*), and Pickerel Weed (*Pontederia cordata*) are common. Submerged and free-floating aquatic plant species also occur and include duckweeds (*Lemna* spp.) and bladderworts (*Utricularia* spp.). Managed brackish and intermediate emergent wetlands principally contain Widgeongrass (*Ruppia maritima*), Saltmarsh Bulrush (*Bolboschoenus robustus*), and Dwarf Spikerush (*Eleocharis parvula*).

Ocean Beach
Schafale (2024) recognizes a suite of habitat types in his "Maritime Grasslands Theme". Those in South Carolina include "Stable Dune Barren (Southern Subtype)", Dune Grass (Southern Subtype)", "Maritime Dry Grassland", and "Maritime Vine Tangle". He also places the sparsely vegetated "Upper Beach (Southern Subtype)" and "Sand Flat" in an "Estuarine Communities" theme. Nelson (1986) treats it as "Maritime Grassland" and "Maritime Shrub Thicket". McMillan et al. 2022 calls the community "Coastal Dunes and Maritime Grasslands". Barry (1980) treats it as "Coastal Dunes" and "Dune-Shrub Communities". To maintain consistency with the 2015 SWAP, two kinds of dune ecosystem are recognized corresponding to vegetation structure, whether grass-dominated, or shrub-dominated. South Carolina's coastline is the 11th

longest in the nation at 301 km or 187 mi. Ocean beaches and the associated transition zones are formed primarily from unconsolidated sand and are ubiquitous features on barrier islands or ocean strands that directly front 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 wind-blown salt spray and sand and may be occasionally flooded, particularly during storms. The following habitats are generally recognized within the beach ecosystem.

- ***Maritime Grassland***
  This concept includes Schafale's "Stable Dune Barren (Southern Subtype)", "Dune Grass (Southern Subtype)", "Maritime Dry Grassland", "Maritime Vine Tangle" and "Upper Beach (Southern Subtype)". The USNVC classification is "South Atlantic and Gulf Coastal Dune Grassland". This represents that portion of the dune system vegetated by grasses and herbs. This habitat includes sand dunes, swales, and flats between dunes as well as between dunes and other features. Characteristic plants include Sea Oats (*Uniola paniculata*), Bitter Seabeach Grass (*Panicum amarum*), Seabeach Evening-Primrose (*Oenothera humifusa*), and Dune Pennywort (*Hydrocotyle bonariensis*).

- ***Maritime Shrub Thicket***
  Thickets of shrubs, vines, and stunted trees are often in swales within secondary dunes. Trees and shrubs must be salt-tolerant and are "pruned" by wind-blown salt spray and sand. Typical plants are Southern Red-Cedar (*Juniperus silicicola*), Common Wax-Myrtle (*Morella cerifera*), Red Bay (*Tamala borbonia*), Silverling (*Baccharis halimifolia*), Saw Greenbrier (*Smilax bona-nox*), and Eastern Poison Ivy (*Toxicodendron radicans*).

- ***Sand Backshore***
  The sand backshore is the area between the front dune and the intertidal beach face. This area is dry under normal conditions. Only a few invertebrates such as the ghost crab live in the backshore. This habitat is generally comprised of >90% sand and no vegetation. Most of the beaches in SC are publicly accessible and provide economic benefits through tourism.

Pine Plantation

This community is new to this revision. In the 2015 SWAP it was treated as part of the broad "Upland Pine" community of the Piedmont Ecoregion and "Pine Woodland" of the Coastal Plain and Coastal Zone Ecoregions. Those classifications, however, also included natural pine-dominated woodlands. Planted pine plantations are abundant and widespread in the Coastal Plain and are an important part of the region's landscape. Like the rest of the State, Loblolly Pine (*Pinus taeda*) is the typical species, although Slash Pine (*P. elliottii*) plantations are also frequent. Pine plantations are generally poor wildlife habitat, however, lacking in both the food and cover needed by native wildlife.

Early-Successional Habitat
Early-successional habitats in the Coastal Zone Ecoregion are important habitats for wildlife species that depend on these open areas. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual and perennial forbs and graminoids, and variable coverage of shrubs, vines, and small trees. A variety of open land cover types represent this category and can include old field sites, open canopy gaps, shrub thickets, recently reforested areas, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat. Maintenance of early successional habitat requires periodic disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of a variety of successional, or seral, stages.

Estuarine Systems

Estuaries form one of the predominant landscapes of the Coastal Zone and are considered the most productive ecosystem in the world. Estuaries form where seawater on the flood tide mixes with freshwater in semi-enclosed areas such as Charleston Harbor, Port Royal Sound, and Winyah Bay and behind barrier islands. Salinity in estuaries varies with the height of the tide, riverine flow, and the amount of runoff from local rainfall. Strong currents, modified by bottom structure, run through estuaries bringing nutrients from uplands and from the adjacent ocean. Incoming ocean currents and tides also bring in the larvae and juveniles of many species of recreational and commercial fish and shellfish. Over 75% of commercially important species use estuaries during some portion of their life cycle (NOAA 2024). Estuaries 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. If all convolutions (bays, inlets, etc.) are included, South Carolina ranks 12th with 4,628 km or 2,876 mi. of shoreline. The USFWS National Wetlands Inventory estimates 628,085 ac (254,177 ha) of Estuarine and Marine Deepwater and Wetlands occur in the estuarine areas of the State. Approximately 40% is subtidal habitat and the remaining 60% is intertidal (e.g. salt marsh, salt pan, intertidal flat). Listed here are the broadly recognized vegetative and geophysical components of estuaries and their inter-relationships.

- ***Salt Marsh***
  This includes the "Salt Marsh" concept of Nelson (1986), McMillan et al. (2022), and Schafale (2024), and as "Salt Marsh and Border Zonation" by Barry (1980). The USNVC classification is "Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh". Salt marshes are intertidal marshlands in estuarine systems near full salinity sea water (salinity ranges ~15 to ~36 ppt) and are variously flooded and drained 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. Other species such as Black Needle Rush (*Juncus roemerianus*), Saltgrass (*Distichlis spicata)*, Carolina Sea-Lavender (*Limonium carolinianum*), and Glassworts (*Salicornia* spp.) may be present. There are 350,000 acres of salt marsh in South Carolina with 75% of fishery resources utilizing it during some stage of their life cycle (Denise Sanger, SCDNR, pers. comm.). Salt marsh habitats are critical nursery and feeding grounds for many fish, crustaceans, and birds as they are highly productive.

- ***Brackish Marsh***
  This includes several types of brackish marsh subtypes of Schafale (2024), including "Saltmeadow Cordgrass", "Needlerush", "Smooth Cordgrass", and shrub transitional subtypes. Barry (1980) and Nelson (1986) treat it as "Brackish Marsh" while McMillan et al. (2022) calls it "Salt Marshes". The USNVC classification is "Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh". They are influenced to a lesser degree by salt than in the Salt Marsh community because of freshwater influences. Vegetation is variable and may contain or be dominated by Black Needle Rush (*Juncus roemerianus*), Small Saltmeadow Cordgrass (*Spartina patens*), or Saltmarsh Cordgrass (*S. alternifolia*). Other wetland graminoids and herbs are usually present in a higher diversity than in Salt Marsh.

- ***Salt Flat / Salt Pan***
  This includes the "Salt Flat" of Nelson (1986), McMillan et al. (2024), and Schafale (2024). The USNVC classification is "Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh". These areas are sparsely vegetated, hypersaline (salinity > 40 ppt), exposed flats of primarily sand. Inundation only occurs during high spring tides. Typical plants include glassworts (*Salicornia* spp.), Saltwort (*Batis maritima*), and Saltgrass (*Distichlis spicata*).

- ***Salt-Shrub Thicket***
  This includes the "Salt Shrub", both "High" and "Low" subtypes, of Schafale (2024) while Nelson (1986) calls it "Salt Shrub Thicket". The USNVS classification is "Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh". The community consists of bands or patches of usually low, dense shrubs that typically interface with high salt marsh and uplands. Characteristic plants include Silver Seaside Oxeye (*Borrichia frutescens*), Marsh Elder (*Iva frutescens*), and Silverling (*Baccharis halimifolia*). These plants are tolerant of salt spray and occasional storm surges.

- ***High Marsh Pool***
  These are poorly drained pools in high salt marsh, often near uplands. Salinity is highly variable depending on the frequency and timing of tidal inputs and rainfall. Both soils and water may become hypersaline (salinity > 40 ppt).

- ***Estuarine Intertidal Flat***
  These are mud and sand flats in estuarine systems that have little or no vegetation and are drained on the ebb tide and flooded during high tides. When these areas have high water

content, it is referred to as pluff mud. These flats may occur between marshlands, channels, and creeks or may be interspersed within marshlands.

- ***Estuarine Intertidal Sandbar***
  These are sandbars in estuarine systems that are partially exposed during part of most tidal cycles (i.e. spring and neap tidal cycles) and river stages but are typically submerged during high tide. These areas are often used as recreational areas by boaters at low tide.

- ***Docks and Bulkheads / RipRap***
  Man-made structures can provide hard surfaces, vertical relief, and structural complexity in the water column, all of which promote the attachment of many aquatic, sessile, and sedentary species. These include algae and mosses in low salinity waters, and algae and invertebrates (e.g. hydroids, bryozoans, sponges, barnacles, oysters, and mussels) in estuarine waters. In 2015, it was estimated that 10% of the estuarine shoreline had erosion control structures (Jackson 2017). Bulkheads and riprap in inland waterways can protect the immediate shoreline while potentially exacerbating erosion of the nearby, unprotected shoreline. Docks are prevalent in the developed areas of coastal South Carolina and provide vertical structure.

Apache Pier in Myrtle Beach, SC (Horry County) provides structure on which sessile marine organisms can attach. Photo by SCW staff.

- ***Oyster Reef***
  These are fringing oyster reefs and extensive reef flats primarily composed of live Eastern Oysters. Oyster reefs are predominantly (>95%) intertidal and are often found in close spatial proximity to salt marshes for which they serve as natural breakwaters (fringing reefs). Oyster reefs also occur as flats between tidal channels and salt marsh. Oyster reefs provide habitat for other invertebrates, and the resulting communities are refuge habitat for many fish and invertebrates as well as foraging habitat for larger fish and shorebirds such as American Oystercatchers.

- ***Estuarine Tidal Channels, Creeks, and Open Estuary***
  These are tidal estuarine waterways of variable depth and with currents generated by riverine and/or tidal flows. This is largely the "Estuarine and Marine Deepwater" habitat described in the National Wetlands Inventory (NWI). This includes both the water column and the bottom habitat which can be sand, mud and shellhash, or in combination. Tidal creeks are smaller, branching systems that meander through and shape salt and brackish marsh platforms. They are conduits for stormwater runoff from the upland to the

larger tidal channels and open estuary. They are also conduits for the fish and crustaceans between the estuary and marsh. The tidal channels and open estuarine areas are deeper and generally have higher dissolved oxygen than the smaller tidal creeks. These are highly productive areas.

- ***Estuarine Subtidal / Submerged Flat***
  These are mud and sand flats with little or no vegetation that are inundated during all tidal cycles. Submerged flats include sand and/or mud bottom areas outside of channels and creeks and usually lie between channel habitats and tidal marshlands. These are important feeding areas for many species.

- ***Intertidal Estuarine Reefs – Man-Made Structures***
  These are living shorelines or man-made intertidal reefs—commonly constructed of shell, refurbished crab traps, concrete coated wire mesh, or concrete blocks—that serve the same purpose as naturally occurring oyster reefs. The hard surfaces and structures are substrate for the attachment of oysters and other invertebrates, and the resulting communities are refuge habitat for many fish and invertebrates as well as foraging habitat for larger fish and shorebirds such as American Oystercatchers. These reefs are often used to stabilize eroding shorelines along tidal creeks and have proved effective at encouraging saltmarsh expansion.

- ***Shell Rakes***
  Shell rakes are piles of "washed shell" which were at one time on the bottom of a channel, perhaps remnants of old subtidal oyster beds. They are so old that their shells are very light-weight, and over time they get moved by boat wakes, dredging, and storms and gradually wash up into the high intertidal zone. They are common along the Intracoastal Waterway but also in many tidal creeks and estuaries. A survey published by the SCDNR in 1979 lists 998 washed shell deposits, 58% of which are in Beaufort County and 36% in Charleston County. That survey says, "Shell deposits are formed in estuarine areas where an abundance of submerged oyster shells are exposed to frequent wave action generated by prevailing winds or boat traffic" (Anderson et al. 1979). Shell rakes are favored nesting, roosting, and foraging areas for many shorebirds such as the American Oystercatcher.

Marine Habitats

South Carolina's coastline is the 11th longest in the nation at 301 km or 187 mi. The state marine ecosystem occurs along all of South Carolina's Atlantic Ocean coastline and extends offshore to the State 4.8 km (3 mi.) jurisdictional boundary, incorporating a surface area of nearly 140,000 ha (345,946 ac.). This is discussed as the Continental Shallow Shelf below. In addition, deep, non-state territorial marine habitats exist including the deeper continental shelf (>4.8 km (>3 mi.)) and continental slope (>113 km (>70 mi.)) Ocean beaches and the associated transition zones are formed primarily from unconsolidated sand and are ubiquitous features on barrier islands or ocean strands that directly front the Atlantic Ocean. The following aquatic habitats are generally recognized within the marine ecosystem.

Intertidal Beach
The front ocean beach region is typically inundated on flood tides and drained on ebb tides. Invertebrate fauna in the intertidal beach zone, such as the Coquina Clam (*Donax variablis*) and the Mole Crab (*Emerita talpoida*), are an integral part of the food chain for shorebirds and seabirds (e.g. Piping Plover, Willet, Sanderling, and Red Knot) that forage on the intertidal beach and at the surf interface.

Subtidal Surf Zone
The submerged portion of the beach area extends offshore to a depth of at least 2 m (6 ft.) at any tidal stage. Marine aquatic species in this zone are heavily influenced by turbulence from wave action. As many as 98 fish and 317 macro-invertebrate species are recognized as at least occasional inhabitants of this zone.

Continental Shelf – State Waters
The continental shelf is a continuation of habitats beyond the Surf Zone and submerged in the Atlantic Ocean offshore to the 4.8 km (3 mi.) State territorial limit. The continental shelf lies along South Carolina's Atlantic Ocean coastline and extends offshore to the State 4.8 km (3 mi.) jurisdictional boundary, incorporating a surface area of nearly 140,000 ha (345,946 ac.). Shallow shelf habitats can be further divided into three important types: soft bottom, hard bottom, and the pelagic zone.

- **Shallow Shelf Soft Bottom**
  Soft bottom is composed of unconsolidated sediments that supply sand to the continental shelf, barrier islands, and beaches; store nutrients in the sediment; and provide critical nursery and feeding habitat to fish and invertebrates. Soft bottom can consist of mud and sand flats with little or no vegetation that are constantly submerged. Vegetation can include algae and marine vascular plants. This habitat type is often called "trawlable" because of the lack of obstructions to bottom trawl gears and are essential for South Carolina's shrimping industry. Animals associated with soft bottom can be infaunal (i.e. buried)—typically invertebrates—or demersal (i.e. free ranging above the surface), which can be either fish or invertebrates.

- **Shallow Shelf Hard Bottom**
  Hard bottom habitats are composed of rock pavement, exposed rocks or boulders, or exposed ledges. Hard bottom habitats are often colonized by attached organisms such as algae, corals, and sponges due to their need for a solid attachment and the increased surface area provided by complex rock formations. Due to the rock and biota structure, many hard bottom habitats attract a variety and concentration of invertebrates and fish, making them attractive locations for recreational and commercial fishers for species such as Sheepshead, Black Sea Bass, and grouper species.

- **Shallow Shelf Pelagic Zone**
  The pelagic zone consists of the water column above either soft or hard bottom habitats where the water and species are not interacting with the bottom. The pelagic zone is governed by wind, currents, light penetration, and nutrient additions, including from estuarine outflow or offshore upwelling. This creates a variable environment of

temperature, nutrients, oxygen, and productivity. The pelagic zone supports many resident nekton (water-column) species (i.e. those capable of determining their position in the water column against tide currents) and plankton species (i.e. those unable to control their positions in the water column), but also forms an important migration route or habitat for transient species.

Piers, Jetties & Groins – Man-Made Structures

For the ocean-facing shorelines, the South Carolina Department of Environmental Services' Bureau of Coastal Management's (SCDES-BCM) inventory on erosion control structures has approximately 133 miles of developed or developable ocean/inlet-facing South Carolina coastline. Based on SCDES-BCM's inventory, approximately 18 miles (13%) of this coastline has erosion control structures. Rock groins, jetties, and piers provide hard substrate, vertical relief, and structural complexity for the attachment of organisms in intertidal and subtidal zones, while exposed rock may be used as resting and foraging habitat for shorebirds and seabirds, most notably the Purple Sandpiper which prefers rocky coast habitats that are generally rare in the Southeast. Submerged rock also provides refuge habitat for many fishes and invertebrates. Hardened structures designed for shoreline and channel protection also disrupt the natural processes of sand movement along beaches and can therefore contribute significantly to beach erosion. Many aquatic, sessile, and sedentary species such as algae and invertebrates (e.g. hydroids, bryozoans, sponges, barnacles, oysters, and mussels) attach to these substrates. Such structures also interfere with the nesting of sea turtles either by totally displacing nesting sites or by rendering them more susceptible to flooding.

- ***Nearshore Subtidal Reefs – Man-Made***

  Nearshore subtidal reefs are comprised of man-made structures that account for a relatively small percentage of the Exclusive Economic Zone (EEZ) off South Carolina. Each site is made up of numerous individual steel or concrete structures ranging from small, prefabricated concrete modules to large, steel-hulled vessels hundreds of feet in length. Each structure provides surface area for the attachment of sessile organisms including algae, barnacles, corals, sponges, hydroids, and bryozoans which become the foundation of the reef community. Once colonized by invertebrates, other marine animals such as crabs, shrimps, urchins, amphipods, and mollusks take up residence as well. Studies have documented nearly 300 invertebrate species attached to or residing on artificial reef structures. The ultimate goal of creating man-made reefs is the creation of finfish habitat for the enhancement of fisheries resources. Over 50 species of fishes have been observed on the State's artificial reefs, including both recreational and commercially important species and in densities usually higher than in natural areas. In addition, nesting and spawning activities on these reefs attest to their use as permanent fish habitat. Artificial reefs off South Carolina have been declared Essential Fish Habitat (EFH) by the South Atlantic Fishery Management Council (SAFMC).

Deep, Non-State Territorial Marine

- ***Continental Shelf***

  The deeper, non-state territorial continental shelf is the portion submerged in the Atlantic Ocean offshore greater than 4.8 km (3 mi.) State territorial limit to approximately 112-129 km (70-80 mi.) The deep continental shelf shares many of the same characteristics as described above for the shallow continental shelf.

- ***Continental Slope***

  The continental slope begins where the continental shelf ends (~90 km or 50 mi. from shore off South Carolina) and is characterized by a rapid increase in depth and reduction in light penetration to the bottom. This habitat can be further divided into bottom and pelagic zone.

  - **Bottom**
    This habitat can be made up of a mixture of hard (rocky) and soft (muddy) benthos. The continental slope is a steep area that begins at the shelf break, usually around 140 m depth. It is often cut by submarine canyons. Different mobile organisms use different substrate types. Density of marine fauna is low in most of this region. However, some economically important species can be found here, such as Snowy Grouper, Atlantic Wreckfish, and tilefish species.

  - **Pelagic zone**
    This habitat is an extension of the pelagic zone above the continental shelf and is of a similar structure. It consists of the upper water column of the continental slope region, not near or associated with the benthos. The regional and vertical distribution of pelagic life is governed by temperature, nutrients, light, oxygen, and ultimately productivity by phytoplankton. Several economically important species use this region, such as marlin species, sailfish species, and dolphinfish species.

- ***Open Ocean (Pelagic Habitats Offshore of the Continental Slope)***

  The open ocean habitat is the area away from coastal boundaries and above the seabed. This habitat encompasses the entire water column and lies beyond the edge of the continental shelf. It is a highly dynamic and heterogenous region. The regional and vertical distribution of pelagic life is governed by the temperature range, abundance of available nutrients, and oxygen levels. The regional and vertical distribution of pelagic life is governed by currents, temperature, nutrients, and photosynthesis by phytoplankton.

- ***Offshore Reefs - Man-made Structures***

  Offshore Reefs are comprised of man-made structures and account for a relatively small percentage of the EEZ off South Carolina. The State's 38 offshore sites are typically 160 acres (0.25 square miles). The offshore reefs share many of the same characteristics as described above for the inshore reefs.

Note: The following species mentioned in this chapter are of cultural significance from a habitat standpoint: Giant Cane (*Arundinaria gigantea*), Longleaf Pine (*Pinus palustris*), and Shortleaf Pine (*Pinus echinata*).

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CHAPTER 4: OVERVIEW OF THE TAXONOMIC GROUPS

For consistency when comparing Species of Greatest Conservation Need (SGCN) lists across states, accepted or official taxonomic standards for plant and animal species were used by consulting recognized sources for naming conventions. These are listed in Box 4-1. Species undergoing active genetic research or having taxonomic discrepancies utilized the latest literature so as not to have to wait on a publication's revision cycle. Many existing conservation plans and initiatives exist for members of these taxonomic groups and are listed in Appendix 1.

Box 4-1: Taxonomic Standards Sources

- **Reptiles & Amphibians**: The Society for the Study of Amphibians and Reptiles (SSAR) is the official taxonomy source for North American amphibians and reptiles north of Mexico.

- **Birds:** The American Ornithologists' Union Checklist of North and Middle American Birds is the official source on the taxonomy of birds found in North and Middle America, including adjacent islands.

- **Mammals**: The American Society of Mammalogists Mammal Diversity Database is used for mammals.

- **Freshwater, Diadromous, & Marine Fishes:** The Common and Scientific Names of Fishes from the United States, Canada, and Mexico, 8th edition, published by the American Fisheries Society (AFS), has the recommended list of common and scientific names of fishes from the United States, Canada, and Mexico.

  Page, L.M., K.E. Bemis, T.E. Dowling, H. Espinosa-Perez, L.T. Findley, C.R. Gilbert, K.E. Hartel, R.N. Lea, N.E. Mandrak, M.A. Neighbors, J.J. Schmitter-Soto, & H.J. Walker Jr. 2023. Common and scientific names of fishes from the United States, Canada, and Mexico, 8th edition. American Fisheries Society, Special Publication 37, Bethesda, MD.

- **Mussels & Snails:** The Freshwater Mollusk Conservation Society has the recommended list of common and scientific names of mussels and snails.

- **Crayfish & Freshwater Shrimp:** The latest edition of Thorp and Covich's Freshwater Invertebrates: Ecology and General Biology has the recommended list of common and scientific names.

  James H. Thorp and D. Christopher Rogers, eds. 2015. Thorp and Covich's Freshwater Invertebrates: Ecology and General Biology, 4th edition. Academic Press. 1148 pp.

- **Marine Invertebrates, Leeches & Freshwater Sponges:** World Register of Marine Species (WoRMS) is referenced for the latest information and taxonomy for marine invertebrates, leeches, and sponges. Sponges also utilize the World Porifera Database associated with WoRMS.

- **Insects & Allies:** NatureServe Explorer and the primary literature are utilized for these invertebrates.

- **Plants**: NatureServe Explorer is used for non-vascular plants. The latest edition of Weakley's book is used for vascular plants:

  Weakley, A.S. 2024. *Flora of the Southeastern United States*. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, North Carolina, USA.

Fifteen main taxonomic groups were evaluated in this edition of the State Wildlife Action Plan (SWAP) and each of these is discussed in this chapter, including their current status, challenges faced, and conservation opportunities available to address these threats. Chapter 5 discusses overarching threats and stressors that impact multiple taxa groups. Likewise, Chapter 8 discusses actions that can be taken to mitigate for those threats for the benefit of multiple species and habitats across many taka groups. Additionally, those taxa groups with all or part of their life cycles in freshwater aquatic systems face a particular subset of threats and stressors.

Herpetofauna: Amphibians and Reptiles

Currently, 148 species of amphibians and reptiles are known to occur in South Carolina. The State's rich herpetofaunal diversity is likely due to the diversity of habitat in the 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. 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 Southern Gray-cheeked Salamander, the Green Salamander, and the Timber Rattlesnake. Bogs in this same region may provide habitat for Bog Turtles, Four-toed Salamanders and Wood Frogs**.** Several species of amphibians and reptiles found in South Carolina's Blue Ridge are peripheral to the 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 significant. 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 multiple rare, threatened and endangered species. Of the 148 species of amphibians and reptiles found in the State, 120 (81%) can be found in the Coastal Plain. Within this province, the Longleaf Pine ecosystem 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 lime sinks provide breeding habitat for numerous amphibians, including the Flatwoods Salamander, Tiger Salamander, and Gopher Frog. Seeps and shrub bogs, embedded in xeric Longleaf Pine habitat in the Fall Line/Sandhills, are home to the Pine Barrens Treefrog.

Challenges

As is the case with most wildlife species, amphibian and reptile populations are impacted by habitat loss. In particular, the loss of rare, uncommon or vulnerable habitats, such as isolated freshwater wetlands, Longleaf Pine communities, and freshwater seepage wetlands is taking a toll on herpetofauna. One of the most significant challenges impacting amphibians and reptiles in

South Carolina is loss of habitat. Wetland habitats, which are critically important to many members of this taxonomic group, have been destroyed by draining and filling throughout the State. Even small alterations to wetlands can make the habitat inhospitable for reptiles and amphibians, which are known to require adequate upland habitat around breeding wetlands. Wetland best management practices (BMPs), that suggest wetland buffers of 50-100 ft, are inadequate for long-term persistence (Semlitsch and Bodie 2003; Buhlmann and Gibbons 2001; Litzgus and Mousseau 2004; Powell and Babbit 2015). Populations of amphibians may be extirpated by the elimination of adequate upland habitat despite the protection of the breeding wetland. Conversely, the drainage or alteration of wetlands in an otherwise unaltered forest may result in the extirpation of local amphibian populations due to removal of appropriate breeding habitat. Many wetlands that still exist are now unsuitable for breeding because they have been left isolated on the landscape as a result of careless farming, development, or timber operations.

Conversion of habitat for agriculture 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, solar farms, and/or loblolly pine plantations in South Carolina. The loss or degradation of Longleaf Pine habitat results in the loss of key components necessary for success of the animals that live in that habitat.

Underground refugia, such as this Gopher Tortoise burrow, are critical habitat components for some herpetofauna species. Photo by Andrew Grosse, SCDNR

One often overlooked component important for reptiles and amphibians is underground refugia. Gopher Tortoises provide important refugia in the form of their burrows, but their range is limited in South Carolina. In the absence of Gopher Tortoises, many species rely on stump holes and/or small mammal burrows to escape extreme temperatures and predators. These habitats are vitally important for the persistence of many reptiles and amphibians, yet removal of stumps remains a common management practice, leaving little to no refugia for the species that remain.

Fire suppression and exclusion contributes to habitat loss for many amphibian and reptile species. Many species in this taxonomic group require an understory that contains a diverse herbaceous plant layer that is maintained by routine burning. However, increased development and changing weather patterns in recent years have resulted in a decrease in adequate fire frequency in many areas of the State, which has resulted in successional changes that render the habitat unsuitable for some species.

Habitat can also be lost to urban development. Nesting habitat for marine turtles and Diamondback Terrapins is lost as coastal development expands. Even if a suitable habitat is available, nesting can be aborted because of human disturbance near nest sites. Further, lighting in coastal areas can result in nesting failure from disorientation of nesting females and

hatchlings. Road mortality is also a significant threat as urban development requires additional roadways. These roads are frequently constructed through amphibian and reptile habitats, and mortality occurs as animals attempt to migrate across roadways.

Disease can lead to severe population crashes or even localized extinctions. Chytridiomycosis is a fungal disease caused by *Batrachochytrium dendrobatidis* that affects the skin of amphibians, compromising water and electrolyte uptake. Because amphibians rely on their skin like humans do their lungs, the hyperkeratosis caused by the fungus can also impact respiration. A closely related pathogen, *Batrachochytrium salamandrivorans*, or *Bsal*, is an emerging pathogen capable of causing significant mortality in salamanders. Though currently only detected in captive salamanders outside of the US, the rate at which captive amphibians are imported for the pet trade–coupled with the potentially devastating impacts *Bsal* would have on native salamanders – make it a significant concern for South Carolina salamanders. Amphibian Perkinsea is an alveolate protist that is responsible for amphibian mass mortality events throughout the US. Amphibians in South Carolina have been severely impacted by this disease in recent years. Another disease in South Carolina, Ranavirus, causes hemorrhaging and ulcers and has been documented in reptiles and amphibians. Eastern Box Turtles are especially susceptible to Ranavirus and are a common vector of the disease. Snake Fungal Disease or SFD (*Ophidiomyces ophiodiicola*) continues to be documented throughout South Carolina. SFD causes swelling, scabs, and lesions. In October 2013, an infected Copperhead was found in Spartanburg County, SC, making it the first confirmed case in the State. Since then, many other species have been documented with SFD throughout the State. Studies on Eastern Diamondback Rattlesnakes, Rainbow Snakes, and Brown Watersnakes have shown extreme susceptibility to SFD, so that the disease continues to be a threat to the snakes of South Carolina.

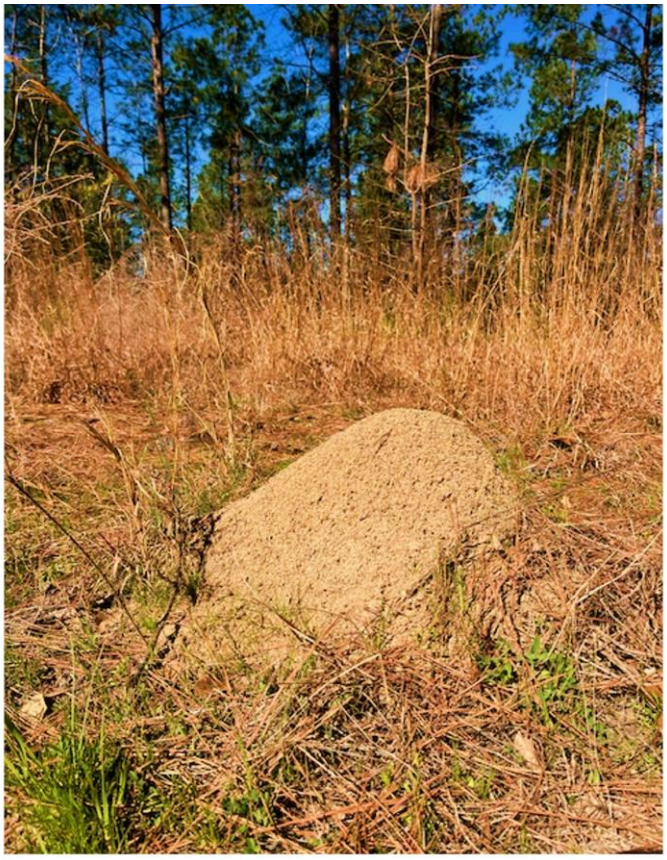
Previously, unregulated harvest was a significant challenge for reptiles and amphibians in South Carolina. In 2019, the South Carolina Department of Natural Resources (SCDNR) passed new regulations that added significant protections for all reptiles and amphibians native to South Carolina from commercial exploitation. Specifically, no native species can be exported from South Carolina, and transfer of possession (buying, selling, trading, etc.) is prohibited. A major component of these regulation changes was increased protections for turtles, which, in addition to prohibiting export and transfer of possession, also added possession limits for individual species as well as in aggregate. Despite these restrictions, several species of reptiles and amphibians in South Carolina continue to be collected for the domestic and international pet trade. This illegal collection increases the risk of drastic population declines for several species in the State, especially turtles.

Spotted Turtles are a species threatened by illegal collection for the domestic and international turtle trade due to their striking appearance, making them attractive to collectors. Photo by Andrew Grosse, SCDNR.

Introduced species can adversely affect South Carolina's reptiles and amphibians. Sightings of nonnative herpetofauna continue to increase. Legislation passed in 2019 protecting all native species from commercial exploitation also included regulations that prohibited the release of wildlife that is not native to South Carolina. In 2021, further legislation passed that allows SCDNR to promulgate regulations to prohibit or restrict certain species of nonnative wildlife in South Carolina that 1) have the potential to become established in the State in sufficient numbers to become a nuisance and/or 2) pose a demonstrable deleterious and widespread threat to wildlife, agriculture, or human health and safety. Due to a rise in confirmed sightings throughout the State, established populations in adjacent states with similar habitats and climate, and documented impacts on similar native species in other states in the Southeast, Argentine Black-and-White Tegus and their hybrids were the first species added to this "Restricted Nonnative Wildlife List".

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

The presence of nonnative fire ants throughout the Southeastern United States has been implicated as a potential reason for the apparent decline of the Southern Hognose Snake (Tuberville and Jensen 2008). Fire ants may also be adversely affecting populations of other fossorial and egg-laying snakes. Further, fire ants are suspected to affect the probability of turtle hatchling survival and are responsible for mortality of released head-started Gopher Tortoises and Gopher Frogs.

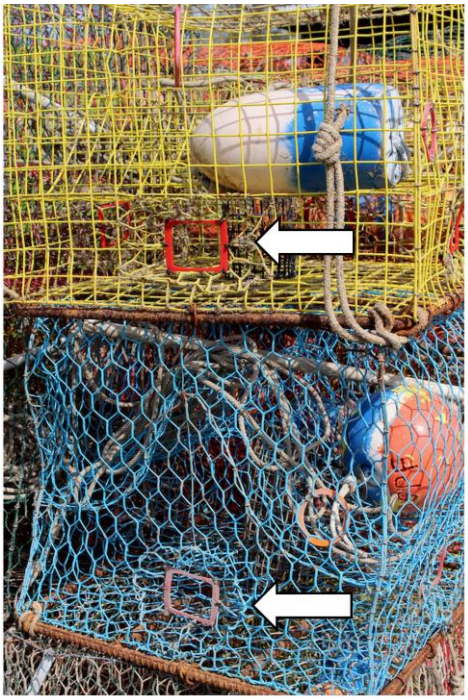


Red Imported Fire Ants can invade sensitive habitats, preying on ground-nesting birds and terrestrial herpetofauna.
Photo by Anna Smith, SCDNR

Feral pig populations continue to be a threat to reptiles and amphibians. Pigs are opportunistic omnivores and eat a variety of plants and animals. A recent DNA metabarcoding study (Canright et al. 2023) found that while vertebrates are consumed less than plant matter, the majority of the vertebrates that were consumed were amphibians, suggesting amphibians may be more vulnerable to feral pig predation than previously thought. In addition to direct mortality, feral pigs also negatively impact reptiles and amphibians when "rooting," especially in sensitive habitats.

Hook-and-line entrapment is a threat to turtles, like this Florida Softshell, when they take fishing bait. Photo by Anna Smith, SCDNR.

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. Progress has been made to reduce this bycatch through turtle excluders for crab pots, and efforts have been made to educate crab fishermen about the importance of removing old pots and using these turtle excluders over the openings.



Diamondback Terrapin exclusion devices affixed to crab pots. Photo provided by Erin Weeks, SCDNR.

Incidental take of Loggerhead Sea Turtles from boat strikes and commercial fishing operations constitutes a major challenge to this species. In a 1990 study, the National Academy of Sciences estimated that between 5,000 and 50,000 Loggerheads were killed annually by the shrimping fleet in the Southeastern Atlantic and Gulf of Mexico (National Research Council 1990). In 1988, South Carolina was the first to enact a law to require Turtle Exclusion Devices (TEDs) on shrimp trawls to reduce incidental take of sea turtles. By 1991, TEDs were required everywhere by the National Marine Fisheries Service. The size of TEDs was adjusted in 2003 to accommodate Leatherback Sea Turtles. The shark longline fishery, which operates all year long off the south Atlantic, may still impact Loggerheads in the neritic environment (Lewison et al. 2004). Turtles are still at risk from entanglement in longlines, float lines, and other ropes and cables (NMFS & USFWS 1991). In addition, sea turtles may mistake floating plastic for jellyfish and ingest it, causing gut obstructions or the absorption of toxic chemicals (NMFS & USFWS 1991).

A juvenile Loggerhead Sea Turtle exits a TED. Photo by NOAA.

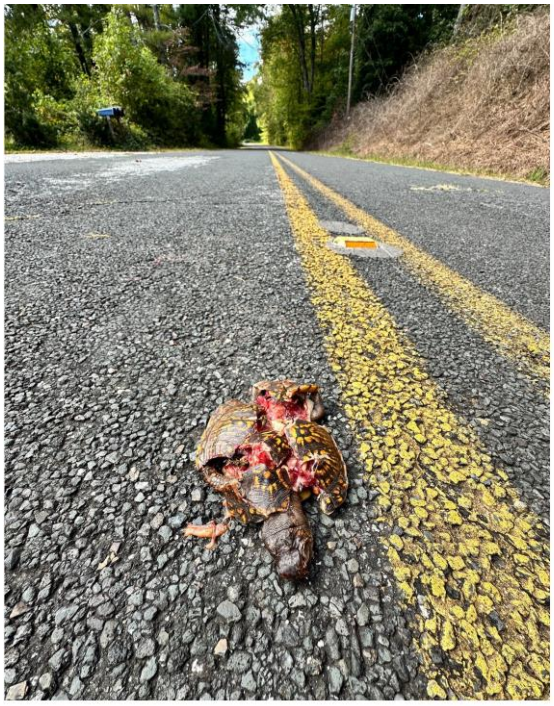
A silent threat to some herpetofauna is the lack of knowledge about the species and thus the uncertainty of their status. There are a number of amphibian and reptile species in South Carolina for which adequate data on their status is lacking, but there is no immediate indication that they are threatened. Several of these species have been

added to the SWAP and categorized as data deficient. Adding these species is important to ensure they are not overlooked due to their cryptic nature.

Despite recent advances in genetics, controversy over the taxonomic status of certain species, or species complexes, continues to result in a lack of certainty in giving a truly fixed number of species for the State. Additionally, 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. Within the last 25 years, Chamberlain's Dwarf Salamander (*Eurycea chamberlainii*), Patch-nosed Salamander (*Urspelerpes brucei*), and Dwarf Black-bellied Salamander (*Desmognathus folkertsi*) were identified in South Carolina and added to the SWAP. In addition, and most recently, the *Desmognathus* salamander genus was investigated, with eight (8) newly described and/or renamed species in South Carolina (Pyron and Beamer 2022, 2023). Other taxonomic issues that still remain include the milk snake/scarlet kingsnake relationship.

Conservation Opportunities

Conservation for most wildlife starts with protection and connectivity of habitat, which includes microhabitats that are essential for species persistence (i.e. breeding, nesting, foraging, and overwintering habitats). Prioritizing habitats based on connectivity, rare and sensitive species habitats, and watersheds should continue to be taken into consideration when new properties are being purchased or otherwise obtained and/or protected. Collaborating with adjacent states, non-governmental organizations (NGOs), and non-profits to protect habitats—as they relate to an overall species range and/or corridors—should be prioritized as it increases the opportunities for additional funding and resources to mitigate costs and better conserve the target species and/or habitats.



A road-killed Eastern Box Turtle (SGCN High) on a rural mountain road in the Upstate of South Carolina. Photo by Keith Bradley, SCDNR

Similarly, exploring opportunities for connectivity of habitats by utilizing “developed” land may allow for alternatives that benefit wildlife. Several reptile and amphibian species are known to occur in green space in and around developments. Habitats such as solar, sand mines, and parks typically leave “green” space that varies in suitability; however, each development type has different requirements for long term management. Better understanding these requirements, keeping an open dialogue with developers, and thinking “outside the box”, should provide future opportunities to work cohesively to benefit wildlife and habitats in these locations.

Increased urban development requires larger and additional roadways. Roads are frequently constructed through amphibian and reptile habitats and pose a significant threat to the longevity of adjacent populations. Mortality

occurs as animals attempt to migrate across roadways. Depending on the number of lanes, traffic volume, and speed limit, some animals may cross safely. However, many reptiles and amphibians have high site fidelity to nesting, breeding and overwintering sites and will likely return year after year, significantly increasing the likelihood of mortality. Additionally, as existing roads increase in traffic volume and/or are widened to accommodate residential growth, they become barriers to gene flow between populations. Finally, road mortality of reptiles and amphibians is not only detrimental to the long-term persistence of populations but it is also a safety hazard for drivers. Hitting large turtles or alligators or attempting to avoid them on the roadway can cause severe damage to vehicles and injuries to drivers. Wildlife crossings have gained popularity and have been successful at reducing mortality when installed and maintained appropriately. Wildlife crossings consist of bridges, culverts and/or tunnels, with fencing that guide wildlife to a particular area to cross roads safely. These crossings have been successful in several other states but have yet to be used in South Carolina and rarely in the Southeast. With the continued increase in development and need for increased infrastructure, there are numerous opportunities for wildlife crossings. All new roads or widening projects should consider wildlife crossings for driver safety, as well as to increase the likelihood that species will persist in adjacent habitats.

Protected lands provide both large- and small-scale restoration and/or habitat enhancement opportunities. Historical aerial maps provide a snapshot of habitats decades earlier and can help inform where restoration opportunities are most appropriate. Similarly, a significant amount of habitat in South Carolina is privately owned. Education on the importance of specific microhabitats should be provided to private landowners as well as management/enhancement techniques for habitats that better represent historical landscapes and is more conducive for increased biodiversity.

Population augmentation and/or re-establishment of historical populations has grown in popularity over the last decade. Population augmentation can differ depending on the species and overall goals and can include different age and size classes as well as head-started individuals. Head-starting, or the process in which hatchlings are raised in captivity to attain a larger size more quickly and thus become more likely to escape naturally high levels of predation once they are released into the wild, has become common practice for Gopher Tortoises and Gopher Frogs in South Carolina. While there are many opportunities to augment existing populations or reestablish historic populations, the overall goals and risks involved should be considered prior to any action to ensure the desired outcomes.

Gopher Tortoise hatchlings await release during a telemetry project. Photo by Andrew Grosse, SCDNR

SCDNR Herpetologist, Andrew Grosse, releases a head-started Gopher Frog into its natural habitat. Photo by Jessica Egan, SCDNR.

Nonnative species continue to be problematic for native reptile and amphibian populations in South Carolina. Feral hogs, red imported fire ants, Red-eared Sliders, and Argentine Black-and-white Tegus have been studied throughout the southeast and their negative impacts to native wildlife and habitats are well known. Even so, more survey, research and/or management opportunities exist to better manage these species in South Carolina. Similarly, the increasing number of new and emerging nonnative species provides an opportunity to proactively evaluate their status and potential impacts prior to invasion. Increasing our knowledge of how nonnative species function in our habitats and interact with our native species allows us to make more informed conservation and management decisions.

Illegal collection of native reptiles and amphibians in South Carolina continues to be a problem. New regulations, passed in 2019, increased protection from commercial exploitation and provided the tools needed to better protect South Carolina's native reptiles and amphibians. Surveillance on public lands indicate illegal collection continues to occur, providing opportunities to utilize these new regulatory tools to enforce regulations and increase education and awareness regarding protections of our native reptiles and amphibians. Additionally, law enforcement should be vigilant to current reptile and amphibian markets. Changes in specific species demand create opportunities to proactively intervene and reduce species and ecosystem impacts before they become detrimental.

Birds

As of 2024, 445 species of birds have been documented in South Carolina. Approximately 181 of these are classified as breeders, though this number may be higher due to some species being considered provisional (CBC 2024). 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

represented in the State (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). The National Audubon Society lists 45 sites in the State as Important Bird Areas (IBAs), 16 of which are recognized to be of global importance.

Three different Bird Conservation Regions (BCRs) transect South Carolina: the Appalachian Mountains, Piedmont, and Southeastern Coastal Plain. 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 certain species.

The Appalachian Mountain BCR spans the Blue Ridge, the Ridge and Valley Region, the Cumberland Plateau, the Ohio Hills, and the Allegheny Plateau and contains the headwaters of several major river systems (US NABCI 2000). A portion of the Blue Ridge transects three counties in the northwestern corner of South Carolina; this diverse temperate forest ecosystem supports habitats found nowhere else in the State (Barry 1980). Several bird species are primarily found only in this portion of South Carolina including Ruffed Grouse, Common Raven, Black-throated Blue Warbler, Chestnut-sided Warbler, Red Crossbill, and Dark-eyed Junco (Cely 2003). This region also supports some of the highest breeding densities of Scarlet Tanager, Louisiana Waterthrush, Worm-eating Warbler, and Black-throated Green Warbler in the State (Cely 2003).

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

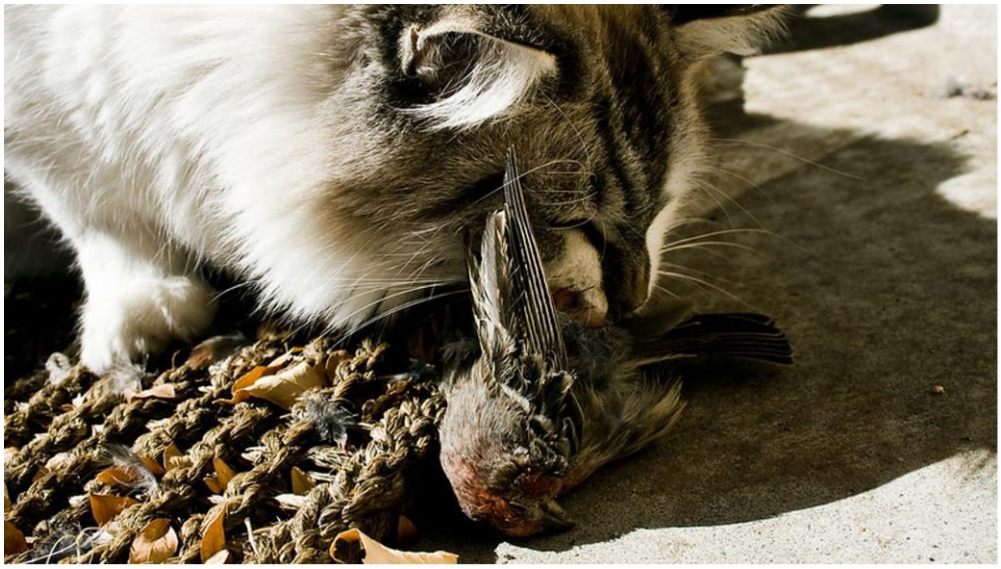
The Southeastern Coastal Plain is a huge area composed of both the South Atlantic Coastal Plain and the East Gulf Coastal Plain physiographic areas (Pashley et al. 2000). In South Carolina, the western boundary is at the Fall Line marking the edge of the hilly Piedmont; the eastern boundary is the Atlantic Ocean (Pashley et al. 2000). The major habitat types include Longleaf and Loblolly Pine interspersed with Carolina bays and pocosins, bottomland hardwoods and maritime forests (Barry 1980). Priority species dependent upon pine habitats include Red-cockaded Woodpecker, Bachman's Sparrow, Brown-headed Nuthatch, Henslow's Sparrow, and Painted Bunting (Pashley et al. 2000). Bottomland forests support high breeding densities of

many Neotropical migrants including Acadian Flycatcher, White-eyed Vireo, Prothonotary Warbler, Hooded Warbler, and Northern Parula (Cely 2003). The coastal intertidal habitats provide critical staging, wintering, and breeding areas for species such as American Oystercatcher, Short-billed Dowitcher, Dunlin, and Red Knot (US NABCI 2000). Offshore islands and coastal areas provide important nesting and foraging habitats for seabirds, waterfowl, herons, egrets, ibis and other species (US NABCI 2000). Impounded wetlands (old rice fields) and backwaters are particularly important for nesting and foraging waterbirds. Many impoundments are managed for waterfowl but also benefit marsh birds, wading birds, and shorebirds. Most wading bird rookeries (excluding the Great Blue Heron) are located in the Coastal Plain, and wading birds utilize a variety of types of wetlands in this region.

A Yellow-crowned Night Heron rests in tidewrack along the shoreline. Photo by Anna Smith, SCDNR.

Challenges

One of the major challenges to birds in South Carolina is outright loss, fragmentation, and/or alteration of habitat. Land use changes and urban development are often to blame. Roads into forests bring native and non-native predators such as rodents and feral cats. Nest parasites, such as the Brown-headed Cowbird, can also move into the forest interior via forest-edge habitats and clearings (Kilgo and Moorman 2003). Birds in the State depend upon varied habitats from the mountains to the coast; changes to habitats can result in loss of feeding or nesting habitat for these species. Wetland habitats, which are important to many members of this taxa, have been destroyed by draining and filling throughout the State. Even small alterations to wetlands can make the habitat unsuitable for nesting and foraging as water levels change and prey species disappear.



Cats allowed to roam outside are non-native, invasive predators to a variety of small animals like birds.
Photo by Will Keightley, Flikr 2007, Creative Commons

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

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

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

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

deaths. Neonicotinoids, the most widely used insecticides on Earth, are lethal to birds. A single seed coated with a neonic can kill a bird, and one tenth of a corn seed per day during egg-laying season can affect reproductive success (Mineau and Palmer 2013).

Black Vulture mortality event in Charleston County, SC from a H5N1 avian flu outbreak in 2022. Photo by Anna Smith, SCDNR

Several diseases and parasites can affect bird populations directly. These include West Nile Virus, Avian Vacuolar Myelinopathy (AVM), cholera, botulism, high pathological Avian Influenza (H5N1), and soft tick infestation. Indirect effects on bird populations include disease outbreaks in important nesting substrates or forage plants. Examples include Sudden Oak Death and Hemlock Wooly Adelgid infestations, which greatly alter the characteristics of the forest type and therefore bird habitats. Non-native predators can also decimate bird populations. In particular, predation by domestic and feral cats is problematic for songbirds. In 2013, researchers reported that an estimated 1.4-3.7 billion birds are killed each year in the United States (Loss et al. 2013.)

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

> *"I now suspect that just as a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer. And perhaps with better cause, for while a buck pulled down by wolves can be replaced in two or three years, a range pulled down by too many deer may fail of replacement in as many decades."*
>
> ***-Aldo Leopold, Thinking Like a Mountain***

Renewable energy production can also have a marked impact on bird populations. Wind turbines kill or maim approximately 700,000 to a million birds every year (ABC 2021). Nighttime migrants and raptors are especially vulnerable. It is estimated that by 2030, the total number of wind turbines in the United States could grow to more than 100,000, essentially doubling the number of bird strikes (ABC 2013). Wind farms themselves also destroy habitat as vegetation is removed and towers are erected. By 2030, 20,000 mi.^{2} of terrestrial habitat and 4,000 mi.^{2} of marine habitat may be impacted. Solar energy facilities, which are rapidly increasing in number in South Carolina, also have the potential to destroy critical habitat if not planned or constructed

with wildlife impacts in mind. Currently, the State is projected to double its solar production to over 5,000 megawatts in the next five years (SEIA 2024).

Window strikes in both city and residential settings kill millions of songbirds annually. Photo by Anna Smith, SCDNR

Collisions with glass buildings claim around 365 million to 988 million birds each year in the United States (Loss et al. 2014). It is estimated that 592 million birds collide with low rise buildings and homes, plus an additional 0.5 million collisions with high-rise buildings (Loss et al. 2014). During the day, birds perceive reflections in glass as habitat they can use. At night, migratory birds are drawn to, and confused by, artificial light. This increases the chance of colliding with windows, and also mortality from exhaustion. Communication tower strikes take an additional 7 million birds per year (ABC 2013). Nocturnal migrants often become confused by the red lights of communication towers and hit the guy wires or the towers themselves.

Migratory species like songbirds and shorebirds will be highly affected by climate change. Migrations and breeding are timed to coincide with abundant prey. If the timing of spawning and/or insect hatching is decoupled from the arrival of the birds along the migration routes, these birds could face higher mortality during migration and lower productivity on the breeding grounds (Robertson et al. 2024, Youngflesh et al. 2023). Breeding grounds are also in trouble. Breeding bird ranges have begun to shift north as is evident by tropical species establishing themselves along the Gulf Coast. As temperatures increase, it's predicted that long-distance migrants, populations at high latitudes, and forest species will be at high risk (Youngflesh et al. 2023). Bird species in remnant boreal forests will have less habitat. In addition, sea level rise will destroy foraging habitat used by wading birds by altering salinity levels and aquatic plant species composition. A multitude of nesting shorebirds and marsh birds will be affected by sea level rise as nesting habitat is inundated. As sea level rises and storm intensity increases, coastal impoundment infrastructure may become more difficult to maintain. Many marsh birds, wading birds, and waterfowl may experience a reduction in nesting and foraging habitats if impoundments can no longer be managed in a way that creates suitable conditions.

Wading birds will be affected by drought conditions as prey abundance in nontidal wetlands diminishes. When wading birds are required to fly greater distances to find food, droughts can result in nesting failures or lower productivity. In addition, lower water levels can make nests vulnerable to mammalian predators, especially when aquatic vegetation becomes established. Unusually high-water levels, as seen during floods, can result in prey being dispersed. Heavy rainfall during the chick-rearing period is an issue for tactile foragers such as the Wood Stork, who require concentrated prey in shallow water to feed efficiently. Coastal areas, where both tidal and nontidal foraging areas can be utilized, will become increasingly important to wading birds if prey availability becomes diminished or unpredictable farther inland. Managing

impounded wetlands near Wood Stork colonies to concentrate prey at critical times during the nesting season can counteract some of the negative effects of droughts and floods on prey availability and improve the survival rates of nestlings.

Conservation Opportunities

Habitat loss is considered the main threat to birds and other taxa. Protection and restoration of habitat should include aspects that are essential for breeding, foraging, and roosting, as well as considerations for variable habitat needs throughout the annual life cycle (i.e. breeding, migration, wintering). Prioritizing habitats based on connectivity and occurrences of rare and sensitive species should be considered when new properties are protected or restored. Habitat protection and restoration should be considered at multiple scales from territory size up to landscape scales. Partnering with other states, federal agencies, NGOs, and non-profits should make conservation efforts more effective.

Other ways to optimize habitat protection is by utilizing already disturbed land for development, minimizing fragmentation, and maintaining habitat management regimes. For example, SCDNR has developed a Solar Siting Tool to help inform large solar development projects about areas of lower environmental sensitivity that could be suitable for solar. Additionally, a Solar Habitat Guide was developed to improve habitat for wildlife at solar developments. Forest fragmentation is one of the biggest problems for forest interior birds. As forest habitat shrinks, bird species that are area-sensitive may abandon smaller woodlots altogether. Identifying and protecting unbroken forest interior tracts, developing habitat corridors, and minimizing the frequency of roads and power line rights-of-ways that bisect those habitats will help maintain those bird populations. Historically, fire, floods, windstorms, and herbivores maintained habitat conditions conducive to disturbance-dependent species (Askins 2001). Specific management regimes differ depending on the habitat, species guild, and also individual species (e.g. early successional, deciduous forest, pine savannah, forested wetland, marsh bird, wading bird species guilds).

Seabird and shorebird nesting habitat is limited along South Carolina's coast, but management of important nesting sites can increase reproductive success. Closures, demarcated with signs and symbolic fencing, can reduce human and dog disturbance to nesting birds. Strategic predator and avian tick control reduce the loss of eggs and

Posting of nesting beaches can help reduce damage to eggs and chicks from people and pets. Photo by Felicia Sanders, SCDNR, of pelicans nesting on Crab Bank in Charleston Harbor.

chicks and minimize nest abandonment.

SCDNR's Bird Conservation Coordinator, Amy Tegeler, demonstrates bird banding of Painted Buntings (SGCN High) to the local Hispanic community. Photo provided by Alix Pedraza Larrotta, SCDNR

Developing partnerships and educating the public about opportunities to integrate habitat management and enhancement strategies into land management activities is an important way to increase bird conservation efforts. Events and strategies to educate the public about how to help conserve birds include workshops, presentations at clubs and organizations, tabling at festivals, bird walks, and social media. Formal partnerships, such as Migratory Bird Joint Ventures and working groups, facilitate sharing conservation techniques and plans that can benefit birds across the landscape.

For most bird species, we do not know if populations are limited during the breeding season, wintering period, or migratory periods (Berlanga et al. 2010). Thus, surveys, research, partnership building, and conservation actions can be taken throughout the species' annual cycle to help identify factors which may assist in restoration and improved conservation of these species and habitats. Southern Wings and the Neotropical Migratory Bird Conservation Act are two programs that help enable habitat conservation for birds and their habitats, research and monitoring, law enforcement, and outreach and education in the United States, Canada, Mexico, Central and South America, and the Caribbean. (See Chapter 11 on international conservation.)

An additional complication is that migratory bird species, especially long-distance migrants, are negatively impacted by climate change. While plant and food resources are tending to become available earlier within the calendar year, birds use photoperiods to determine when they migrate. The result is an increasing level of mismatched timing for migration and available food resources. More detailed information about food availability, foraging, and demographic impacts is needed to further clarify implications of these phenological mismatches (Robertson et al. 2024).

In the past thousands of years, South Carolina's salt marshes adapted to sea level rise by migrating inland. Climate change is causing sea level rise, but lands adjacent to salt-marsh edges are often developed and/or armored, limiting the natural process of salt marshes migrating inland. Rising seas are causing salt marshes to drown, thus reducing the size of this valuable

wildlife habitat (Tibbetts 2007). Facilitated marsh migration and nontidal (inland) wetland creation in South Carolina can offset some of this loss of saltmarsh habitat.

Window collisions can be reduced by being conscientious about tree and shrub placement, installing screens on the outside of the window, or by using decals, film, paint, or other markers (FLAP and Mosco 2024) to break up the reflection and make the glass more visible to birds. The proximity of bird feeders and bird baths to windows can also reduce collision severity (Barges and Morris 2023; FLAP and Mosco 2024). Artificial light can be reduced by using down-shielded light fixtures with bulbs less than 3000 Kelvin, using motion activated lights, setting light timers, closing blinds or curtains, and only lighting areas that need to be lit (ABC 2024). Collisions with communication towers can be reduced by using the Recommended Best Practices for Communication Towers (USFWS 2021). Through education and regulatory actions, bird-friendly building requirements should be considered by states and/or municipalities. Resources for bird-friendly ordinance and statues can be found online: Dark Sky International's Principles for Responsible Outdoor Lighting can assist with lighting choices and American Bird Conservancy's (ABC) glass collision information can provide building code design ideas, especially for mid-rise buildings where most songbirds fly and forage (Barges and Morris 2023).

Imprint of a Mourning Dove that collided with a window. Photo by Anna Smith

There are a few ways to decrease the impacts of chemical contamination and diseases to birds. Using native plants in landscaping and establishing seed banks provides food resources, directly through production of seeds and berries, and indirectly by creating habitat for insects. Minimizing the use of neonicotinoids and rodenticides can be challenging since they are commonly used. However, efforts to preserve and improve water quality can reduce contamination of aquatic insect food resources—the base of the food chain—by neonicotinoids and other contaminants. The need for rodenticides can be minimized by rodent-proofing buildings. Some diseases affecting birds can be reduced by thoroughly, and regularly, cleaning bird feeders and other locations where birds tend to congregate.

A Carolina Chickadee feeds at a black oil sunflower feeder. Regular disinfection of feeders and waterers can limit the spread of infectious diseases in wild birds. Photo by Anna Smith, SCDNR.

Mammals

According to the American Society of Mammalogists, South Carolina is home to approximately 101 native species of mammals with a higher diversity found in the Coastal Plain and the Mountains. The largest group of mammals in the Southeast is the rodents at around 36 members. However, back in colonial times, South Carolina was also home to several additional species including the American Bison, Eastern Elk, Red Wolf, Gray Wolf, and Eastern Cougar. Overhunting, persecution, and habitat changes eventually led to their extinction in the region. Declines in other species such as White-tailed Deer in sections of the State prompted the creation of restocking programs beginning in 1951 and ending in 1989 which were extremely successful. Because all 642 deer were not brought in from other states to accomplish this, the genetic integrity of the species was retained (C. Ruth, SCDNR, pers. comm.). Beavers, which had been extirpated in the 1800s, were reintroduced to the Pee Dee region in the 1940s by the USFWS. Fox squirrels have also been translocated from healthy populations in the State to depauperate areas in the Coastal Plain by SCDNR, the University of Georgia, and other private entities (B. Dukes, pers. comm.). South Carolina is experiencing changes in its mammalian assemblage once again as new species colonize the landscape. Some have been introduced by humans, as in the case of Coyotes and feral pigs, while others have made it here on their own such as the Nine-banded Armadillo.

Six Southeastern Myotis pack into a weep hole in Jasper County, SC. Photo by Jennifer Kindel, SCDNR

The following mammal species are legally classified as furbearers and may be taken by hunting or trapping during the open season by those with a valid license: Bobcat, Coyote, Red Fox, Gray Fox, Virginia Opossum, Raccoon, North American River Otter, American Mink, Long-tailed Weasel, Striped Skunk, Spotted Skunk, Muskrat and North American Beaver. All these species, except for the Coyote, are also classified as small game. Although the Spotted Skunk, American Mink, Appalachian Cottontail, Swamp Rabbit, and Southern Fox Squirrel are considered priority species for the purposes of the SWAP, they are still game animals capable of being harvested. Their populations are currently stable, and hunting has not been found to be a threat to their continued existence in the State. They are monitored here due to concerns about potential population fluctuations as regulated species.

Challenges

One of the major challenges to mammals in South Carolina is loss, fragmentation, and/or alteration of habitat. Disease, exposure to pollutants, and wind turbines also have a significant negative impact on mammal species in the State.

<u>Terrestrial Mammals</u>

As urban development expands, changes to forests and grasslands often lead to outright loss or degradation of foraging, roosting (bats), and denning/nesting habitat. Additionally, habitats are

fragmented by development. Roads can limit movement of many species and often result in mortality to individuals.

Destruction of habitat can also come in the form of wind turbines. Turbines can also cause mortality directly through collision, and unfortunately bats may be attracted to wind turbine towers, increasing their chance of mortality (Cryan and Barclay 2009). Wind energy around the world is growing by 10%–20% per year (IRENA 2022), and an estimated 500,000 bats are killed every year by wind turbines in the United States (Voigt et al 2024).

Pollutants from a variety of sources can impact mammals. The American 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. Trash and litter pose challenges to both terrestrial and aquatic mammals. Small mammals can become trapped in bottles and other litter while foraging.

A Northern Short-tailed Shrew's (*Blarina brevicauda*) skeletal remains were found after being trapped in a discarded beer bottle. P

An Eastern Woodrat in a live trap. Photo by Anna Smith, SCDNR.

Two diseases, raccoon roundworm and Sudden Oak Death (SOD), can adversely affect mammals in South Carolina. Raccoon roundworm can cross species boundaries to infect other mammals, resulting in death. It has been suspected in the decline of the Eastern

Woodrat in some states. The disease is undergoing a range expansion and may impact counties outside of the Appalachians. SOD attacks and destroys oak trees which are vital mast producers used as food sources by several mammals on South Carolina's Priority Species List including the Eastern Woodrat. In addition, Hemlock Wooly Adelgid has defoliated and killed hemlocks in South Carolina, altering hemlock coves which are important to some small mammals such as Masked and Pygmy Shrews.

Another disease, White-nose Syndrome (WNS) affects bats. WNS is a disease caused by a white fungus species, *Pseudogymnoascus destructans*, that forms on the nose, wing membranes, and ears of affected hibernating bats. Mortality rates attributed to WNS have reached up to 90-100% at hibernacula (Kunz and Tuttle 2009) causing the death of between 5.7 to 6.7 million bats in North America since it was first documented in New York during the winter of 2006/2007 (USFWS 2012). In less than 10 years, WNS has killed over 90% of Northern Long-eared, Little Brown, and Tri-colored Bat populations (Cheng et al. 2021). On February 21, 2013, a Tricolored Bat was found dead at Table Rock State Park. Testing by the Southeastern Cooperative Wildlife Disease Study in Athens, GA confirmed that the bat had WNS, the first case in South Carolina. In April 2013, an Eastern Small-footed Myotis infected with the fungus was found in a more southerly portion of the same state park. After WNS was confirmed in the State, Tricolored Bat populations in major Upstate hibernacula declined at an alarming rate, up to 97%. A total decline of 91% at a single major site occurred after only a period of three years. Though recent hibernacula surveys show those populations leveling out or beginning to rebuild, despite the continued presence of the fungus, Tricolored Bats only have 2 pups per year so it will take many years to return to pre-WNS populations.

The estimated annual value of bats in pest suppression services to South Carolina's agricultural industry is nearly $115 million, with the US agricultural industry estimate at $22.9 billion (Boyles et al. 2011). The beneficial ecological effects of bats can extend past insect consumption as they indirectly suppress pest-associated fungi and the toxic compounds they produce in corn (Maine and Boyles 2015), as well as reduce the need for pesticides which have substantial impacts on many other wildlife species (Pimentel 2009).

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

Several species of mammals are regarded by humans as "pests;" this view can lead to persecution of these species. Examples include Raccoons, and species of moles, mice, squirrels, skunks, and bats.

Finally, global warming could shift suitable high elevation habitat farther north and into higher elevations not found in South Carolina (W. Mark Ford, pers. comm.). This would affect the

Woodland Jumping Mouse and both species of moles on South Carolina's priority list. A study from 2023 shows that North American small mammals have been decreasing in body size in response to the warming of terrestrial ecosystems, likely impacting the structure and function of these mammal communities (Searing et al 2023).

Marine Mammals

Human interactions in the marine environment (e.g. vessel strikes, entanglement, coastal development, pollution, anthropogenic noise, climate change) pose significant challenges to marine mammals in South Carolina waters. Marine transportation corridors often exist in the same areas used by marine mammals including the coastal and estuarine stocks of Bottlenose Dolphin and migrating Atlantic Right Whales. Collisions with vessels (boat strikes) can injure or kill marine mammals and are especially challenging to Florida Manatees occupying shallow water areas, and to the Bottlenose Dolphin stocks utilizing estuarine and coastal waters. Marine mammal stranding data for South Carolina show fishery interactions, primarily crab pot buoy line entanglements, to be the leading cause of anthropogenic mortality in Bottlenose Dolphins (McFee et al. 2007; McFee et al. 2009; Krzewinski et al. 2024). Incidental entanglement in derelict fishing gear may also impede an animal's ability to properly forage, navigate, or avoid collisions with vessels. The presence of warm water industrial discharge in areas of coastal development encourage Florida Manatees to prolong their visits to areas far beyond their wintering grounds and can lead to cold shock and death when cold weather arrives. Also, navigational locks on riverine systems can inadvertently crush Manatees not visible in the dark waters.

Bottlenose Dolphin. Photo by SCDNR.

Pollutants and contaminants from a variety of sources (e.g. urban and industrial development, manufacturing, wastewater discharge, stormwater runoff) can impact marine mammals. Species in coastal areas with more urban and industrial development are at risk of accumulating higher concentrations of contaminants (Houde et al. 2009; Fair et al. 2010; Battaglia et al. 2020). As pollutants and contaminants enter the aquatic environment, they bioaccumulate in fish and other organisms and are transferred to marine mammals primarily through the ingestion of prey (Fair et al. 2010, Battaglia et al 2020). Exposure to contaminants can cause adverse health conditions in marine mammals including increased susceptibility to infectious diseases and reproductive dysfunction (Fair et al. 2010). Specific emerging diseases include brucellosis (McFee et al. 2020), erysipelas, coronovirus, lobomycosis (lacaziosis), and paracoccidiosis (W. McFee, personal communication, November 11, 2024). Trash and other marine debris that enter the marine environment can be mistaken for food items and ingested resulting in morbidity and/or mortality.

Anthropogenic noise pollution from commercial and recreational vessels, dredging operations, bridge construction, land development, and other marine activities may affect marine mammal abundance, distribution, and behavior. Noise pollution can disrupt communication, foraging,

social activities, reproductive success, and cause displacement from home ranges and preferred habitats. In Charleston Harbor, the Charleston Estuarine System Stock of Tamanend's Bottlenose Dolphin increased their vocalizations in the presence of vessel noise, suggesting they may be modifying their vocal behavior in response to increased anthropogenic noise (Transue et al. 2023, Tribble et al. 2023).

Warming sea temperatures due to climate change can affect marine mammal prey availability, habitat availability, spatial and temporal distribution, behavior, physiological stress, and their overall health. A shift in the availability of prey could result in the lack of available food resources causing emaciation and starvation. Additionally, species may exhibit changes in their spatial or temporal distributions from historic norms. Trends in South Carolina strandings data suggest there may have been a shift in the migration patterns of the Southern Migratory Coastal Stock of Bottlenose Dolphin due to increasing ocean temperatures, with the southern migration beginning later in the year and the northern migration beginning earlier in the year (Krzewinski et al. 2024).

Conservation Opportunities

Terrestrial Mammals

As with other wildlife, the protection and restoration of habitat while utilizing already disturbed land and minimizing fragmentation is an opportunity for conservation. Identification of high priority habitat for rare and sensitive SWAP mammals in differing ecoregions and seasons should be conducted, and prioritizing those habitats based on connectivity and other key factors such as river corridors, streams, and marsh habitat for differing mammal species should be maintained. With that information, a focus should be placed on those high priority habitats for protection through future land acquisition and/or enhancement of current protected lands.

State of South Carolina

Governor's Proclamation

WHEREAS, bats provide important ecological services that contribute substantially to the economy of the United States by protecting American forests and agriculture from crop-damaging insect pests and by providing the fundamental benefit of pollination; and

WHEREAS, South Carolina is home to fifteen bat species that save our state's agricultural industry over $115 million each year in pest suppression services and help reduce the spread of dangerous mosquito-borne viruses; and

WHEREAS, recent bat population losses from white-nose syndrome and other factors require attention to ensure the sustainability of our food production systems and protect environmental and human health; and

WHEREAS, it is critically important to continue federal and state efforts, including developing new public-private partnerships and increasing citizen engagement, to promote the health of bat populations; increase the quality and quantity of bat roosting and foraging habitat; and help restore bat populations to healthy levels.

NOW, THEREFORE, I, Henry Dargan McMaster, Governor of the great State of South Carolina, do hereby proclaim October 24 - 31, 2024, as

SOUTH CAROLINA BAT WEEK

throughout the state and encourage all South Carolinians to learn more about the vital significance of protecting the health of bat populations and celebrate their contributions to healthy ecosystems, our food supply, and human health.

HENRY DARGAN MCMASTER
GOVERNOR
STATE OF SOUTH CAROLINA

Public outreach and partnerships with others across the State about the challenges faced by terrestrial mammals is key to their conservation, especially for privately owned high priority habitats. Regional partnerships for habitat protection, and working groups and cooperative study groups for outreach and research connections are beneficial opportunities for

conservation. For example, the goals of the Eastern Spotted Skunk Cooperative Study Group are to promote the conservation of the Eastern Spotted Skunk across their distribution through (1) enhancing communication about the species, (2) identifying management and resource priorities, and (3) facilitating collaborative planning, funding, outreach, monitoring and research opportunities. The mission of the South Carolina Bat Working Group is to conserve South Carolina bats through communication, collaboration, education and research. Other regional conservation focused organizations include the Southeastern Bat Diversity Network and the Colloquium on the Conservation of Mammals in the Eastern United States.

Research should continue to investigate the impacts of environmental contaminants on terrestrial mammals. It should also focus on estimating the amount of habitat necessary to sustain viable populations, and the effects of prescribed fire on differing mammal populations, ecoregions and seasons. Additional data needs to be collected to further determine population genetics, density, and viability, as well as to delineate regional and seasonal distribution and maintain long-term demographic data to better monitor, identify, and manage their declining populations.

Marine Mammals

In South Carolina waters, there are five Tamanend's Bottlenose Dolphin (*Tursiops erebennus*; Costa et al. 2022) stocks as well as the North Atlantic Right Whale (*Eubalaena glacialis*) and other migrating Right Whales that are protected under the Marine Mammal Protection Act of 1972 and Amendments. Further, Florida Manatees are protected in South Carolina waters and administered by the United States Fish and Wildlife Service (USFWS).

The National Marine Fisheries Service has created marine mammal stranding networks nationwide under the Marine Mammal Health and Stranding Response Act of 1992, and South Carolina has had an active SC Marine Mammal Stranding Network since 1992 led by the SCDNR (1992-2005), National Ocean Service (2006-2008), Coastal Carolina University (2008-2020), and the Lowcountry Marine Mammal Network (2021- present). The objectives of the US Marine Mammal Stranding Response Network are to: "1) monitor, track, and investigate causes of marine mammal illness, injury, death, health trends and effects of climate change, 2) collect data for scientific investigations, management decisions, and law enforcement investigations, 3) minimize the risk to public health and safety of stranded marine mammals, 4) provide for the welfare of live stranded or otherwise distressed marine mammals, 5) advance public education and engagement in ocean conservation, and 6) enhance the conservation and management of wild marine mammal populations and the wider marine ecosystem (https://fisheries.noaa.gov/national/marine-life-distress)."

In addition, conservation aims to mitigate human interactions by reducing bycatch in commercial fisheries and reduce collisions with vessels. Take Reduction Plans and teams are in place for multiple species to provide information for agency regulations related to vessel strikes, mortality and serious injury reports, investigations into effects from harmful algal blooms, monitoring of climate change effects, and investigations into Unusual Mortality Events. Individual private organizations regularly assist with outreach and education to the public, as well as investigate strandings through a competitive Prescott Grant Funding program (https://fisheries.noaa.gov/grant/john-h-prescott-marine-mammal-rescue-assistance-grant-program).

Research should continue to investigate the impacts of environmental contaminants on marine mammals (Houde et al. 2009, Fair et al. 2010), as well as microplastics (Battaglia et al. 2020), and emerging diseases and pathogens (McFee et al. 2020). It should also focus on continuing dolphin photo-identification (Speakman et al. 2010; Bouchillon et al. 2019), acoustic studies (Transue et al. 2023, Tribble et al. 2023), and human interaction studies (McFee et al. 2006, 2007, 2009). Additional data needs to be collected to further determine population genetics, density, habitat shifts due to climate change, as well as to delineate regional and seasonal distribution and maintain long-term demographic data (Krzewinski et al. 2024) to better monitor, identify, and manage populations.

Freshwater Fishes

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

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

Challenges

One of the major challenges to freshwater fishes in South Carolina is degradation and loss of habitat. As urbanization through development occurs, waterbodies are altered in ways that change both the topography and hydrology of streams, rivers, wetlands, lakes and ponds. Removing riparian vegetation can result in siltation, increases in nutrient and pollutant loading, increases in velocity of flow both into and within the waterbody, and temperature increases. Erosion from agriculture and silviculture (logging) can significantly lower water quality and cause drastic adverse reactions in aquatic life (Butler 1968). Runoff carries silt, chemicals and nutrients into wetlands that, acting alone or in combination, can be lethal to aquatic life, and particularly to larval forms (Matthews et al. 1980, Aust et al. 1997). Runoff can cause sedimentation while nutrients can encourage algal blooms, both leading to eutrophication and possible dissolved oxygen (DO) depletion (Matthews et al. 1980, Lockaby et al. 1997). Siltation can also cause an increase in water temperature (Aust and Lea 1991, Perison et al. 1993). Forestry Best Management Practices (BMPs) for bottomland forests are recommendations to landowners in order to conserve site productivity—primarily for silviculture—and are voluntary (SCFC 1998). When BMPs are not used, braided streams may be obstructed by plant material and disturbed soils; excessive ruts may channel eroded sediments into streams. Additionally, partially stagnated waters may become nutrient-rich and promote algal growth that can die under extended periods of cloud-cover (J.W. McCord, SCDNR, pers. obs.). These factors contribute to increased water temperature and reduced DO.

Rapid development in some parts of South Carolina also contributes to siltation in many ways. Impervious surfaces such as roads, buildings and parking lots increase erosion in adjacent areas and contribute to flooding. Clearing riparian vegetation also destabilizes stream and riverbanks allowing excessive siltation. Clear cutting in a substantial part of a watershed can also contribute to siltation even if a riparian buffer is maintained. In a study of several watersheds in the Georgia piedmont, streams in urban and agricultural watersheds had much higher nutrient and suspended sediment concentrations than watersheds that remained mostly forested. Suburban watersheds had intermediate levels of nutrients and suspended sediments when compared with watersheds dominated by forested or urban and agricultural land use (Meyer and Couch 2000).

When streamside management zones are not maintained and cattle are allowed into the creek, bank sloughing and sedimentation occurs, smothering aquatic life. Photo by Ericah Beason, SCDNR.

The use of motor vehicles in streams and along banks can also degrade the stability of banks, stir up benthic sediments, and increase siltation. Factors that contribute to siltation can also change the topography of

the stream or river by changing the slope of the bank and eliminating heterogeneity in the channel.

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

The SC Statewide Aquatic Research Program team electrofishing. Photo by Charles Dymock, SCETV.

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

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

Climate is a primary force driving ecosystem dynamics, and aquatic systems are particularly susceptible to alterations in the hydrologic cycle. Our ability to predict the consequences of climate change is limited by uncertainty in climate predictions compounded by complexity in ecological system behavior. Climate will interact with a host of other ongoing system alterations—such as land use change—with which organisms must cope. Changes in precipitation timing and amount will affect water quantity and quality and timing of flows.

Conservation Opportunities

Some of the unique characteristics of aquatic ecosystems in South Carolina that must be considered when planning for climate change impacts include: (1) a high level of aquatic organism diversity and endemism; (2) if migration of fishes is limited to within drainage networks, preventing natural migration across watershed boundaries; and (3) if barriers to connectivity within drainages are widespread, limiting natural migration upstream and downstream. Data collected during the South Carolina Stream Assessment are being used to model potential consequences of climate change for streams in the State. Other opportunities include continuing to work with federal, state, and NGO partners to remove barriers to dispersal, genetic and life history studies to inform management, and stream restorations.

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 Alosidae): American Shad, Hickory Shad, and Blueback Herring. The alosines are highly migratory species that occur along much of the Atlantic coast of North America and spawn in freshwater during late winter and spring. Genetically distinct populations occur in most coastal, freshwater drainage basins throughout the range of these species, including those in South Carolina (ASMFC 1985; ASMFC 1999; ASMFC 2020; ASMFC 2024). Because of similarities in life history, the alosines face similar threats and are often included in single, comprehensive management plans just as they are addressed in the Supplemental Volume of this SWAP.

Atlantic Sturgeon is the largest species of fish found in freshwaters of Eastern North America (Robins and Ray 1986). The Atlantic Sturgeon is a Federally Endangered anadromous species in South Carolina, and both juveniles and non-sexually mature adults may move between fresh, brackish, and marine habitats during much of their lifespan (ASMFC 1990; McCord 2003; Post et al. 2014). Atlantic Sturgeon are genetically distinct by Atlantic coastal ecoregions or distinct population segments (dps) (Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic) (Wirgin 2000; White et al. 2021). The current extent of genetic mixing between drainage basin-specific populations or stocks is unknown. Atlantic Sturgeon occur in most major river systems along the east coast and exhibit a periodic life history strategy that increases their vulnerability to exploitation and habitat change, thus complicating conservation and recovery efforts (Winemiller 2005).

The Shortnose Sturgeon, also Federally Endangered, displays a variant anadromous life cycle in southern populations (Dudley et al. 1977; Kynard 1997; McDowall 1988; NMFS 1998). Shortnose Sturgeons can 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, Post et al. 2014). 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). However, some anadromous stocks exist in the Edisto, Combahee, and Savannah Rivers.

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 SGCN 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). Likewise, Atlantic Sturgeon also undergo migrations north during certain times (Post et al. 2014) 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.

The six diadromous species (American Shad, Hickory Shad, Blueback Herring, Atlantic Sturgeon, Shortnose Sturgeon, and American Eel) are considered to be highest priority species. All perform integral roles in the diverse habitats and ecosystems in which they reside during all portions of their complicated life cycles, and all have faced impacts that have caused stock declines, sometimes dramatic, in at least some river basins, both in South Carolina and across their broader ranges (ASMFC 1985; ASMFC 1990; NMFS 1998; ASMFC 1999; ASMFC 2000; ASMFC 2024). The ecological functions of these species are described in detail within the species profiles. These species are all currently covered by dynamic management plans

developed through the Atlantic States Marine Fisheries Commission (ASMFC) or the National Marine Fisheries Service (NMFS). Such management plans are primarily guidance documents that require action and cooperation by individual states. Several plans include mandates to the states that require specific monitoring or management actions. Unfortunately, funding associated with such plans and mandates has been insufficient to support actions necessary to collect information essential to assess and protect most basin-specific populations.

The Shortnose Sturgeon is a Federally Endangered species under the Endangered Species Act (ESA). However, individual basin-specific stocks of other anadromous species may be more imperiled than are many Shortnose Sturgeon stocks. All of the State's priority diadromous species are currently, or have been, targeted by commercial and/or recreational fisheries. Management of these species has generally been limited to control of fisheries. This is oftentimes based on limited data, perceived population levels, and regulatory actions presumed to produce desired positive effects. Currently, all take of Shortnose Sturgeon is prohibited because of its Endangered status.

The Atlantic Sturgeon is also a Federally Endangered species under the Endangered Species Act. State law has closed commercial gear fisheries for alosines in several rivers and has limited such fisheries within the past decade. In past years, the Blueback Herring and American Eel were petitioned for listing under the Endangered Species Act by the NMFS and the USFWS but found to be unwarranted. However, stocks will continue to be monitored. 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 diadromous 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 available for major rivers but is lacking for many state river basins. Also, the known or perceived status of individual populations for which there is 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; NMFS 1998; ASMFC 1999; ASMFC 2000; ASMFC 2024). Information on current distribution and stock status of all six high priority species is highly applicable to Federal Energy Regulatory Commission (FERC) relicensing considerations for dams and other water diversion facilities. Many dams on drainage basins within South Carolina are currently, or soon will be, undergoing the FERC-relicensing process. Both the National Marine Fisheries Service (NMFS) and the USFWS have primary authority over fish passage and diadromous fish restoration issues related to FERC-relicensing (ASMFC 1985; ASMFC 1990; NMFS 1998; ASMFC 1999; ASMFC 2000). However, state natural resource agencies generally participate in such activities as well.

Because of the broad diversity of life history characteristics and habitat utilization displayed by diadromous species, and because of their complicated life cycles, survey and monitoring techniques must be diverse and performed for a decade or more to establish meaningful trends

indicative of stock status. Most survey and monitoring to gather information on stock status of diadromous species in South Carolina over the past two decades or more has been funded by various federal grants and takes place only on major rivers. These studies have been primarily performed in response to mandates in ASMFC management plans. Funds have not been sufficient to allow for either comprehensive studies of all populations in South Carolina, or for the accumulation of sufficient long-term data to provide for conclusive indications of stock status for even any single population.

Furthermore, mandated data collection is most extensive for American Shad, and such data collection is not required for all populations since participants in the ASMFC management plan development process understood (and currently understand) funding limitations. Generally, small rivers are not covered by mandates within the ASMFC plan for alosines (ASMFC 1999; ASMFC 2002; ASMFC 2020). ASMFC management plans for the Atlantic Sturgeon and the American Eel include few mandates, but like all ASMFC plans, the National Marine Fisheries Services' recovery plan for Shortnose Sturgeon (NMFS 1998) and other management plans, make numerous recommendations for data collection needs. These studies will help to establish population status and conservation actions needed to restore or enhance individual populations or population segments.

In many South Carolina river basins, basic surveys must be conducted to determine either presence or absence of these species. Population surveys in some rivers may be useful as indicators of probable stock trends in similar basins. Perhaps among the highest priorities should be the continuation or expansion of existing surveys (i.e. a survey of sturgeons in the Waccamaw River initiated in 2018) for sufficient duration to follow multiple year classes and allow for characterization of stock status.

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

Climate change also has the potential to affect all diadromous fishes in one way or another. Long-term observations confirm that the climate is changing at a rapid rate. Some of the major impacts to diadromous fishes will include loss of nursery habitat, loss of spawning habitat, and reduced flows. Expected consequences would be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000). Increasing temperatures over time is already beginning to result in earlier spawning migrations of many alosine species (Nack et al. 2019).

Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development—and this stress may be exacerbated by changes in climate—anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch et al. 2000). A global analysis

of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al. 2008). Consistently low stream flow can limit available spawning, thermal refugia, and foraging habitat.

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

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

Lastly, piscivorous birds such as the Double Crested Cormorant and White Pelican, and non-native, invasive species can impact populations of diadromous species. Blue Catfish and Flathead Catfish are both presumed to act as both competitors and predators to sturgeon, for example (NMFS 1998).

Conservation Opportunities

Many dams in South Carolina are currently, or are soon to be, required to go through the Federal Energy Regulatory Commission (FERC) re-licensing process, which includes considerations for improved access for passage and migration of diadromous species. Therefore, increasing opportunities for passage, habitat enhancement, and monitoring studies are possible in the future. For example, after almost 30 years, Santee Cooper received their long-awaited license in 2023. Requirements in the 40-year license include

American Eel ladder at St. Stephen Dam on the Rediversion Canal, Santee River. Photo by SCDNR staff.

monitoring studies and construction of passage facilities at both the Pinopolis and Santee Dams for the American Eel. Requirements also include monitoring and passage studies for American Shad and Blueback Herring in the Santee and Cooper Rivers. Additionally, the Biological Opinion for Shortnose and Atlantic Sturgeon concurrently issued by NMFS as part of the license, requires up to 40 years of monitoring studies and increased minimum flows (NMFS 2020). Duke Energy also received their license for the Yadkin Pee Dee in 2015. As part of the requirements in this license, an eel ladder was installed at Blewett Falls Dam and began passing fish in 2022. In addition, the utility began required American Shad monitoring and is constructing a fish passage facility. Lastly, Duke Energy received a license for the Catawba Wateree System in 2015. Requirements in this license continued monitoring of an already constructed eel ladder and American Shad monitoring at and below the Wateree Dam in Lugoff, SC.

Although these opportunities are mandated through the FERC process, they are ever so important due to the long-term monitoring commitment for diadromous species. These partnerships between utilities and State and Federal agencies are crucial in maintaining annual catch data for sustainability of diadromous species resources. Because federal funding continues to decrease annually, reducing the ability to fund long-term monitoring/research projects, conservation opportunities such as those mentioned are vital.

Freshwater Mussels

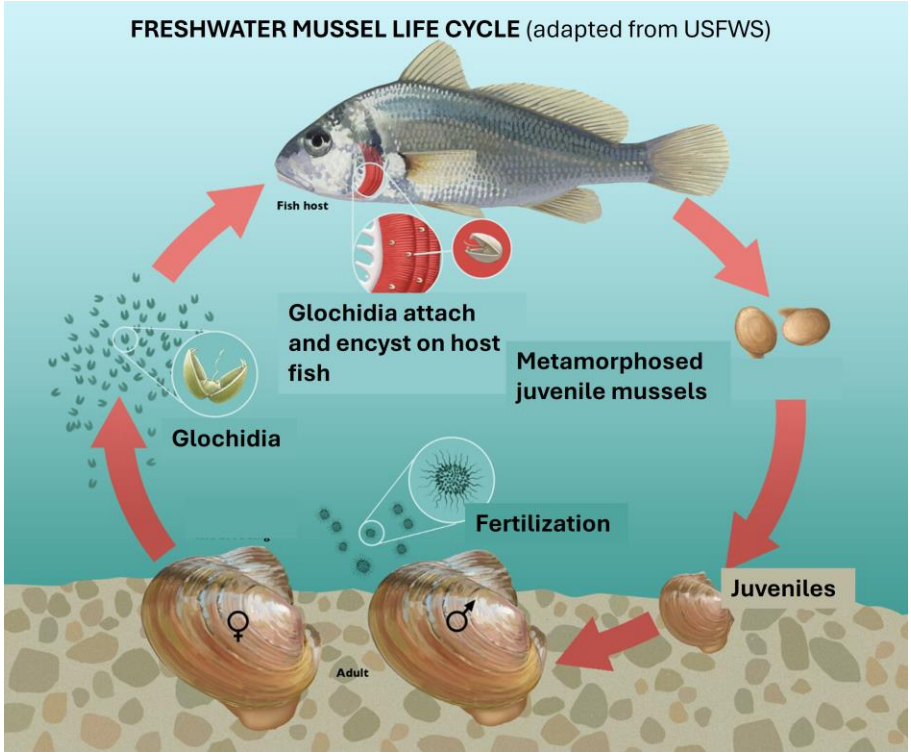
Freshwater mussels native to the United States are bivalve mollusks belonging to the order Unionoida and superfamily Unionoidea. There are two families within Unionoidea, Unionidae and Margaritiferidae; all of South Carolina's species belong to the family Uniondiae. North America has the highest diversity of freshwater mussels in the world with roughly 300 species recognized; however, they are one of the most imperiled groups of organisms with approximately 70% of species in North America considered either threatened, endangered, or extinct (Bogan 1993, Williams et al. 1993; Haag and Williams 2014; Lopes-Lima et al. 2018). In 1993, the American Fisheries Society evaluated the conservation status of freshwater mussels in the United States and Canada (Williams et al. 1993) and they determined that 7.1% of mussel species were endangered and possibly extinct, 20.6% were endangered and extant, 14.5% were threatened, 24.2% were of special concern, and 4.7% had an undetermined status. Only 23.6% of mussel species were determined to be stable. In recent years, unionid mussel populations in North America, including both rare and common species, have faced

Native freshwater mussel being used in a chub mound. Photograph taken by Ericah Beason, SCDNR.

dramatic declines (Bogan 1993, Vaughan and Taylor 1999) resulting in loss of benthic, filter feeding biomass, and ecosystem services provided by such animals.

The conservation of North American freshwater mussels has many broad implications beyond the survival of individual mussel species. As filter feeders, unionid mussels, even in low densities, remove algae, diatoms, bacteria, and particulate organic matter from the water column and then convert that material into dissolved nutrients that can be taken up directly by the algae (Vaughn et al. 2004). These effects are far greater when unionid biomass is high, water volume is reduced, and flows are low (Vaughn et al. 2004). Freshwater unionid mussels also affect stream nutrients by burrowing into the substrate which enhances the rate at which nutrients release from the sediment (Matisoff et al. 1985). Not only does burrowing allow for the release of nutrients, but it also aids in the structural integrity of the substrate, aiding in the creation or improvement of habitat that can be utilized by other invertebrates (Vaughn et al. 2008). Mussel shells left in the system after an animal dies are also important for creating and enhancing habitat. Sometimes mussels themselves are used by other species and in South Carolina, some have been observed being used in chub mounds.

Additionally, macroinvertebrate assemblages are influenced by unionid mussels, and densities of macroinvertebrates were positively correlated with unionid density (Vaughn and Spooner 2006). Macroinvertebrates provide many ecosystem services such as breaking down organic matter and acting as a staple food source for higher trophic levels (Covich et al. 1990, Nery and Schmera 2016). Unionid mussels are also an important food resource for fish, crayfish, flatworms, waterfowl, turtles, muskrats, raccoons, and river otters. Not only are freshwater mussels a food source, but their biodeposits (feces and pseudofeces) also act as a food source. For example, the Western Pearlshell's (*Margaritifera falcata)* biodeposits act as a food source for larval lampreys in oligotrophic streams; it was found that over 80 days, the lamprey grew twice as fast when caged with mussels in western California (Limm and Powers 2011). Since mussels are sometimes found at densities as high as 200 to 400 per m^2 (19 to 37 per $ft.^2$), removing them from our rivers and streams can have drastic consequences for these ecosystems, particularly in terms of nutrient processing (Bogan 2001).



Freshwater unionid mussels have a unique life cycle and larvae require

attachment on a species-specific host fish to complete metamorphosis into juvenile mussels. Most freshwater mussels are dioecious (separate sexes), although a few species are hermaphroditic (Van der Shalie 1970; Kat 1983; Johnston et al. 1998). During spawning, male unionid mussels release sperm or spermatozeugmata, a hollow, spherical aggregate of sperm, into the water column. If filtered by the appropriate female, the sperm fertilizes eggs which are inside of the female mussels' gills. Female mussels deposit eggs in primary water tubes of gills, called marsupia or brooding chambers, and the location of where eggs are deposited varies among species (Williams et al. 2008). Once fertilized, embryos develop until they become glochidia (larvae), and the duration of embryo and glochidia retention in the marsupium varies among phylogenetic groups (Williams et al. 2008). Species generally fall within two groups, the short- (tachytictic) and long- (bradytictic) term brooders (Ortman 1911), though a handful of mussel species differ from these patterns. Short-term brooders, as the name suggests, brood embryos until they become mature glochidia (generally less than 2 months) before immediately releasing them, which typically occurs in the spring and summer (Weaver et al. 1991, Garner et al. 1999). Long-term brooders' eggs are usually fertilized in late summer or fall and glochidia, like glochidia of short-term brooders, develop within about two months. However, glochidia are not released immediately after maturing, rather, they are brooded over winter until the following spring or summer (Zale and Neves 1982). Upon release, glochidia must attach to the fins, skin, or gills of species-specific host fish, or in a few cases, a salamander, to transform into juvenile mussels. If glochidia attach to an appropriate host fish, they become encysted on the host, which occurs as fish cells encapsulate the glochidia; if they attach to a non-suitable host, they will be rejected by the fish's immune system and be sloughed off the fish (Haag 2012).

Glochidia can survive in the water column from a few hours to a couple of weeks before attaching to a host, but this time frame depends on mussel species, water chemistry, and temperature (Fisher and Dimock 2000, Zimmerman and Neves 2002). If glochidia do not successfully find a host during that period, they die. To increase chances of survival, unionid mussels have developed unique methods of dispersing glochidia which aim to increase their odds of attaching to an appropriate host. Common, known host infection strategies include broadcasting, conglutinate production, and luring. Broadcasting is a strategy utilized by many opportunistic mussel species and involves free releasing glochidia into the water column in hopes they encounter a suitable fish, or releasing glochidia in mucus threads or webbing which allow glochidia to get "trapped" onto host fishes (O'Brien and Williams 2002, Aldridge and McIvor 2003). Mussel species that utilize the broadcasting strategy are often host generalists and glochidia can successfully transform on different species of fish, although the percentage of success still differs among species (Haag 2012). Conglutinates are specialized packages of glochidia that range in complexity from "loose conglutinates" that contain little structure, to highly specialized conglutinates such as those seen from the kidneyshell (*Ptychobranchus fasciolaris*) which encapsulate glochidia in a pigmented, membranous capsule that mimics larval insects or fish fry—prey items for darters—and can attach to rocks or vegetation (Watters 1999). Different conglutinate types seem to target different fishes. Pelagic conglutinates are simple structures composed of undeveloped eggs and mature glochidia. They are small, lance or oval shaped, and usually uniform in color; they usually target drift-feeding minnows (Haag 2012). Demersal conglutinates vary widely in shape, size, and color but they are complex structures that remain at or near the streambed and target benthic invertivores such as darters (Haag 2012). Mucoid conglutinates are loose conglomerates of glochidia in large, unpigmented, packages that

mimic caterpillars or worms and are also associated with the bottom of a system; these conglutinates typically target catfishes (Haag 2012). Lastly, some mussel species produce a lure from modified mantle tissue which usually mimics prey for specific fish species. Lures range in size and complexity, but all lures aim to attract host fishes within proximity to the female mussel for release of glochidia. For instance, the Yellow Lampsmussel (*Lampsilis cariosa*), which is found in South Carolina, produces a lure that mimics a small minnow that attracts piscivorous fish species such as the White Perch, a known host fish species (Kneeland and Rhymer 2008).

As a group, freshwater mussels are found in a variety of environments throughout South Carolina, though the majority of targeted sampling efforts have occurred in wadeable streams. Many of South Carolina's species can be found throughout the Atlantic slope, but there are several species that are endemic to one or a few river drainages, see species profiles for more information. Furthermore, some species are endemic to only North and South Carolina or only to South Carolina and Georgia (Bogan and Alderman 2004, 2008).

Since the conservation plan for freshwater mussels of South Carolina was drafted nearly 20 years ago, substantial efforts have been made to survey mussels in the State by a variety of organizations including The Nature Conservancy, the USFWS, the South Carolina Department of Natural Resources, and private consulting groups. Many significant distribution records across the State have been accumulated because of these surveys, but comprehensive ranges of some species are still unknown (e.g., *Utterbackiana implicata*). During the "South Carolina Stream Assessment" from 2006–2013 (funded by a State Wildlife Grant (SWG)), freshwater mussels were recorded at 77 of 397 random stream sites in 17 ecobasins across the state. Although these records do not reflect the actual presence and abundances accurately because no standardized surveys were completed, they do provide useful distribution information and museum specimens that will be used by mussel specialists to reassess the taxonomy and conservation status of various species. In 2018, SCDNR began its Freshwater Mussel Program and employed a dedicated freshwater mussel biologist, with the primary focus being on the conservation and monitoring of the Federally Endangered Carolina Heelsplitter (*Lasmigona decorata*). Since 2018, the program has grown and, while it still focuses on the Carolina Heelsplitter, it also prioritizes species distribution data collection, life history research, and conservation and monitoring of all freshwater mussels within the state. From 2021-2024, the Freshwater Mussel Program completed a SWG grant "Occupancy and Distribution of SWAP Listed Freshwater Mussel Species" that prioritized conducting standardized freshwater mussel surveys across the State. A total of 45 sites were surveyed and collected occupancy data was used to update the Natural Heritage Database. Though these efforts aided in updating species occupancy within the State, more work is needed to fill distribution data gaps, unknown life history strategies, habitat preferences, and environmental and toxicological tolerances of freshwater mussel species in South Carolina.

Freshwater mussels are ecosystem engineers and have important roles and interactions with other freshwater species in numerous freshwater systems. Unfortunately, species throughout North America have historically faced many large declines due to commercial harvesting. Within the last 50 years, declines are largely associated with anthropogenic sources of pollution and habitat degradation, agriculture, habitat loss, invasive species, and climate change.

Challenges

There are many challenges regarding freshwater mussels in South Carolina, and additional challenges may be discovered as associated habitat, population range and trends, and species-specific threats are determined for unionid mussel species in the State. Some of the known challenges regarding freshwater unionid mussels in South Carolina include uncertain taxonomy and species' distributions, limited life history research, systemic exploitation and habitat destruction, invasive species, and climate change.

South Carolina is home to 30 recognized freshwater mussel species; however, the taxonomic identification of mussels to species can be difficult, and ongoing genetic research informs changes to species designations regularly. Like many taxa, freshwater mussel species were originally designated due to shell morphology and/or internal anatomy. Because of this, many species have been described as distinct or synonymized based on geographic variation and/or phenotypic plasticity of a single species. Phenotypic plasticity, in this document, refers to non-heritable variation of size, shape, and coloration of individuals due to environmental parameters such as, but not limited to, substrate, shear stress, stream size, water chemistry, etc., that the individuals interact with during life. Recent molecular data continues to reveal that speciation cannot be determined simply based on shell morphology but must consider shell morphology, internal anatomy, location, and genetic analysis before synonymy or species designations can be made (Zanatta and Murphy 2006; Raley et al. 2007; Kuehnl 2009; Smith et al. 2018; Whelan et al. 2023). Many of South Carolina's species' designations currently in use may change as more comprehensive, range-wide genetic analysis is completed, and this is likely to alter the presumed distributions of species which may lead to changes in conservation priorities.

Historical occupancy data in South Carolina is minimal and standardized surveys did not begin until 2019 which make determining short- and long-term population trends difficult, and the difficulty in identifying mussels has only added to the challenges of quantifying species' decline (e.g. *Elliptio producta*). Historic species identifications are often questioned, and the extent of a species' historic range is usually uncertain. Museum specimens are especially lacking in South Carolina because there is no state natural history museum, and collections are not in a centralized location or remain uncatalogued; however, there are several natural history museums in the eastern United States that contain mussel specimens from South Carolina. Mussel specimens collected during the South Carolina Stream Assessment and subsequent Mussel Program assessments (2006–2011, 2019-present) were deposited in the North Carolina Museum of Natural Sciences for long-term storage and for use by mussel specialists, but temporal gaps in data exist because surveys have not been conducted at regular intervals prior to 2019. Unresolved taxonomy of mussel species contributes further to the difficulty in making identifications. Taxonomic and systematic studies continue to be done on mussels in South Carolina, and over the next decade or two, additional species diversity will likely be known from the State because of these efforts.

Additionally, most freshwater mussel sampling by SCDNR has occurred in wadeable streams, and while this has aided in the collection of many occurrence data points, it does not provide comprehensive, range-wide distribution data for freshwater mussel species in South Carolina, especially for species that seem to prefer large river habitats. Effort is needed to target large, non-wadeable streams across South Carolina, particularly areas with historical occupancy of

highest conservation priority species outlined in the 2025 SWAP. Consequently, research is needed to determine the effects of impoundments on mussel species in large rivers, although pre-impoundment data may be minimal or nonexistent.

Another challenge regarding freshwater mussels in South Carolina is the lack of life history data. While the identity of the host fishes for more than half of South Carolina's mussels is now known (Bogan and Alderman 2004, 2008), most studies are laboratory trials and have not verified host usage in the wild, although some have (e.g. Kneeland and Rhymer 2008) and others have been attempted (e.g. Poelmann et al. 2023). Spawning and brooding cycles are also understudied for many species in South Carolina which would make propagation efforts, if needed, difficult. Oftentimes, spawning cycles are temperature-dependent, and without known temperature thresholds, management techniques cannot be suggested or implemented. Habitat preference data is also lacking for species within South Carolina, and unfortunately, streams continue to be degraded from anthropogenic sources making it difficult to determine pre-impact habitat preferences.

Historically, mussels have been used for a variety of commercial purposes including food resources for human consumption, pearl collection, and even button creation. In the mid- to late-1800s, harvesting mussels for pearls was common across North America and was initially sparked by the 1857 sale of a pearl collected from New Jersey for 12,500 francs, approximately $98,000, in 2024 US dollars (Dakin 1913). This led to harvesting of mussels almost to complete elimination in the north which forced pearl hunters south and west to continue collecting mussels (Kunz 1898). After the "first great pearl excitement," periodic accidental pearls collected from mussels resulted in "pearl rushes" that would last until the mussel beds in nearby streams were depleted (Kunz 1898; Dakin 1913; Sparks et al. 1990). Freshwater mussels were collected to near extirpation in some areas and harvesting mussels for pearls began to subside in the early 1900s due to low returns and increasing competition from the button industry which, unfortunately, did not slow mussel harvests (Kunz 1898, Haag 2012).

The modern shell button industry began in the 1890s and is largely credited to Johann Boepple, a German immigrant; however, shell buttons have been in literature as early as 1802 (Haag 2012). Shell camps were established along banks, and collected mussels were brought to camp, steamed open, had their shells removed, and then tissues were sifted through to find pearls which were still of value (Kunz 1898, Coker 1919). In 1902, it was estimated that 20,000 people were harvesting mussels from just the Mississippi River (Knott 1980), and in 1920 there were more than 2,600 boats used for mussel collection in Illinois (Danglade 1914). The industry peaked in 1916 with at least 196 factories in 20 states assisting with the manufacturing of buttons (Coker 1919, Claassen 1994). As was seen in the harvesting of pearls, mussels were once again exploited and nearly depleted around shelling camps and factories which forced harvesters to new areas. The shell button industry withered in the mid-1940s when the development and production of plastic buttons became popularized (Claassen 1985).

Today, there is still some demand for mussel shells for use in the pearl industry and large-scale harvests still take place, but not in the same sense as before. Now, mussel shells are harvested and sold to the pearl industry where the shells are ground into beads that are used to form the nucleus of cultured pearls (Williams et al. 1993). Large-scale commercial harvesting currently

does not occur in South Carolina, and it is unlawful to take, possess, transport, import, export, process, sell, offer for sale, ship, or receive native unionid mussels without a permit from SCDNR. Although illegal, some members of the public voluntarily reported using native mussels as fishing bait, human food, and pond maintenance.

In the last 60 years, large-scale harvesting has not been the primary cause of mussel diversity and abundance declines are largely due to an influx of anthropogenic impacts, invasive species, and more recently, climate change. Mussels are an indicator species and are often the first taxa to be affected when pollutants are present in streams. Freshwater mussels and snails represent the most sensitive taxa in the EPA's 2013 criteria for ammonia, which resulted in a reduction of the acute criterion for total ammonia nitrogen being listed (USEPA 2013). Unionid mussels represented the top 7 most sensitive species to ammonia compared to other species tested which included species of freshwater fishes, other freshwater mollusks, freshwater amphibians, and other freshwater invertebrates (USEPA 2013). Although among the most sensitive taxa, tolerances vary across species. As of 2013, only 17 species of freshwater mussels have had ammonia toxicity testing. Ammonia in freshwater systems is naturally occurring; however, it is a common toxicant introduced at elevated concentrations through effluent discharge and agricultural, industrial, and urban runoff.

Copper is another toxicant that is naturally occurring in freshwater systems in trace amounts (0.2-30µg/L; Bowen et al. 1985); however, it becomes toxic to some organisms at elevated levels. Like ammonia, copper is introduced to freshwater systems through anthropogenic and industrial inputs. Copper is found in many herbicides and algaecides and is a byproduct of mining, leather and metal production, and is found in runoff from copper bearings in industrial use (McKnight et al. 1983, Patterson et al. 1998). Copper toxicity testing using glochidia of 9 freshwater mussel species found that most 24-hour median effective concentrations (EC50s) for survival were <45µg Cu/L (Wang et al. 2007). More research is needed to determine acute and chronic lethal concentrations of copper and other pollutants to different species of unionid mussels.

Keller and Zam (1991) found through acute toxicity testing that juvenile paper pondshell mussels (*Utterbackia imbecillis*) were more sensitive than commonly tested fish and aquatic invertebrates to six metals (zinc, copper, chromium, nickel, cadmium, and mercury), with cadmium being the most toxic in both soft and moderately hard water. Mercury was also found to have significant negative effects on mussel growth (Beckvar et al. 2000). Keller and Zam (1991) noted that hardness had a major effect on metal toxicity to mussels (and other organisms), with metals becoming less soluble in hard waters as they form complexes with carbonates. Much of South Carolina has soft waters, lower pH, and low alkalinity which may increase the toxicity of metals in stream. Acidification also appears to have drastic effects on the survival and

Erosion and shell damage of an *Elliptio complanata* mussel that is still alive. Photograph taken by Ericah Beason, SCDNR.

shell structure of mussels (Fuller 1974). Many mussels in South Carolina that are collected are found with heavily eroded shells which weaken their protection against predation and environmental disturbances. Wang et al. (2017) found that in compiled databases for all freshwater species, one or more mussel species were among the four most sensitive species for alachlor, ammonia, chloride, potassium, sulfate, copper, nickel, and zinc. Unionid mussels have demonstrated a high degree of sensitivity to many inorganic toxicants; but unionid mussels, at least those on which toxicology tests were performed, were not among the most sensitive organisms to organic chemicals in acute exposures; however, chronic toxicity tests are needed (Wang et al. 2017). Although it is undeniable that freshwater unionid mussels are sensitive to common pollutants, toxicity testing is still needed to determine species-specific acute and chronic endpoints and behavioral and physiological effects from toxicant exposures.

Most pollutants enter freshwater systems due to anthropogenic and agricultural sources and this is exacerbated by increased runoff due to impervious surfaces (roads, buildings, parking lots, etc.), clearcutting of land that reduces contact time of runoff with vegetation, and disjunct or missing riparian buffers. A riparian buffer is the section of trees, woody plants, bushes, shrubs, grasses, and even downed vegetation adjacent to a waterbody that partially protects it from impacts from surrounding land use. Clearing riparian vegetation also destabilizes stream and riverbanks allowing excessive siltation and destruction of instream mussel habitat.

Siltation is the accumulation of fine particles in water bodies and historically results from clearing land for agriculture and development, mining operations, and dam construction. In South Carolina, observational data suggests that siltation is largely attributed to clearcutting land for pasture, housing developments, and mining operations. Like pollutants, the effects of siltation are exacerbated when impervious surfaces increase, cattle are allowed to enter streams, and sufficient riparian buffers are not maintained. Clearcutting in a substantial part of a watershed can also contribute to siltation due to exposed sediment and increased runoff even if a riparian buffer is maintained. The use of motor vehicles and allowing livestock 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, thereby harming species that require highly oxygenated water.

Most studies that discuss the impacts of sedimentation on unionid mussels are related to sudden sediment deposits like that seen in the creation of dams, dredging, and channelization. No studies have determined the direct effects on unionid mussels of slow deposition of silt, like that usually seen in free-flowing waters. In (1980) Marking and Bills found that mussels' ability to emerge from burial under sediment declined with increasing sediment depth from 5-25cm and mussels that did not emerge died. Responses varied across species. Ellis (1931) found >90% unionid mortality in the bottom of hatchery raceways which reportedly had slowly deposited silt, but the rate of siltation, water chemistry parameters, and "control" animal (mussels held above the bottom in wooden frames) mortality was not reported. Another study by Imlay (1972) found that mussels held in jars buried under 8-18cm of sediment did not reemerge from burial and many died; however, no controls were used. Although the sudden onset of several centimeters of silt is unlikely in free-flowing rivers, observation data (e.g. Stewart and Swinford 1995, Nicklin and

Balas 2007) suggest that over time, siltation in flowing waters can lead to increase embeddedness and changes in habitat which may lead to the decline of certain mussel species. In South Carolina, observational data show that many streams in urban areas are dominated by unstable sand which is not suitable habitat for most species of mussels as they become dislodged during high flows (Allan 1995, Gordon et al. 2004). Habitat alteration is not only seen in response to sedimentation but also direct habitat destruction from small (off-road vehicles in streams) to large scale (impoundments and channelization), and these have undeniable negative effects on unionid mussels.

The construction of impoundments directly and drastically alter sthe physical characteristics of a stream and shift the lotic (flowing) system into a lentic (still) one. When this occurs, riverine habitat is directly lost, species richness and abundance decline, and host fish assemblage and distribution is affected. Dam construction across the United States skyrocketed from the 1910s-1940s and river impoundments were constructed for water storage, hydroelectricity, navigation, and transportation. By the mid-1940s, thousands of dams were constructed, the Ohio River was canalized by 1929, and the upper Mississippi River and Tennessee River were completely impounded by 1940 and 1944, respectively (Haag 2012). The construction of impoundments causes the direct loss of riverine habitat and at least 12 unionid mussel species were directly eliminated by the construction of impoundments and an estimated 8% of all North American mussel fauna were lost because of habitat destruction (Haag 2012). After construction, impoundments that create deep reservoirs show shifts in mussel assemblages from lotic to lentic species and may lead to localized extirpation of riverine mussel species (Garner and McGregor 2001; Vaughn and Taylor 1999; Haag and Warren 2007). Lentic unionid mussel species display opportunistic life history strategies which allows them to quickly colonize lentic environments. Opportunistic mussel species typically have short life spans, fast growth rates, and high population growth rates; they are usually host generalists or use an impoundment-tolerant host fish species, may tolerate lower dissolved oxygen, and are adapt to finer sediments, all traits that are needed in unstable environments (Haag 2012). Haag and Warren (2007) found that across four habitats that represented a gradient from lotic to lentic habitats, mussel abundance and density were highest at lotic sites, and lentic sites were mostly inhabited by opportunistic mussel species. The shift in mussel species assemblage and abundance may not only be attributed to changes in habitat for mussels but also changes in habitat that affect the distribution of fish species, which can affect recruitment and distribution of unionid mussels. Impoundments do not only change the habitat which may affect fish species' presence, but they can directly impede fish migration which affects mussel distribution and range (Watters 1996, Eads et al. 2015).

Non-native, invasive *Corbicula* clams in Lake Marion, Orangeburg County, SC. Photo by Anna Smith, SCDNR.

There are several non-native species in South Carolina that can have negative impacts on unionid mussels, although their impacts and interactions have not been

directly studied in South Carolina. The Asian Clam (*Corbicula fluminea*) is an invasive freshwater bivalve that has spread throughout the United States (Benson et al. 2024b). *Corbicula* are small (< 50mm) bivalves that have distinct, concentric sulcations (ridges), and vary in color from pale yellow to almost black. *Corbicula* often co-occurs in large numbers with native mussels and may compete for food and habitat, but research suggests that *Corbicula* do not reach high densities in established, dense, adult unionid mussel patches (Vaughn and Spooner 2006b). Although small, *Corbicula* have much higher mass-specific filtration rates than unionid mussels and this could limit the available food for adult mussels, but the high metabolic demand for *Corbicula* could be why it cannot reach high densities in dense, adult native mussel patches (Vaughn and Spooner 2006b). *Corbicula* seems to have more negative effects on juvenile mussels through food competition, displacement of juveniles, siphoning juveniles and glochidia, and increasing ammonia above acute tolerance levels of juvenile mussels (Vaughn and Spooner 2006b). During the South Carolina Stream Assessment (2006–2011), *Corbicula fluminea* was recorded at 68 of 397 random stream sites in 21 ecobasins, and as of 2024, it remains widely distributed in all river basins in South Carolina. Research on the direct interactions and effects of *Corbicula* on mussel species in South Carolina is needed. Unfortunately, there seems to be no pre-invasion data to assess impacts on native populations in systems such as Lake Marion where *Corbicula* overwhelmingly dominates the benthos (B. Taylor, pers. comm.).

The Zebra Mussel (*Dreissena polymorpha*) was introduced into the United States and has become well established throughout the Great Lakes, Ohio, Upper and Lower Mississippi, and Texas Gulf drainages (Benson et al. 2024). Zebra Mussels are small (<50mm) and typically have a striped pattern on their shell. They differ from *Corbicula* by producing byssal threads which are used to attach to hard surfaces such as rocks, pipes, and even unionid mussel shells. Zebra Mussels are a much more problematic bivalve than *Corbicula*. Establishment of Zebra Mussels can cause the rapid decline of native mussels by competing for food and fouling unionid mussels which impedes locomotion, valve closure, and energy stores (Ricciardi et al 1998, Strayer 1999). Zebra Mussels have invaded nearby parts of Tennessee and may eventually spread into South Carolina, although the risk of them becoming established has been assessed as low due to unsuitable water chemistry, specifically low calcium concentrations, and lower pH (Cohen and Weinstein 2001, de Kozlowski et al. 2002). In 2021 and 2024, Zebra Mussels were found attached to Marimo Moss Balls (*Aegagropila linnaei*) in the aquarium trade and efforts were made to collect and dispose of all potentially contaminated moss balls. As of 2024, there are no known populations of Zebra Mussels in South Carolina.

In addition to invasive mollusks, the introduction of Red Swamp Crayfish (*Procambarus clarkii*) could also have negative effects on unionid mussels. Red Swamp Crayfish are native to the Mississippi drainage and were first observed in South Carolina in 1988 (Hobbs et al. 1989). While their effects on native mussels in South Carolina are unknown, a study by Covich et al. (1981) found that Red Swamp Crayfish preyed on juvenile *Corbicula* that were less than 6mm in length. Observational data also show crayfish feeding on the mantle tissues of exposed mussels in South Carolina, but this has not been formally documented. Additionally, non-native fishes such as Black Bullhead, Flathead Catfish, Blue Catfish, and Channel Catfish are known to feed on mussels (Forbes 1888; Edds et al. 2002; Grist 2002; Haag 2012), but the extent of their effects on mussel populations in South Carolina is unknown. Targeted effort is needed to determine the

interactions between native unionid mussels and non-native species in South Carolina and what potential threats they pose to the organisms themselves, or the habitat in which they exist.

Collectively, environmental instability and habitat alterations are two primary driving forces behind the continued decline of native freshwater mussels in South Carolina. Changes in the climate, such as increasing air and water temperatures and altered precipitation patterns, are likely to exacerbate such conditions. Climate change is the shift in climate patterns mostly caused by greenhouse emissions which cause heat to be trapped by the Earth's atmosphere. Both natural (e.g. forest fires, earthquakes, etc.) and human activities (e.g. energy production, industrial activities, etc.) are primary sources for greenhouse gas emissions (Yue and Gau 2018, Endenhofer et al 2014). Global warming is not expected to be uniform across space and time, rather warming will be substantially greater in many land regions and less in most ocean regions; regional seasons may be substantially warmer or cooler than global averages (Collins et al. 2013; IPCC 2018). Impacts of climate change are not limited to changes in temperature; other impacts include rising atmospheric CO_2, shifting rainfall patterns, rising sea levels, increased ocean acidification, and extreme floods, droughts, and heat waves (Lee et al. 2018, IPCC 2018). Climate change impacts that are most likely to impact freshwater mussel diversity, abundance, and distribution are increasing stream temperatures, extreme precipitation events (e.g. flood, drought, etc.), and sea level rise.

Freshwater unionid mussels are mostly sessile and are unable to escape detrimental habitat changes such as rising water temperatures and dewatering events. Rising water temperatures are associated with global climate change, altered precipitation and hydrology, land-clearing, and urbanization (Bates et al. 2008; Burlakova et al. 2011; Hester and Doyle 2011). Drought conditions exacerbate in-stream temperatures, and South Carolina regularly experiences drought conditions (Figure 1, https://www.drought.gov/) from abnormally dry (D0) to exceptional (D4), the most intense category.

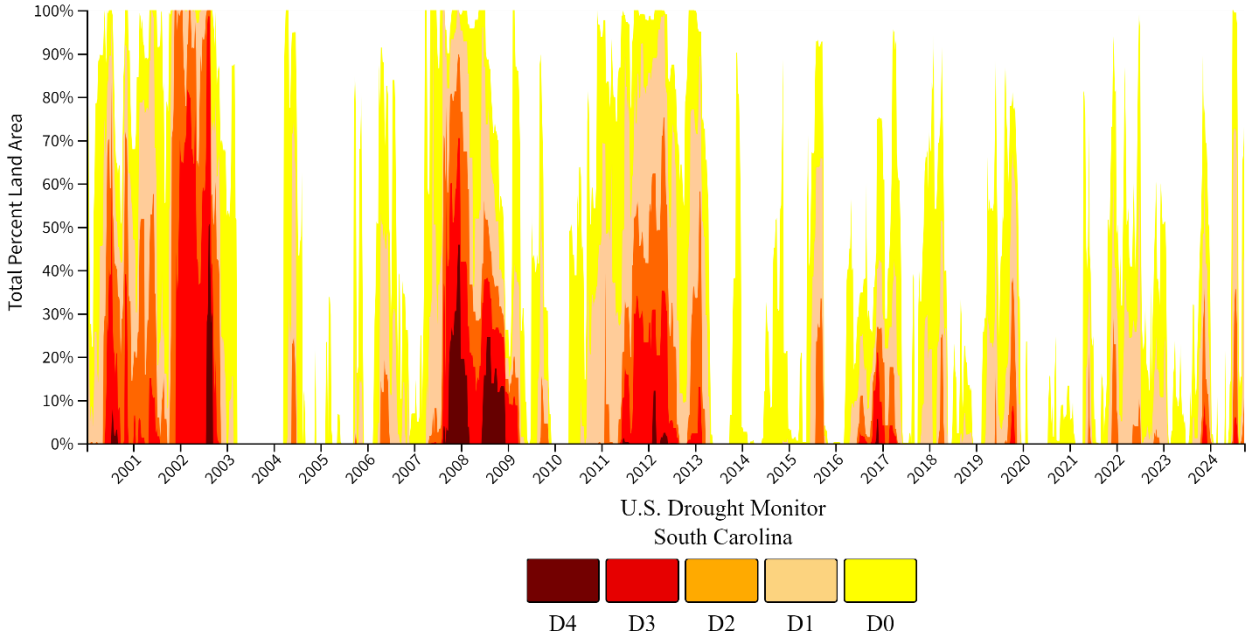
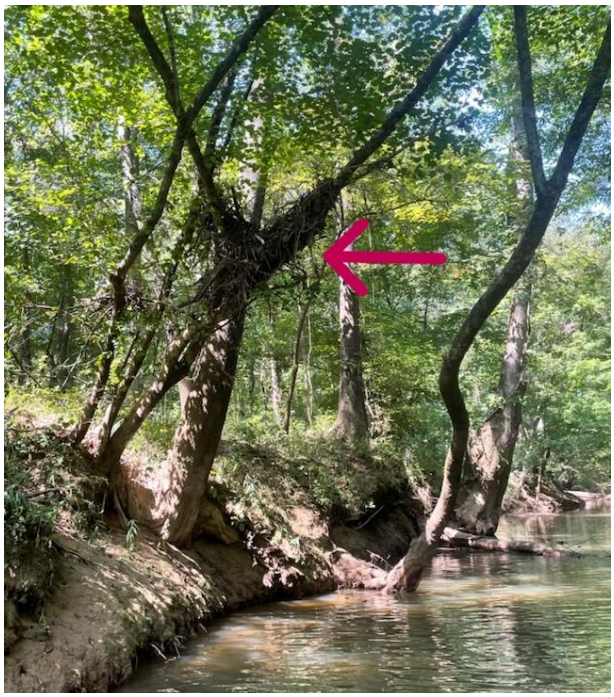


FIGURE 1: Graph of intensity of drought from U.S. Drought Monitor which is updated every Thursday by authors from NOAA, USDA, and the National Drought Mitigation Center, see Drought.gov for more details.

Freshwater mussel stranded during drought. Photo by Ericah Beason, SCDNR.

The effects of rising temperatures and drought conditions on native freshwater mussels are numerous and may be direct (e.g. mortality) or indirect (e.g. habitat loss). As of 2023, lethal thermal tolerance estimates have only been determined for ~10% of mussel species in the order Unionida; mean acute median lethal temperatures were 32.8°C/91.0°F for glochidia (19 species), 35.0°C/95°F for juveniles (13 species), and 36.3°C/97.3°F for adults (4 species) (Fogelman et al. 2023). Unfortunately, most studies do not determine the physiological responses and thermal tolerance of a species across its geographic range which vary across longitudinal gradients (Malish and Woolnough 2018, Fogelman et al. 2023). Water temperatures in South Carolina regularly exceed 30°C/86°F (USGS), and only 2 priority species in South Carolina have temperature studies completed on glochidia and juveniles. See Pandolfo et. al 2010 for *Alasmidonta varicosa* and Archambault et al. 2014 for *Lampsilis cariosa*, one priority species has a temperature study on adults (no glochidia or juveniles). See Galbraith et al. 2020 for *Strophitus undulatus*. Additionally, increased water temperatures exacerbate adverse effects of most pollutants (Cushway et al. 2024). Research on the effects and tolerances of temperature for mussel species in South Carolina is needed, especially studies that look at compounding effects due to other stressors and temperature (Fogelman et al. 2023, Cushway et al. 2024).



Debris caught in trees during high flow event in Sixmile Creek. Photograph taken by Ericah Beason, SCDNR.

The adverse effects of drought on native mussels are comprehensive, with effects ranging from individual mussels (e.g. mortality, behavior, physiology, etc.) to population responses and ecosystem services provided by mussels (Cushway et al. 2024). During standardized mussel surveys in South Carolina during periods of drought,

native mussels are regularly encountered dead from emersion due to reduced, or even non-existent flow. Drought conditions may also lead to concentrated pollutants, low dissolved oxygen, and altered habitat which have varying effects on native mussels (Cushway et al. 2024). Climate change impacts are not only likely to affect drought periods in South Carolina. The intensity and frequency of precipitation events are likely to result in more intense flooding, and like most threats to freshwater mussels, the effects of flooding are exacerbated by urbanization, inadequate riparian buffers, and excessive clearcutting of land. Due to their mostly sedentary lifestyle, native mussels can be buried, dislodged, or stranded during periods of flood, and some species may be more susceptible to stranding than others (Tucker 1996; Tarter et al. 2023). Small streams, like many of those found in South Carolina, are especially vulnerable to intense flooding and drought. During periods of drought or floods, mussels have been observed stranded in the floodplain and on sandbars. During sampling, debris stranded in trees from high flow periods in small streams is regularly seen 8-15ft above base flow. Stable habitat provides refugia from scour during floods and (Strayer 1999b, Hastie 2001), and burrowing behavior may aid in the stability of mussels during high flows (Schwalb and Pusch 2007). A singular flood event can have catastrophic impacts on mussels. For instance, in 1998, a historic flood in Scotland resulted in the conservative estimate of 50,000 mussels killed (Hastie et al. 2001). There have been no estimates of the amount of direct loss or displacement of mussels due to extreme drought or flooding in South Carolina.

Lastly, sea level rise and saltwater intrusion is another climate change concern in South Carolina as all freshwater unionid mussels, except for *Glebula rotundata*, are found strictly in freshwater. Salinity tolerance studies for unionid mussel species are minimal, and even less than that of thermal tolerance studies, with only ~5% of unionid species being evaluated (Johnson et al. 2018). Sea level rise has been largely attributed to thermal expansion, glacier melt, and ice sheet melt (Bindoff et al. 2007; Cazenave and Llovel 2010). As sea levels rise, saltwater will intrude upon freshwater systems which is likely to have adverse effects on freshwater mussels in South Carolina.

Conservation Opportunities

Thanks to genetic studies over the years, the 2025 SWAP includes 7 taxonomic name changes which are outlined in Table 1. Additionally, *Elliptio waccamawensis* was synonymized with *Elliptio congaraea* and *Elliptio hopetonensis* was added to the list of recognized species in South Carolina.

TABLE 1: Freshwater mussel scientific name changes since the 2015 SWAP.

Name as seen in 2015 SWAP	Name as it appears in 2025 SWAP
Anodonta couperiana	*Utterbackiana couperiana*
Anodonta implicata	*Utterbackiana implicata*
Leptodea ochracea	*Atlantichonca ochracea*
Ligumia nasuta	*Sagittunio nasutus*
Villosa constricta	*Venustachonca constricta*
Villosa modioliformis	*Villosa vibex*
Villosa vaughaniana	*Sagittunio vaughanianus*

There will continue to be changes in the knowledge of the freshwater bivalve fauna of South Carolina, including new records of both native species and non-native species, along with information on their life histories, habitat preferences, distributions, and threats and stressors which will collectively result in substantial changes to the list of SGCN.

Freshwater Snails

Freshwater snails are a diverse group of animals within the class Gastropoda (phylum Mollusca) and are broadly distributed worldwide. North America is of global importance, having one of the highest numbers of freshwater snail species recognized. In 2013, Johnson et al. completed a conservation assessment of 703 species of native freshwater snails from Canada and the United States, representing 16 families and 93 genera. Here they described that freshwater gastropods have 67 species (10%) considered likely extinct, 278 (40%) endangered, 102 (15%), threatened, 73 (10%) vulnerable, and 26 (4%) have uncertain taxonomic status. This makes 74% of the entire fauna imperiled, exceeding levels of fishes (39%), crayfishes (48%), and even bivalves (72%) by a small margin. The remaining 157 of North American species, only 26%, are considered stable.

Freshwater gastropods are an important component in their aquatic ecosystems; most feed on periphytic and epiphytic algae and biofilms (Covich et al. 1999). In some habitats, freshwater gastropods may be the principal grazers and are capable of significantly influencing algal primary production; others are suspension or deposit feeders, capturing and resuspending nutrients in the water column (Brown and Lydeard 2010). Furthermore, snails historically were and presently are important food sources for fishes, turtles, birds, and muskrats (Johnson et al. 2013).

Campeloma decisum in the Waccamaw River in Horry County, SC. Photo by Keith Bradley, SCDNR.

In South Carolina, as of the 2023 Freshwater Mollusk Conservation Society (FMCS) gastropod names list, a total of 45 species are recognized to potentially occur in the State; however, 8 are non-native to South Carolina and 2 need to be genetically confirmed. The bulk of observations which lead to species recognition in South Carolina came from Burch and Tottenham (1980), placing the species in South Carolina, or Dillon et al. (2019) reporting observations from 1952-2019. In recent years, efforts have been made to survey and identify snails in the state by Dr. Robert T. Dillon, Jr. and colleagues, private consulting groups, and the South Carolina Department of Natural Resources. During the South Carolina Stream Assessment (2006–2011), freshwater gastropods were recorded at 50 of 397 stream sites across the State. In addition, more collections were made as part of other research projects. Identifications were made possible with the kind assistance of

Robert Dillon. *Campeloma decisum* was the initial identification given to the snail specimens collected most often and in greatest abundance, but that species is not recognized by FMCS (2023) to occur in the southern Atlantic slope. *Campeloma limum* is the species recognized to occur in South Carolina, and collected specimens were likely this species but verification is needed. Although these records do not reflect the actual presence and abundances accurately because no targeted surveys for gastropods were conducted, they do provide useful distribution information and museum specimens that can be used for taxonomic or biological studies.

All SCDNR snail records were provided to Robert Dillon for inclusion in the web-based Freshwater Gastropods of North America. Gastropod specimens from the South Carolina Stream Assessment were deposited in the North Carolina State Museum of Natural Sciences for long-term documentation and so that the specimens can be used for morphological and genetic research that will contribute a better understanding of the diversity of gastropods in South Carolina. In 2023, the Freshwater Mussel Program at SCDNR began collecting voucher snail specimens at freshwater mussel stream survey sites and vouchers will be deposited at the North Carolina State Museum as well.

Recently, the taxonomy of freshwater snails in South Carolina has received some attention, resulting in the description of a new species, *Physa carolinae*, which occurs in Georgia, South Carolina, North Carolina, and Virginia (Wethington et al. 2009), but substantial genetic work is still needed, see data deficient snail guild for more.

Challenges

To date, there have been no known standardized surveys for freshwater snails in South Carolina, and most surveys have been completed by one group of individuals. The lack of knowledge and information about life histories, habitat requirements, and current distributions for freshwater snails represents the most significant challenge. There are also challenges that lie solely in creating a standardized survey for snails as species are found in a variety of habitat types from swift riffles to moist leaf litter on land but near freshwater. Additionally, many species have patchy distribution and very specific microhabitat requirements that can be overlooked when sampling at a large scale. Other sampling concerns in South Carolina lie in the unfavorable survey conditions of some species' preferred habitat. Some species are often found in swamps which are difficult to navigate and pose additional challenges due to mosquitos, alligators, and deep, soft mud that is can be dangerous to traverse. The lack of sampling and collection of vouchers in South Carolina makes determining species' distributions and short- and long-term population trends difficult.

Like freshwater mussels, nomenclature and uncertain taxonomy pose a specific challenge when placing observation records in South Carolina. The South Carolina SWAP aims to provide a framework for the conservation of species with the greatest need for conservation in the State; however, it proves difficult to place a conservation ranking on species with minimal data. Because of this, 9 species representing 6 families are given a data deficient conservation ranking, highlighting the need to prioritize collection of baseline data.

Like other aquatic organisms, freshwater gastropods are largely threatened by rapid habitat changes due to anthropogenic development, inputs, degradation, or modifications. Johnson et al.

(2013) point to habitat destruction in medium and large rivers as the primary cause for most extinctions of highly endemic species (those occurring in a single lake, stream, or spring), citing damming and channelization (45 species, 67% of total), drainage or diversions of lakes (8 species, 12%), alteration of springs (4 species, 6%), and potential effects of exotic fish introduction (2 species, 3%).

Siltation of streams and rivers through agricultural runoff and erosion of unstable streambanks appears to be another main threat to freshwater snails (Dillon and Keferl 2000). Siltation is the accumulation of fine particles in water bodies and historically results from clearing land for agriculture and development, mining operations, and dam construction. In South Carolina, observational data suggests that siltation is largely attributed to clearcutting land for pasture, housing developments, and mining operations. The effects of siltation are exacerbated when impervious surfaces increase, cattle are allowed to enter streams, and sufficient riparian buffers are not maintained. A riparian buffer is the section of trees, woody plants, bushes, shrubs, grasses, and even downed vegetation adjacent to a waterbody that partially protects it from impacts from surrounding land use. Clearcutting in a substantial part of a watershed can also contribute to siltation, even if a riparian buffer is maintained due to exposed sediment and increased runoff. The use of motor vehicles and allowing livestock (e.g. cows) 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, thereby harming species that require highly oxygenated water.

Collectively, environmental instability and habitat alterations are two primary driving forces behind the continued decline of freshwater snails in North America, and changes in the climate such as increasing air and water temperatures and altered precipitation patterns are likely to exacerbate such conditions. Climate change is the shift in climate patterns mostly cause by greenhouse emissions which cause heat to be trapped by the Earth's atmosphere. Both natural (e.g. forest fires, earthquakes, etc.) and human activities (e.g. energy production, industrial activities, etc.) are primary sources for greenhouse gas emissions (Yue and Gau 2018, Endenhofer et al 2014). Global warming is not expected to be uniform across space and time, rather warming will be substantially greater in many land regions and less in most ocean regions; regional seasons may be substantially warmer or cooler than global averages (Collins et al. 2013, IPCC 2018). Impacts of climate change are not limited to changes in temperature; other impacts include rising atmospheric CO_2, shifting rainfall patterns, rising sea levels, increased ocean acidification, and extreme floods, droughts, and heat waves (Lee et al. 2018, IPCC 2018). Climate change impacts that are most likely to impact freshwater snail diversity, abundance, and distribution are increasing stream temperatures, extreme precipitation events (e.g. flood, drought, etc.), and sea level rise.

Conservation Opportunities

There will continue to be changes in the knowledge of the gastropod fauna of South Carolina, including new records of both native species and non-native species, along with information on their life histories, habitat preferences, distributions, and threats and stressors which will collectively result in substantial changes to the species of greatest conservation need.

Crayfishes and Freshwater Shrimps

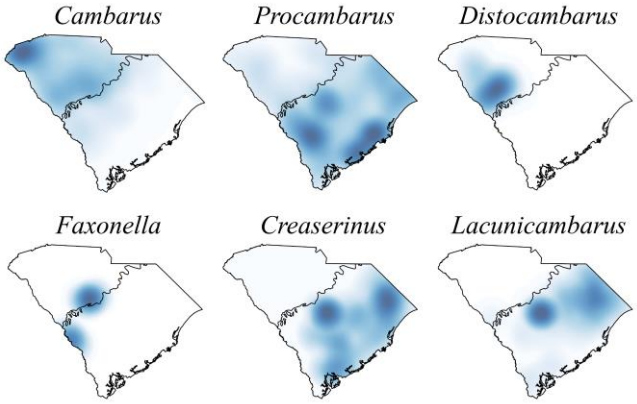


FIGURE 2: Heat maps showing dominant collection areas for the six crayfish genera known from SC.

Decapod crustaceans, including crabs, lobsters, crayfishes, and shrimps, are found across the State of South Carolina from coastal waters to upland habitats. As compared to marine-oriented crustaceans like crabs, lobsters, and penaeid shrimps, other major groups of decapod crustaceans such as crayfishes, river shrimps, and grass shrimp are often associated with freshwater environments but can also be found from estuarine waters near the coast to underground burrows in the mountains. These inland species represent an important component of South Carolina's biodiversity and are critical to the State's various ecosystems. For example, the southeastern United States is a global hotspot of crayfish diversity with >350 native species (Richman et al. 2015) with South Carolina home to at least 39 native species across 6 genera (Figure 2) and at least two non-native crayfishes. Many crayfish have limited ranges, leading to high rates of endemism for this group. Additional decapod crustaceans in South Carolina include caridean shrimp in the family Palaemonidae (e.g. *Palaemon* and *Macrobrachium*). The eastern grass shrimp *Palaemon paludosus* occurs throughout the Coastal Plain of South Carolina. Six river shrimps in the genus *Macrobrachium* occur in estuarine and freshwater rivers of the United States (Bowles et al. 2000) with two native species found in South Carolina. River shrimps spend most of their life cycle in freshwater rivers and streams, but adult females migrate to estuaries to spawn their eggs since larval development requires more saline conditions (Rome et al. 2009).

Decapods play several important ecological roles in inland aquatic habitats. They make up a large portion of the invertebrate biomass and represent a critical nexus of aquatic food webs as they feed on algae, detritus, or small animals while also serving as prey for higher trophic levels including several game fish species, migratory and wading birds, and mammals (Probst et al. 1984; Rabeni 1992; Roell and Orth 1993). Some South Carolina snakes, such as Crayfish Snakes and Queen Snakes, for example, rely heavily on crayfish as 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 crustaceans are poorly understood. New species are frequently being discovered and existing species are often reclassified. In fact, multiple species on South Carolina's SGCN list warrant, or are currently undergoing, taxonomic work (Kendrick and Williams, *In Review*). Much less is known about the abundance, distribution, and taxonomy of river shrimps and grass shrimp, so additional concerted efforts are needed to better understand their conversation status (Cooper 2011).

Historically, the conservation of crustaceans has received little attention by regulatory agencies; however, there has been some progress over the past decade. In 1996, the American Fisheries Society considered 65 species (19.2%) of North American crayfish as endangered, 45 (13.3%) as

threatened, and 50 (14.8%) as special concern (Taylor et al. 1996). In 2007, updates to the previous assessment resulted in nearly the same composition with 66 species (18.2%) of North American crayfish as endangered, 52 (14.3%) as threatened, and 54 (14.9%) as special concern (Taylor et al. 2007). Listing with the American Fisheries Society does not give species any protection. The USFWS website currently lists the following six species known from South Carolina as 'USFWS Focus' species: *Distocambarus carlsoni, Distocambarus youngineri, Cambarus spicatus*, *Procambarus echinatus*, *Cambarus strigosus*, and *Procambarus lepidodactylus*.

Commonly thought to inhabit strictly aquatic environments, crayfish can utilize a variety of habitats. All species rely on water for reproduction, but many burrowing species 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, while others inhabit streams, small lakes, or temporary ponds, occasionally digging terrestrial burrows during dry periods. Hobbs (1981) distinguished crayfish as primary, secondary, or tertiary burrowers. Primary burrowers spend almost their entire lives in the burrow. Secondary burrowers spend much of their lives in a burrow but may move to open waters during rainy periods. Tertiary burrowers live primarily in open water but may move into a burrow to escape frost or drought and when brooding eggs. The habitat requirements of many species, particularly primary burrowers, are not well understood, but research has been underway in South Carolina to better understand requirements.

Challenges

There are a number of potential challenges to both crayfishes and river shrimps. It is, however, 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 all of these species. However, complex life histories (e.g. Macrobrachium moving between fresh and salt water to spawn), small endemic ranges, and a variety of habits and habitats (e.g. crayfish burrowing habits) make studying these underrepresented species difficult. Genetic and taxonomic work is particularly important where there are questions regarding classification because misidentification can obscure the presence of rare species in need of conservation. The case of the Keeowee Crayfish (*Cambarus* sp. nov. "B" cf. *longirostris*), which was mistaken for an introduced species, is an excellent example. It has previously been treated as an introduced population of *C. longirostris* in South Carolina (McLaughlin et al. 2005, Taylor et al. 2007), and as of October 2023 this species remains undescribed. Formal description of this species is sorely needed to ensure its conservation status.

The arrival of introduced species is probably the greatest challenge to these crustaceans (Lodge et al. 2000a,b). The ranges and abundances of many native crayfish may have been reduced by invasive crayfish, both in the United States and in Europe (Lodge et al. 2000a; Hobbs et al. 1989). In Europe, crayfish introduced from the Southeastern US are responsible for the spread of crayfish plague to native European 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 waters draining into the Gulf of Mexico into waterways throughout South Carolina, with concurrent declines in native crayfishes (Kendrick et al. 2024). Potential negative effects of its introduction include the spread of fungal diseases, helminth parasites for which this species is an intermediate host (Hobbs et al. 1989, Rothman et al. 2024), and viruses that can broadly infect many decapod crustaceans (Sasson et al. 2024). In South Carolina, *P. clarkii* has been collected at sites at which native crayfishes were present in some cases and absent in others (Poly 2007, Kendrick et al. 2024). Several sites in North Carolina that once had native species of crayfishes now have only *P. clarkii* (Cooper and Armstrong 2007), suggesting that *P. clarkii* has also possibly displaced native taxa in that state.

The Bristled River Shrimp, *Macrobrachium olfersii*, is native to Central and South America (Holthuis and Provenzano,1970), but has been introduced to South Carolina with unknown impacts on native species (Cooper 2011). The Virile Crayfish *Faxonius virilis* and the Rusty Crayfish *Faxonius rusticus* have been widely introduced outside of their native Midwestern US states (Hobbs et al. 1989). The Virile Crayfish is now known to occur in the Catawba River of South Carolina, with potential deleterious impacts on native fauna as well as unknown impacts on the iconic Spider Lily, *Hymenocallis coronaria*, that grows expansively on shoal outcrops in this river system. The Rusty Crayfish has been reported from the upper Broad River drainage in North Carolina (Cooper and Armstrong 2007) and possibly could spread downstream into South Carolina. Several shipments of crayfishes to South Carolina schools for educational use have contained Rusty Crayfish (W. Poly, pers. obs.).

Prevention of future introductions is most likely the only effective way to deal with the challenges caused by non-native crayfish. No methods for eliminating invasive species without also harming native species are currently available. Even if effective biological control methods are developed, preventing introductions will still be much easier than eradicating an established species. Other non-native crayfishes and shrimps have also been introduced into South Carolina. *Cherax quadricarinatus*, *Macrobrachium rosenbergii*, *Macrobrachium nipponense* were introduced to South Carolina for aquaculture (Smith et al. 1978; Brummett and Alon 1994; Procopio and Daniel 2024). While these species do not appear to have become established in the wild, additional sampling is needed, especially for *M. nipponense*.

Some species, such as *Cambarus* sp. nov. "B" cf. *longirostris*, have been eliminated from parts of their range because of damming activities associated with reservoir construction of upstate systems, while damning of large Coastal Plain rivers has likely had negative impacts on river shrimps that make catadromous migrations from large rivers to estuaries for spawning. Channelization and dredging can also be very detrimental to aquatic crayfish that require rocks, crevices, or tree roots along undercut banks as hiding places (Hobbs and Hall 1974).
The most serious known challenge to terrestrial burrowing crayfish is the alteration of soil hydrology. These species occur in association with some agricultural fields, timber harvest practices, and roadside ditches, but it is unclear how soil manipulations may have impacted some populations. 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.

These crustaceans are harmed by a variety of insecticides, herbicides, and industrial chemicals (Eversole et al. 1996). Juvenile crayfish are generally about four times more sensitive to water-borne pollution than adults; early instars are about three times more sensitive as juveniles (Eversole and Sellers 1996). There is little knowledge of the differences in sensitivity to toxins among species. Nutrient enrichment is less likely to harm crayfish than other aquatic life because they are omnivorous and can act as scavengers as well as primary and secondary consumers. Hobbs and Hall (1974) noted several casual observations in which crayfish were 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. Additional work is needed to understand pollution tolerances of river shrimps.

Conservation Opportunities

Crayfishes are in need of additional assessments to determine their distribution, abundance, and life histories so that effective conservation strategies can be applied in a way that will have the most direct impact on these species.

Freshwater Sponges

Freshwater sponges are found in diverse environments including fast flowing and deep rivers, shallow (<3 cm deep) streams, or slow flowing ponds and ephemeral wetlands. Species grow on both natural (rock, vegetation roots and stems, live and dead wood) and artificial (plastic and wooden docks and pilings) substrates. Sponges are found near the surface and down to a depth of approximately 10 cm. Species are generally found in clear water but have also been found in turbid waters, though rarely. They have been identified at sites both distant from and near human development and pollution. Members of this group are widespread within both the Coastal Plain and Coastal Zone Ecobasins.

A freshwater sponge clings to the underside of a rock in Turkey Creek, Edgefield, SC. Photo by Keith Bradley, SCDNR

Challenges

Sponges as a group are not threatened globally, but freshwater sponges may be at increased risk due to pollution and temperature fluctuations, as well as habitat destruction. Observations suggest that adult sponges die off at some sites in South Carolina during high temperatures in the summer. Following these mortality events, sponge gemmules (asexual

buds) are left behind on the substrate to "hatch" into sponges again once environmental conditions are favorable. In many cases, these gemmules are embedded in a tough, resin-like structure underneath the adult sponges. Although little is known about these die-offs in South Carolina, it is possible that they may become more frequent under future climate change and that sponges will rely on gemmules more frequently to overcome these environmental challenges. [Chris Freeman, pers. comm.]

Conservation Opportunities

There are no known conservation accomplishments pertaining to freshwater sponges, but any initiatives that protect wetlands and maintain water quality are likely to protect habitat for these organisms. Several recommendations would improve our understanding of this group. For example, determining the role of freshwater sponges in nutrient and organic matter cycling in freshwater systems in South Carolina would be beneficial. Establishing baseline growth rates for dominant species is also needed. The use of freshwater sponges by aquatic insects (particularly the use of sponges by insect larvae) needs to be assessed. Reproductive cycles and seasonality of freshwater sponges and their use of gemmules to survive high or low temperatures or other disturbances should be examined. Wetlands should be protected from human development or other anthropogenic impacts that might destroy sponge habitat or contribute to pollution.

Leeches

Leeches (Phylum Annelida; Order Hirudinida) occur in a diversity of freshwater, marine, and terrestrial habitats. They are key components of ecosystems in which they reside, serving as detritivores, predators, or ectoparasites. Leeches are indicators of water quality and wetland health but may also play a role in the transmission of pathogens among hosts. Much of our understanding of leech diversity in South Carolina is rooted in work done over 40 years ago (e.g. Sawyer 1972; Sawyer and Pass 1972; Sawyer et al. 1975; Sawyer and Shelley 1976; Sawyer 1979). The 2015 SC State Wildlife Action Plan reported 25 leech species known to occur in South Carolina and, while that number remains approximately the same, recent surveys (Moser et al. 2017, 2022; B.W. Williams unpublished) integrating molecular, morphological, and ecological data, have begun to substantially revise our understanding of leeches in the Southeastern US.

Challenges

Among the largest challenges to the conservation of leeches is a lack of basic understanding of the taxonomy and distribution of species. Despite how common they are in aquatic habitats, leeches are difficult to encounter in targeted surveys and are most frequently found opportunistically. Furthermore, they are often overlooked by field biologists focused on other taxa, including hosts. As such, most leech species in South Carolina are known from only a handful of localities at best. This dearth of sampling presents a challenge to understanding the basic ecology of leech species, including host preference (for ectoparasites) and in turn, the potential for host health. Many leech species are taxonomically challenging; this is particularly true for the genera *Erpobdella* and *Helobdella*. In addition, ontological variation occurs among and within species such that misidentification is common. These taxonomic difficulties are compounded by the admittedly onerous and slow manner by which leeches should be fixed for

ideal identification purposes; leeches placed directly into fixative tend to curl tightly, making morphological identification very tricky, if not impossible.

Conservation Opportunities

The conservation of leeches is inextricably linked to the conservation of their habitats and, for the ectoparasitic species, their hosts. This means that furthering our understanding of leech diversity, distribution, and ecology serves as a critical umbrella that covers numerous other taxa. To do so will entail a highly collaborative effort among herpetologists, aquatic biologists (both freshwater and marine), and other folks who may encounter leeches in their work, either free-swimming or on host taxa. Collection of leech specimens with sufficient locality information is foundational to every other aspect of the conservation of these worms.

Marine Fishes and Invertebrates

Atlantic Ribbed Mussels at Cape Romain NWR. Photo by WDPM field trip participant.

Most marine fishes and invertebrate species have rather broad geographical distributions that extend outside of South Carolina's jurisdictional boundaries to the north or south and/or offshore, outside of the 3-mile (4.8 km) state territorial limit and in some cases outside the United States EEZ (200 miles) off the coast. Many species—particularly marine and diadromous fishes—are highly migratory, and some occur in state marine waters or federal waters off South Carolina 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.

American Horseshoe Crabs congregate to spawn along South Carolina Beaches.
Photo by SCDNR-MRD/MRRI staff

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. Further, 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.–

Challenges

There are a number of 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. In some cases, regional management organizations (South Atlantic Fisheries Management Council, Atlantic States Marine Fisheries Commission) are currently conducting stock assessments to determine the health of the populations.

One of the major challenges to marine organisms in South Carolina is the degradation and loss of habitat. As rapid human population growth, coastal development, and urbanization occur along the coast, marshes, beaches and water bodies are altered in ways that change both the 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 juvenile stages 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 the disposal of dredged material. These types of habitat alterations are particularly detrimental to benthic fishes and invertebrates.

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

Several marine fishes may be adversely affected by fishing pressure. Many marine fishes are not managed as either commercial or recreational species but are targeted by recreational fishermen. If left unchecked, such fishing pressure can reduce population abundances. Many species of finfish and invertebrates are harvested as by-catch in commercial fishing operations. Even if alive when discovered and released, many animals can die due to stress or physical damage sustained during harvest. Some of South Carolina's priority species, such as Sheepshead (*Archosargus probatocephalus*), are often caught as by-catch.

SCDNR's Marisa ValeCruz tags Atlantic Blue Crabs for a SC Sea Grant Consortium-funded project that will help researchers learn more about the species' movement patterns within the Charleston estuary. Photo on left by Hailey Murphy, SC Sea Grant Consortium; photo of crab on right by SCDNR-MRD/MRRI staff.

Unregulated harvest threatens some marine species. For example, South Carolina does not currently regulate a commercial Cannonball Jellyfish fishery. This species is a major component of endangered sea turtles' diets; however, this fishery does exist in other portions of the cannonball's range. Asian countries are developing fisheries management plans to conserve jellyfish because populations are unstable or declining due to pollution, overfishing, or climate

change. Consequently, dealers are looking for new sources of jellyfish (Hsieh et al. 2001). Interest in Cannonball Jellyfish from the United States increased recently because of high consumer demand in Asia (Hsieh et al. 2001). Rising demand in Japan and Southeast Asia may create an international market for Cannonball Jellyfish from South Carolina coastal waters. Likewise, some marine species are collected for the aquarium trade; many of these collections are also unregulated.

Non-native invasive species also have the potential to negatively affect native populations of marine finfish and invertebrates either directly (through predation or the transmission of disease), or indirectly (through competition for resources, such as food and space). On an ecosystem level, the introduction of non-native species is one of the major causes of decreased biodiversity (*e.g.* Molnar et al. 2008). Examples of introduced marine organisms include the Indo-Pacific Lionfish (*Pterois volitans/miles*) and the Asian Tiger Shrimp (*Penaeus monodon*).

Non-native, invasive Lionfish in a South Carolina reef.
Photo by SERFS survey personnel.

As the climate changes and becomes warmer, oceans are warming and becoming more acidic. Stressed by these environmental conditions, marine fish and invertebrates may experience decreases in reproductive success. Further, outside the long-term warming trend, incidences of marine heatwaves may have an outsized effect on stock productivity if it leads to increases in natural mortality and/or declines in productivity. Additionally, parasite loads on fish may increase. It is also expected that with climate change and increased temperatures, some species will increase their geographic range northwards in a phenomenon known as 'Caribbean creep' with such range expansions and/or contractions now becoming common. The outcome of the interactions between these new invaders and native communities are difficult to predict but based on precedents have the potential to be negative.

Conservation Opportunities

The numbers of marine species—both fishes and invertebrates—that can be found within the boundaries and/or jurisdiction of South Carolina is vast. Prior to beginning the process of preparing South Carolina's conservation strategy, lists for these taxonomic groups did not exist. Development of completed species lists for these taxa represent a major accomplishment for the SCDNR. Opportunities exist for further study of life histories, genetics, habitat usage, threats and stressors for these species.

Conservation opportunities for marine fishes and invertebrates varies depending on the aquatic system(s) used by individual species. This is in respect to both the types of marine water used (estuarine, coastal, open ocean) as well as the portion (e.g. benthic, mid-water, surface) of water column used. As such, the techniques used to conserve species of greatest conservation need

must be able to adapt to the different challenges imposed and the opportunities afforded in specific systems and habitats.

Often the most readily apparent conservation opportunity are techniques designed to mitigate habitat loss and degradation in estuarine and coastal ocean environments. This is particularly important to species reliant on benthic or highly structured habitats often associated with salt marshes and/or intertidal oyster reefs. These habitats are often those most immediately impacted by local development and shoreline hardening. While it is unlikely coastal development will significantly slow or stop in the near-term, techniques such as the promotion of the use of living shorelines *in lieu* of bulkheads and sea walls to control coastal erosion and the enforcement and use of riparian buffers along coastal properties are of great benefit. Further, the direct acquisition and/or placement of conservation easements on adjacent upland areas restricting development should be promoted. This is particularly important when considering the impacts of sea level rise and its potential impacts to coastal South Carolina salt marsh habitats. Historically, South Carolina's salt marshes adapted to sea level rise by migrating inland or through sediment accretion that increased their elevation in step with rising sea levels. These processes are reliant on having the upland space to be able to migrate naturally or sufficient sediment supplies to the localized area to support accretion rates sufficient to offset sea level rise.

Opportunities also exist to promote the development and rebuilding of intertidal oyster reefs throughout coastal South Carolina. Oyster reef habitats are used by many marine fish and invertebrates identified as species of greatest conservation need during at least portions of their life stage. Further, fringing oyster reefs act as a natural buffer to coastal South Carolina salt marshes, reducing erosion rates due to wave action and coastal storms. Research suggests that appropriate substrate, not oyster spat recruitment, is often the limiting factor controlling the placement, size, and rate of expansion/contraction of oyster reefs in appropriate habitats along coastal South Carolina. As such, programs promoting the responsible harvest of oysters along the coast, the recovery and placement of harvested shell back into estuarine waters, and construction of alternative substrates for oyster spat recruitment should be a high priority. This should be coupled with ongoing research on techniques and materials most suitable for the creation and expansion of oyster reefs in different estuarine environments.

Beyond habitat loss and habitat degradation, an additional major concern facing marine finfish and invertebrates are declines in water quality. While there are local drivers impacting water quality, such as nutrient runoff leading to eutrophication of estuarine waters, tackling this driver is much more nebulous than direct habitat loss owing to the impacts of local development coupled with the upstream impacts affecting freshwaters throughout the State. This implies a concerted effort must be made to work with both local and upstream watershed municipalities to implement sound management plans with respect to waste water treatment including both sewer and septic systems, ground water and surface water withdrawals, proper application of riparian buffers in both agricultural and urban areas, and upstream impoundment flow regimes. Each of these can lead to declines in estuarine and coastal ocean water quality, whether it be the effects of saltwater intrusion, due to altered riverine flows, groundwater/surface withdrawals, changing riverine flow regimes, or the effects of eutrophication leading to lower dissolved oxygen and harmful algal blooms due to nutrient inputs both locally and upstream through agricultural and development practices.

Related to degradation in water quality, all marine systems are currently threatened because of the impacts of contaminants of emerging concern. Such contaminants of emerging concerns include per- and polyfluroalkyl substances (PFAS), micro- and nanoplastics, marine debris, estrogen-like compounds, and water soluble pharmaceuticals. While some of these, like PFAS, are likely to impact more benthic-dominated food webs, evidence suggests many can affect a wide range of marine habitats ranging from estuarine benthic habitats to offshore pelagic habitats. As in many cases, these are emerging threats so research is needed to investigate the potential impacts on marine fish and invertebrates and to assess the fate of these compounds in aquatic ecosystems. Such information is critical for conducting ecological risk assessments and ultimately understanding potential human health impacts. At the same time, it is imperative we work with local and regional municipalities, governments, and agencies to mitigate the impacts and sources of these contaminants to marine environments through sound policy and enforcement of such policies.

Climate change, and its resultant impacts on the productivity and spatial distribution of marine finfish and invertebrates is another conservation opportunity to highlight. One aspect of the impacts of climate change was discussed previously concerning habitat degradation and loss due to sea level rise. Beyond that, climate change is set to pose a more insidious threat to marine environments through long-term changes in temperature and salinity patterns, the more acute effects of marine heatwaves, and predicted increases in climate variability along coastal South Carolina. While long-term changes in temperature and salinity patterns may be overcome for some non-sessile organisms by their ability to move, this inevitably will lead to species range expansions and hence conflicts with native species, the consequences of which are hard to predict. Such range expansions are already occurring, with several sub-tropical species (e.g. Common Snook, Atlantic Tripletail, Tarpon) typically rare in South Carolina becoming more abundant and competing with native species. At the same time, increasing ocean temperatures and changing salinity patterns are leading to phenological shifts in the timing of ecological events (e.g. spring phytoplankton blooms) likely to affect the productivity of higher trophic levels. More insidious is the effects of marine heatwaves and increased intensity of storms and their long-term effects on marine ecosystems and productivity of SGCN. In both cases, the impacts of relatively short—but highly abnormal—thermal and precipitation patterns may have a more direct effect on marine systems through higher natural mortality, altered spawning behaviors, or decreases in natural ecosystem productivity. Such effects are becoming more evident, with one example being the effect of intense precipitation events during and after the Red Drum spawning season can have on recruitment. While it will not be possible to halt the effects of climate change, studies are needed to better understand and predict its effects on coastal South Carolina marine finfish and invertebrates of greatest conservation need.

A unique conservation opportunity for marine finfish and invertebrates relative to many of the other species identified in this document is our ability to address the direct removals of these organisms from the environment through human harvest. Unlike many of the other organisms identified, many marine species still support commercial, recreational, and subsistence fisheries with commercial and subsistence fisheries (either fish or invertebrates) being one of the last large-scale wild sources of meat protein to feed the human population. In contrast, most wild populations of terrestrial and freshwater organisms no longer support the bulk of the protein need

for humans with the primary terrestrial and freshwater sources being derived from farming activities (e.g. poultry farms, cattle farms, freshwater aquaculture). While it is unlikely interactions of these organisms via fisheries will disappear, there is the opportunity to work at the local, state, regional, and national level to address overfishing of these resources and to adapt these fisheries due to changes in ecosystem productivity. To this end, we need research to evaluate the impact fisheries have had on these resources and ecosystems historically, the socio-economic impacts of the current fisheries, the historical and future effects of traditional (e.g. harvest controls) and non-traditional (e.g. effort controls, ecosystem-based controls) management strategies, and management in the face of changing ecosystem productivity.

Finally, building upon the long history of stock enhancement research conducted by SCDNR, the role of population augmentation as both a conservation tool and research tool for marine finfish and invertebrates and needs continued evaluation. As a conservation tool, such population augmentation can be used to offset the effects of some of the other challenges facing marine finfish and invertebrates, whether it be to offset the impact a marine heatwave or intense storm has on the productivity of an individual species or ecosystem in a given year or as a long-term restoration tool for a distinct population segment. Such historic examples include stock enhancement programs for Cobia and Spotted Seatrout, the latter to assist rebuilding a severely over-exploited distinct population segment and the former to offset the effects of high mortality during winter marine cold spells where water temperatures drop below lethal temperatures. Care must be taken to undertake any such stock enhancement using a responsible approach, and the overall goals and risks involved should be considered prior to any action to ensure the desired outcomes. As a research tool, stock enhancement and population augmentation can be used to investigate the effect climate change, marine heat waves, changing weather intensity and precipitation patterns, and water quality are likely to have on wild populations so that we can better predict their future impacts. For over 20 years, we have been using such approach to investigate the recruitment of Red Drum throughout coastal South Carolina, although many more questions both within and external to this species still need to be addressed.

Some of South Carolina's most iconic species are in the SWAP, including whelks and other shelled species beachgoers find along the shore. Photo by Anna Smith, SCDNR.

Insects and Allies

Insects, along with other terrestrial invertebrates, are the planet's most species-rich group of organisms. They exist in almost every terrestrial ecosystem conceivable, absent only from the extreme heat of volcanic vents and permanently frozen polar icecaps. Despite their prevalence, they are relatively poorly known compared to other taxonomic groups. Their small size often

renders them inconspicuous and generally unremarkable to the casual observer, yet their presence on this planet has a profound influence on all other life forms. Their complex life cycles and seemingly endless diversity make basic identification and taxonomy challenging, even for skilled entomologists. The task of developing conservation strategies for this group of animals is further complicated by their understudied life histories and habitat needs.

The actual number of insect species is unknown. Of the estimated 2 million named species, approximately 1 million are insects (Roskov et al. 2024). Erwin (1983), through work conducted in tropical forests, estimated that at any one time there are approximately 10 quadrillion (10,000,000,000,000,000) individual insects alive, representing as many as 30 million species (Erwin 1997). More recent analysis of taxonomic data has further refined the estimate to approximately 5.5 million species of insects, not including another possible 1.5 million species of non-insect arthropods (Mora et al. 2011, Stork 2017). There are debates about what estimates are correct, but even at the lowest estimates, as much as 80% of the world's entomofauna remain unknown to science. Despite the lack of resolution about the number of total species on Earth, data consistently show that insects are the single largest component of world biodiversity and a major component of animal biomass.

Insects and their allies (related arthropods) are an extremely important taxa group for their roles in pollination, natural pest control, and decomposition (deMaynadier et al. 2024). In South Carolina, invertebrates such as mussels are considered "wildlife" in state statute; therefore, by extension of that definition, insects and their allies are also animals falling into the "wildlife" category. For this edition of the SWAP, even though most of the insects are data deficient, there was at least a knowledge base in place for 42 distinct groups to be considered eligible SGCN with at least one member in each. Having insects and related species included in the South Carolina SWAP provides visibility and encourages research and management efforts (deMaynadier 2024) for this huge base of the food web and both terrestrial and aquatic ecosystems.

Challenges

Some challenges for insect conservation are similar to those faced by plants and other animals. Degradation of habitat through land use changes, exotic and invasive species introductions, urban sprawl, and hydrologic modification such as dredging and dam construction alter insect communities, often resulting in reduced species richness. A factor that will have unpredictable effects on insect ecology is a changing climate. While some studies indicate increasing biomass and species richness of insects across an increasing temperature gradient (Welti et al. 2022), changes in plant communities, soil conditions, and associated natural forages will ultimately alter insect assemblages at local scales (Outhwaite et al. 2022). Insects also suffer from introductions of novel pathogens (Vilcinskas 2019), but our extremely poor understanding of pathology in native insect populations makes it impossible to determine the degree to which novel diseases will affect insect conservation (Flaminio et al. 2022).

Insect conservation differs from conservation of vertebrates and some marine animals in two very distinct ways. One is that direct "take" by humans generally has no measurable effect on populations. While there are rare exceptions, such as tropical butterflies where commercial harvest may be profitable, insects are not generally harvested from the wild for consumption or

profit in South Carolina. On the contrary, most insect species are under-collected and underrepresented in museum collections. Collecting and cataloguing insects for monitoring and scientific purposes will almost certainly benefit the conservation of this diverse but understudied group of animals.

The second distinct threat that insects face is widespread and expanding use of pesticides, which generally has a much lower acute effect on vertebrate populations. While pesticide related impacts are reported in vertebrates—especially among amphibians and fishes—the general effects of pesticide exposure to these larger organisms tend to be sublethal in nature and affect populations in inconspicuous ways. Exposure of insects to these compounds has immediate and measurable negative affects, which is understandable because many commonly used active ingredients specifically target arthropods (insecticides and miticides). Still other widely used compounds that do not target arthropods specifically—such as herbicides, fungicides, and adjuvants—have indirect impacts to insect populations by eliminating host plants, natural forages and nesting sites as well as impeding insect development, altering behavior, and reducing immunity to natural stressors (Bartling et al. 2024).

While insects face numerous perils, one of the greatest challenges to invertebrate conservation is the relative scarcity of entomologists dedicated to studying this diverse group of animals. Robert May (2010) noted that while invertebrates comprise at least 90% of named species, only one-third of professional taxonomists specialize in invertebrates. Thus, the fundamental task of describing and naming insect species, or simply the ability to identify them accurately, is lacking and probably will be for the foreseeable future until greater emphasis is placed on training skilled entomologists. The SWAP should incentivize academic institutions and funding agencies to prioritize describing and naming insects, determining their evolutionary relationships, and studying their life histories, empowering conservationists to infer the unknown from that which is known.

A variety of insects are displayed in museum drawer. Photo by Clemson University Entomology Department.

There have been some positive trends that allow for a better understanding of insect diversity. Molecular analysis is improving our understanding of the evolutionary relationships among insects, their functions, and their habits. These genetic analytical tools are already helping to refine and rearrange even higher taxa within the arthropods. The advancement of computer technology and digitizing arthropod collections now enables the cataloguing and sharing of data with greater speed and efficiency. Confocal imagery is improving photographic detail and records of diagnostic characters, and geospatial tools such as mapping and global information systems (GIS) that are accessible online have revolutionized the tracking and recording of where species occur. Computing technology has become so advanced that mobile devices now have applications, such as iNaturalist, that are capable of recording images, geospatial data, and—through artificial intelligence—assisting with identification of organisms. This opens the collection and sharing of insect occurrence data to conservationists and citizen scientists that are not specifically trained entomologists, which greatly expands the data set for understanding where insects are observed and their phenologies.

Conservation Opportunities

Because the insects contain such a vast number of species, conservation of this group is daunting. Each species has unique habitat needs and phenologies. Many insects, as in the case of some dragonflies or cicadas, may require years to complete development, whereas others, such as aphids or midges, can complete their entire life cycle in a matter of days. Some insects are generalists, thriving in several ecosystems or on numerous hosts, while others are specialists, requiring very specific nesting sites or hosts to reproduce and finish development. A comprehensive statewide conservation strategy for native insects would require developing an action plan for each species, which is not feasible for the reasons already discussed. For this reason, the South Carolina SWAP must focus on certain taxa or life habits that, through their conservation, will benefit the widest swath of species.

An Eastern Tiger Swallowtail, State butterfly of South Carolina, visits a native Buttonbush. Photo by Anna Smith, SCDNR

Aquatic macroinvertebrates have long been used as indicators of water quality. Their sensitivity to hydrological changes, sediments, and pollution among the numerous species of aquatic invertebrates provides a method for monitoring the health of freshwater ecosystems and watersheds. Sensitive taxa such as the stoneflies (Plecoptera), mayflies (Ephemeroptera), and caddisflies (Trichoptera), among others, deserve conservation attention. Their presence in the environment is a principal measure of the suitability of water resources to other organisms, so conservation of these insects and the streams and bodies of water where they live has a profound influence on the conservation of organisms throughout the watershed.

In a similar manner, pollinating insects serve as biological monitors of terrestrial environments. Approximately ¾ of the plant species in South Carolina are Angiosperms (flowering plants), most of

which rely on insect pollination for sexual reproduction. This coevolutionary relationship is over 100 million years in the making, to the extent that the long-term survival of most plant species in the State is directly dependent on the insects that visit their flowers. Pollinators are worthy of attention also because they forage over relatively large areas compared to other insects. While some invertebrates, such as springtails (Collembola) who spend their entire life in a single meter of leaf litter, or scale insects (Coccomorpha) which may spend their entire life on a single plant, pollinators traverse the landscape moving through different environments and ecosystems seeking food and nesting sites. In so doing, they expose themselves to pollutants and to changes in those environments. Their occurrences provide an indirect measure of the effects of changing land uses, invasive species, chemical pollutants, and alterations in local climates. Removal of either their forage plants or their nesting sites or exposure to chemical toxins or harsh climatic conditions results in their removal from the ecosystem which ultimately affects the plants they pollinate and the animals that rely on them for food. In particular, the bees, which include hundreds of native species in six families collectively called the "Anthophila" (a.k.a. pollen lovers), are the most efficient pollinators of most groups of native plants. Because bees rely specifically on pollen as their primary source of protein, they are particularly sensitive to the distribution and condition of their host plants in the landscape. Conservation of the bees through expanding suitable habitat and natural forages as well as reducing pesticide exposure ultimately benefits a wider array of pollinator species and the animals and plants that rely on them and their ecosystem services.

A few individual insect species and easily recognizable groups of species deserve conservation attention because of their influence on public awareness. The South Carolina state insect is the Carolina Mantid, *Stagmomantis carolina*. This relatively large and charismatic insect is widely considered to be a beneficial predator which exhibits intriguing behaviors. Fireflies (Lampyridae) also garner public attention through ecotourism by their conspicuous behavior of bioluminescence (e.g. Blue Ghost Firefly tours across the Blue Ridge Ecoregion and the annual Synchronous Fireflies Event at Congaree National Park and Audubon's Firefly Nights at Beidler Forest in the Coastal Plain). Once common across the State, these easily recognizable beetles are becoming rare in many areas and drawing attention to the impacts of pesticide use and light pollution. Finally, certain butterflies (*Rhopalocera* within the Lepidoptera) are easily recognized because of their relatively large size, dramatic colors, and flight patterns. The most iconic species in this group is the Monarch Butterfly, a quintessentially North American species that migrates from Canada across the continental US to Mexico. Because of its interesting migratory patterns where the majority of individuals overwinter in very specific locations such as southern California, Mexico's Sierra Madre Oriental Mountains, and more recently observed in the Lowcountry of South Carolina, this species allows for annual monitoring of the entire population of the species. For several decades, overwintering populations have declined, a trend attributed to the elimination of their host plants

A Snappy Single Sync Firefly (*Photuris frontalis*), a species that can be seen displaying at Congaree National Park in Richland County, SC.
Photo by Xerces Society/Richard Joyce.

(milkweeds, *Asclepias* spp.) across their migratory paths. A hallmark of insect conservation and the power of restoring habitat and raising public awareness, the monarch is rebounding largely through initiatives to replant and protect milkweeds across the continent and the attention it receives through citizen science projects. If conservation initiatives can restore insects such as the Monarch Butterfly, then there is hope that similar attention to other species such as is provided in the South Carolina SWAP will result in more widespread appreciation and conservation of insects in general. Future editions of the SWAP will hopefully see habitat descriptions to accompany the list of SGCN insects and their allies.

Plants

South Carolina boasts about 2,752 native vascular plant species (SCDNR internal data; Weakley et al. 2024). Six of these species occur nowhere else in the world but South Carolina. The State is also rich in bryophytes (mosses, liverworts, and hornworts) and lichens. Precise data are not available, but there are approximately 500-700 bryophytes and over 1,000 lichens in the State. The diversity of plants in the State is much higher than most groups of animals except insects. Over half (56%) of all federally listed species in the United States and its territories (i.e. those listed under the United States Endangered Species Act (ESA) of 1973, as amended) are plants. Diversity of plants is threatened globally. Pimm and Raven (2017) estimate that one fifth of the world's plant species are at risk of becoming extinct in the wild.

The SCDNR recognizes that plants are an important component of the landscape. They provide the foundation for most habitats, are the base of food chains, regulate floods, influence the climate, and many are also of major cultural significance. The conservation status of plants, with so many native species, is also an indicator of statewide environmental problems. In addition, some of South Carolina's SWAP priority species, such as insects, depend upon some of the State's plants of conservation concern for some part of their life cycle. For example, the Ohoopee Dunes Crossidius Beetle's (*Crossidius graham*) host plant is Woody Goldenrod (*Chrysoma pauciflosculosa*), while the Okeefenokee Zale (*Zale perculta*) utilizes Vine Wicky (*Pieris phillyreifolia*). There are many more plant species that are not in peril themselves but should be maintained for the sake of the insects and other animals that rely on them for survival. Monarch Butterflies (*Danaus plexippus*) and other migratory butterflies are highly dependent on Silverling (*Baccharis halimifolia*) as a nectar plant (J.W. McCord, pers. obs. 2003, Urquhart and Urquhart 1976), and Monarchs also depend upon milkweeds (*Asclepias* spp.) as a larval food plant. Maintaining associations such as these are ways to ward off population declines and the need for listing species. The SCDNR therefore is being proactive in the discussion of plant species of concern in this iteration of the SWAP. It has been suggested that the recovery costs for plants may be less than those for vertebrates, so perhaps it is time to start considering their inclusion (Stein and Gravuer 2008). Currently, the federal guidelines for the State Wildlife Grants Program exclude plants from funding. This is because plants are harder to protect on private lands because laws protect plants within South Carolina only if they occur on federal property or if a federal activity on private lands would harm them. There is also the precedent set forth during colonial days that suggests that animals fall under the jurisdiction of the Crown and plants belong to the people (Stein and Gravuer 2008). However, about 31 states have created Acts or state ESA requirements that do cover plants along with animals (Stein and Gravuer 2008, Camacho et al. 2017). South Carolina does not provide legal protection for rare plants.

A 2024 assessment by SCDNR found that of the native vascular plants known to exist in South Carolina, about 48% (1,322 species), are considered as Critically Imperiled, Imperiled, or Rare, and tracked by the agency. This tracking follows guidelines by NatureServe for subnational conservation rankings (S-ranks) (NatureServe 2015) which have been applied to about 82% of the state's native plant species. This indicates the dire state of South Carolina's plant diversity. In fact, 594 species are S1 ("Critically Imperiled"), usually with five or fewer populations and/or small population sizes. An additional 77 species haven't been located in the State in recent years (48 Historical (SH), and 29 Extirpated (SX)).

This SWAP includes 874 species of plants, specifically 843 vascular plants, 16 bryophytes, and 15 lichens, an increase of 163% from the 332 species in the 2015 SWAP. Assignment of plants to the SWAP priorities included a combination of subnational ranks (S-ranks) as delineated by SCDNR, global ranks (G-ranks) as delineated by NatureServe, Federal status under the Endangered Species Act, and presence on the Regional Species List of Greatest Conservation Need (Radcliffe et al. 2023). Neither floristic diversity nor the richness of rare plant species is uniform across the State. Data is not available for all five of the ecoregions defined in the SWAP, but Weakley et al. (2024) and SCDNR internal data show that about 2,276 native species are in the Coastal Plain (which includes the SWAP Coastal Zone and Sandhills), 1,771 are in Piedmont, and 1,439 are in the Blue Ridge. SWAP priority species are richest in the Coastal Plain Ecoregion with 455 species, followed by the Piedmont (303), Blue Ridge (264), Sandhills (250), and Coastal Zone (222). Within the Blue Ridge Ecoregion, Rich Cove Forests have the highest diversity of SWAP plant species (82). Fens and Spray Cliffs (73), Mountain Alluvial Communities (71), and Montane Rock Outcrops and Glades (65) are also rich in rare species, but the habitat with the most "Highest Priority" species is Fens and Spray Cliffs with 11such species. There are also 11 Federally listed/At-Risk species. These Federal species occur in several different habitats, including Southern Appalachian Purple Pitcherplant (*Sarracenia jonesii*), Mountain Sweet Pitcherplant (*Sarracenia purpurea* ssp. *montana*), Swamp Pink (*Helonias bullata*), and White Fringeless Orchid (*Platanthera integrilabia*) in fens, Rock Gnome Lichen (*Cymatoderma caperatum*) on a cliff face, and Persistent Trillium (*Trillium persistens*) in Acidic Cove Forests. Some are fire dependent, such as several of the fen species, and Smooth Purple Coneflower (*Echinacea laevigata*).

Federally Threatened Swamp Pink and a Red Salamander at Ashmore Heritage Preserve in Greenville County, SC. Photo by Mary Bunch, SCDNR, ret.

Within the Piedmont Ecoregion, the communities with the highest diversity of SWAP plant species are Floodplains and Riparian Zones (69) and Basic Mesic Forest (68). There are also nine

Federally listed/At-Risk species. Surprisingly, the next most diverse habitat is Early-Successional Habitats (55) which likely indicates—on one side—the radical disturbance to natural habitats in the Ecoregion, but also to the persistence of sun-loving species that were likely once present in fire-maintained habitats such as Piedmont Prairies and Woodlands. The habitat with the most "Highest Priority" species is Basic Mesic Forest with 10 species.
The Sandhills Ecoregion has the highest diversity of SWAP species within the most common habitat in the zone, Longleaf Pine Sandhill (72), which also has the most "Highest Priority" Species (11). There are also 11 Federally listed/At-Risk species. However, this broad "Longleaf Pine Sandhill" ecosystem classification doesn't capture the variation in the ecosystem, many of the rare species are in habitat subtypes such as "bean dips", edges of wetter habitats, sandstone outcrops, or the deepest xeric sands. Sandhill seeps have the next richest diversity (50) and are also one of the most threatened habitats in the State. They are almost entirely restricted to powerline rights-of-ways, except for small examples on protected lands in Chesterfield and Richland counties.

The Coastal Plain has the highest richness of rare plant species of any ecoregion by far. There are also 16 Federally listed/At-Risk species, the most of any ecoregion. Pine Savannas and Flatwoods have at least 144 SWAP species, followed by Depression Wetlands, and Carolina Bays (109). Early Successional Habitats, with 74 species, are also very diverse, with many of those species found in disturbed habitats along roadsides or other areas such as utility rights-of-ways that are maintained to be free from woody plant encroachment. The habitat with the most "Highest Priority" species is Pine Savannas and Flatwoods with 20 species. In terms of diversity of rare plants, this habitat has more SWAP species and "Highest Priority" SWAP species of any habitat in South Carolina.

A Squirrel Treefrog and Yellow Pitcher Plant demonstrate a mutualist relationship in Lewis Ocean Bay Heritage Preserve, Horry County, SC. Photo by Anna Smith, SCDNR.

The Coastal Zone has the fewest number of SWAP plant species but is also the smallest ecoregion. There are six Federally listed/At-Risk species. The most diverse habitat is Pine Savannas and Flatwoods (54), despite only a fairly small representation, mainly in northern Charleston County. Early Successional Habitats are the next richest with 45, tied with Depression Wetlands. The habitat with the most "Highest Priority" species is Pine Savannas and Flatwoods with 9 species.

Challenges

Threats to plants in South Carolina, both at the species level and ecosystem level, are many. These threats are not unique to the State but shared across the Southeast and the globe. Because plants form the foundation for most of the State's habitats, the threats facing plants mean that those are also threats to the wildlife species that depend on those plant species or habitats. Noss et al. (2020) summarizes these major threat categories and each is discussed below.

Habitat loss, fragmentation, and disruption of functional connectivity. This factor is the biggest challenge to conservation of the State's biodiversity. This has been a long-term problem that started with early European settlement and agricultural activities. Cotton cultivation from ~1820 to 1920 resulted in ecologically devastating changes in the Piedmont Ecoregion because of deforestation and subsequent severe erosion and gullying (Trimble 1974, Galang et al. 2007). This devastated most of the ecoregion's ecosystems, radically altering ecosystem structures and processes. In the Coastal Zone Ecoregion, widespread impoundments of Tidal Freshwater Marsh for rice cultivation in the 18th and early 19th centuries altered most of a once extensive ecosystem along all the State's tidal rivers (Odum 1984). While we have inherited this legacy of landscape changes, the current and future threat is habitat loss due to development. As the State's human population increases, natural areas containing rare species are under constant threat.

Habitat fragmentation isolates species into smaller populations and creates deleterious edge effects. With plants the isolation of species from pollinators and seed dispersers is a major concern (Nayak and Davidar 2010). Disruption of plant-animal interactions will be a challenge that is difficult to overcome. Pollinators and dispersers often have limited travel distances, and they may be absent or have small population sizes in isolated habitat fragments. This results in lower pollination, fruit set, and limited gene flow between populations. Further, populations of pollinating insects between fragments are often limited by pesticide use (Brittain et al. 2010).

Climate change. Alterations of the earth's climates will have a variety of impacts on plant species throughout the State. Wrobleski et al. (2023), in an evaluation of 771 plants listed under the ESA, considered all the species to be threatened by climate change. The increase in temperatures is a major concern, but other factors are also important including sea level rise and changes in precipitation. These could alter physiological responses of plants to their environments, alter ecosystem structures and functions, change flower and fruit phenology, alter plant-animal interactions, and cause cold-sensitive species—including exotic invasive species—to migrate.

Maritime forests and marshes succumb to sea level rise along South Carolina's coast. Photo by SCDNR Marine Resources Staff.

The most urgent threats to South Carolina's rare plants are the impacts of sea level rise. There are 222 SWAP species in the Coastal Zone with four that are listed under the ESA. Schwab (2009) states that "Changes in storm activity that might accompany climate change, coupled with anticipated increases in sea-level rise, are expected to strongly affect low-lying, heavily

developed areas of the coast." Thus, species that occur in sensitive habitats—including Beach Dunes, Maritime Forest, Marsh Hammock, and Tidal Freshwater Marsh—are particularly imperiled. For example, Seabeach Amaranth (*Amaranthus pumilus*) grows only on the foredunes of Ocean Beach habitats and has declined dramatically in the State due to coastal erosion.

As the climate continues to warm while the amount of atmospheric carbon dioxide (CO_2) increases, forests will expand and trees will grow more in a given year due to an extended growing season (SCFC 2010). The increased atmospheric CO_2 will benefit some plant species but not others due to the way it is absorbed (C3 versus C4 plants). Palatability and nutritional content of crops and native plants will decline as a result of the increased CO_2 uptake (SCFC 2010). Looking further into the future, drought and increased heat will take its toll, possibly turning forests into open savannahs or grasslands under extreme climate scenarios. With increases in temperature (and therefore milder winters) come the threat of invasion of more non-native exotic plants, timber and crop pests, and emerging diseases (SCFC 2010). Together with increased drought, these stresses are likely to accelerate tree death. As dead and dying trees contribute to the buildup of the litter layer, this material will act as mulch to help retain ground moisture but also serve as potential fuel and thus increase the risk of wildfire. One Southern pine species that is being called the "wonder tree" due to its ability to take the heat is Longleaf Pine (*Pinus palustris*). Not only is it a prime candidate in the Southeast for carbon sequestration efforts, but it is more tolerant to fire, drought, overly wet conditions, beetle infestations, forest pathogens, and hurricane-force winds.

Altered disturbance regimes. Periodic natural disturbances are critical to the formation and maintenance of many habitats. Fire is usually the most important factor in many ecosystems across the State, from all pine-dominated habitats across the State to Piedmont Prairies and Woodlands and even Blue Ridge Ecoregion habitats such as some fens and heaths. Other disturbances can also be important including floods, herbivory, windstorms, and drought. In absence of regular fires, habitats can change quickly causing succession to a woody plant dominated habitat and loss of biodiversity.

Invasive species. "Invasive species" are defined here as plants that have been accidentally or intentionally introduced from parts of the world outside of South Carolina that are reproducing on their own within the State (exotic species) but are also invading natural habitats (invasive species). These invasive species occur throughout all of South Carolina's ecoregions and threaten to disrupt the community composition, structure, and function of a variety of habitats. Exotic plant species, even if not invading natural habitats, may also have adverse impacts on succession of disturbed habitats or on agriculture. Invasive plants are characterized by a combination of traits that make them preadapted to their invaded habitats including their ability to establish, increase quickly, and spread, resulting in outcompeting native species (Gioria et al. 2023).

A total of 130 exotic pest plant species have been identified as posing potential (54) to severe (76) threats to South Carolina's habitats (South Carolina Invasive Pest Council 2024). Serious infestations generally result in a significant loss of biodiversity in impacted areas. According to the South Carolina Exotic Pest Plant Council (2004), approximately 100 million acres in the United States already bear some environmental degradation due to invasive plant species. Recognizing potential threats and generating public awareness and support is the first

step in preventing further spread of invasive plants. Management to recapture sites already affected presents an enormous on-going effort. Aquatic habitats are also affected by noxious weeds, with tremendous removal and control efforts provided by SCDNR, Clemson University, and others. In a combined effort, through the South Carolina Aquatic Invasive Species Task Force (2008), a list of noxious weeds for aquatic and wetland habitats has been developed. Invasive plants, and illegal aquatic plants, are listed in Appendices 3A and 3B, respectively. An example of a common exotic species is Johnson Grass (*Sorghum halepense*) from Eurasia. It is not invasive in South Carolina's natural habitats (i.e. not an invasive species), but is an economic threat to agriculture, has become herbicide resistant, is toxic to grazing animals, and invades early successional habitats (Travlos et al. 2019). An example of one of South Carolina's most problematic invasive species is Chinese Privet (*Ligustrum sinense*) from China. This shrub/small tree was introduced for landscaping in 1852 but by 2008 occupied over 1 million acres in the Southeastern United States. It invades a wide range of forests and other habitats (especially moist), especially alluvial communities. Where it occurs, it changes light regimes, shading out native species while also affecting soil nutrient cycles and soil microbial and fungal communities, altering native plant-animal interactions, and sometimes changing fire regimes, making it very costly to manage (Cash et al. 2020). Human activities, including ornamental uses and human-induced climate change, have caused some species that are native to parts of South Carolina to become invasive outside of their former ranges. For example, the iconic Southern Magnolia (*Magnolia grandiflora*) is now common in natural areas far away from its former narrow range right along the coast.

While this discussion so far has dealt only with invasive plants, other exotic or invasive organisms are also threats to the State's habitats and plant species. Feral Pigs (*Sus domesticus*) rooting in natural area are threats to many rare plant species, especially those in wetter soils. Exotic insects have long altered South Carolina ecosystems. Chestnut Blight (*Cryphonectria parasitica*) dramatically changed Appalachian forests including those in the Blue Ridge Ecoregion, eliminating a dominant canopy species by the 1930s. This kind of threat continues; a threat to forest structures in the Coastal Plain is the Redbay Ambrosia Beetle (*Xyleborus glabratus*) from Asia that spreads fungal symbionts in the genus *Raffaelea* that kill bay trees (*Tamala borbonia*, *T. palustris*, =*Persea borbonia*, *P. palustris*) and can harm other members of the Laurel family *(Lauraceae*).

A patch of Ginseng at Chestnut Ridge Heritage Preserve in Greenville County, SC.
Photo by Mary Bunch, SCDNR, ret.

Other factors are also a threat to the State's flora but are not discussed by Noss et al. (2020). These include:

Poaching. Intentional removal of some plant species from the wild is a threat to some plant species including rare ones. Some have been referred to as "game species" in the botanical world—those wild specimens harvested for human use (Stein & Gravuer 2008). Many plants are desired by collectors and harvesters because they are aesthetically pleasing with their foliage colors, patterns, growth habits, and floral components; are novelties for niche collectors, such as carnivorous plants or orchids; are medicinal species such as American Ginseng (*Panax quinquefolius*), or for food, medicine, or natural materials. Unfortunately, it is some of these highly sought-after properties that have put certain plant species at risk from overharvesting and poaching (Stein and Gravuer 2008). Such poaching has been documented on SCDNR properties, such as illegal harvest of Venus Flytrap (*Dionaea muscipula*) (Luken 2005).

Land Management Constraints. Given the suite of challenges detailed above, management of the State's habitats face exhaustive hurdles. There are always financial limitations on what land managers can accomplish, be they government, NGO, or private landowners. Difficulties include staffing limitations, plant species identification (rare and also invasive), and the demands of protecting highly localized populations of rare species that can be dependent on specific soils and microclimates (Stein and Gravuer 2008). With most of the State in private ownership, long-term land protection is lacking.

The most important land management activities to protect the State's habitats and rare plant species are prescribed burning to restore historic fire regimes in fire-dependent ecosystems and the control of invasive plant species. For instance, dormant versus growing season burns in pine forests have markedly different outcomes in regard to understory composition (Roth and Franklin 2009). There is a long list of other land management needs that are often site-specific including restoration of hydrology, revegetation, erosion control, and control of human impacts like foot traffic and poaching.

Federally At-Risk Venus Flytraps are an example of a rare endemic plant species. Photo taken by Anna Smith at Lewis Ocean Bay Heritage Preserve, Horry County, SC.

Legal Protection. There is limited regulatory protection for plants in South Carolina. Only one state law addresses plant protection explicitly. This is SECTION 16-11-590 that makes it unlawful to "cut, collect, break or otherwise destroy the rare Venus Flytrap (*Dionaea muscipula*), or the common, but sensitive, Sea Oats (*Uniola paniculata*)". Attempts have also been made to control harvest of Ginseng (*Panax quinquefolius*), but no bills have made it through the State Legislature. The ESA therefore affords the only other legal protection to the State's plants, but it is limited to those species listed under the Act (22), and only on Federal lands, or otherwise where some Federal action is involved.

Conservation Opportunities

Like most of the animal groups discussed in this SWAP and written in each, the foundation for protecting the State's plant diversity is identification of places with important habitats and their subsequent protection. This protection can take many forms such as acquisition by a government agency or a land trust to a conservation easement on private land. However, this is only the first step in protecting biodiversity. This is for several reasons: 1) all of the habitats in South Carolina have been altered to some degree, and those alterations need to be mitigated; 2) external threats are still faced on protected lands; and 3) regular management always needs to occur such as prescribed burning. There are many conservation opportunities to protect South Carolina's plant life in the long term.

Isolation of habitat fragments from pollinators and seed dispersers can be mitigated to some extent by actions to and outside of the fragment. The most directly controlled by land managers is restoration of and applications of appropriate management techniques. Effective restoration and management can be effective in creating healthy and resilient pollinator populations (Kaiser-Bunbury et al. 2017). More difficult is maintaining health of pollinators and dispersers between fragments. This can be accomplished by reducing pesticide use, maintaining early successional habitats that provide nectar and food resources, and in planting native plant species in landscapes that are also beneficial to the same species guilds.

Rights-of-ways are important sites for plant diversity and the support of pollinator populations and can be important as stepping stones between habitat fragments. They are well known in the Southeast as refugia for many rare plants (Sheridan et al. 1997). Areas such as utility easements or road edges are maintained by utility companies and road managers as sunny, early-successional habitats either with herbicides or by mechanical control. Usually sunny, herbaceous species often thrive in such habitats and can include diverse communities of native plants, some of which are rare. This management can be improved to promote plant and wildlife diversity by carefully restricting woody plant control to times of year that promote, rather than hinder, plant populations so they have time to grow, flower, and set seed. This is best accomplished by limiting management to the dormant season but can be modified depending on which species are present and if they are spring, summer, or fall flowering.

Evans' Reindeer Moss (*Cladonia evansii*) is a rare lichen. Photo taken in Marion County, SC by Anna Smith, SCDNR.

A variety of land management techniques are essential to maintaining diversity of habitats that support diverse plant and rare plant populations. Proper management is essential to not only maintaining habitats and biodiversity, but in making ecosystems and species more resilient to stochastic events and influences of climate change (Saha et al. 2011). Among the most necessary is the use of prescribed fire which is essential to prevent encroachment of woody plant species, but fires also have other effects such as stimulating flowering and promoting seed germination. Management of nuisance plant species,

especially exotic invasive species, is also critical. Control of these species can be accomplished with prescribed fire, mechanical control, and herbicides, or a combination of those techniques. Training is also needed for land managers to identify these plant species and how to control them.

In habitats that have been restored and are being managed, there are opportunities throughout the State for restoration of rare plant populations where populations are either small or have been extirpated. These efforts usually involve a combination of ex-situ conservation collections followed by augmentation or reintroduction. These should follow protocols guided by genetics, ecology, and plant biology and followed by proper site management (Maschinski and Albrecht 2017).

Legal protection would afford additional protective measures to be put in place, but there are challenges to passing laws that are effective. However, efforts should be made to give plants some of the same protection as our rarest wildlife species. Poachable species such as Ginseng (*Panax quinquefolius*), orchids, or carnivorous plants would be better protected by increasing fines for unauthorized collection on both private and public lands. Other legal protections could be approached to give "endangered" and "threatened" status to plants on the state level.

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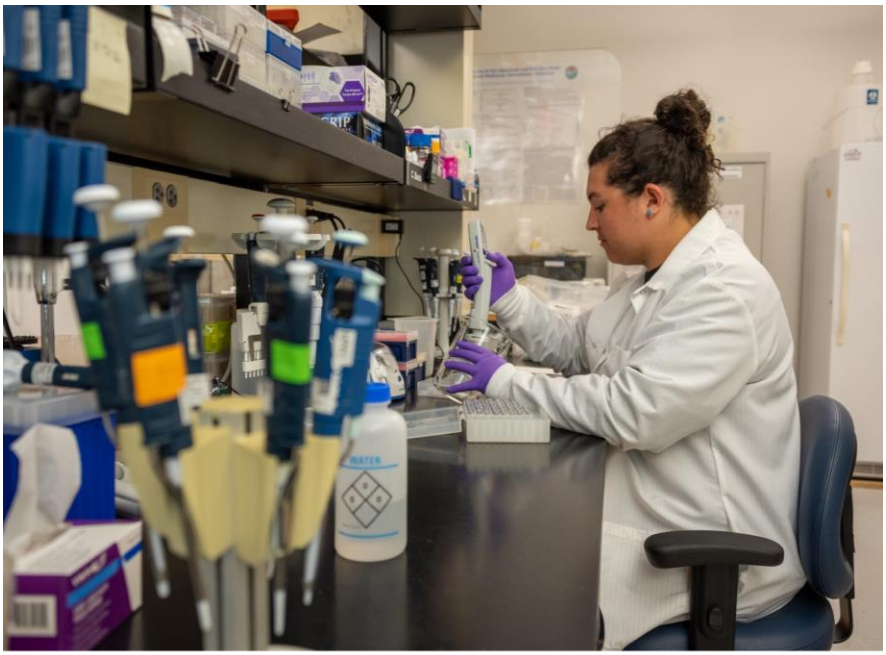
CHAPTER 5: COMMON THREATS AND STRESSORS

In the Supplemental Volume of this State Wildlife Action Plan (SWAP), each Species of Greatest Conservation Need (SGCN) is given its own species account or guild (group) account in which specific threats are identified along with targeted action items needed to mitigate for these threats. Sometimes lack of life history data or population size is the threat, creating uncertainty as to the species' true vulnerability in the face of compounding stressors. Additionally, whole taxa groups may face similar threats and are discussed in Chapter 4. Despite these individualistic concerns, common themes do emerge across all taxa groups which can be summarized in a standardized threat analysis, presented in Table 5-1. These standardized threats are loosely modeled after both NatureServe's Rank Calculator V.2.0 and those of the Conservation Measures Partnership (CMP; 2016), of which the latter can be accessed at Georgia's SWAP Revision Support Website. Both NatureServe and CMP developed their categories using the Salafsky et al. (2008) framework with modifications. Primary threats and stressors are overarching themes under which associated impacts are defined. Both levels are further elaborated on in the specific sections that follow. Many times, the same threats are repeated across some or all categories.

> "No matter how intently one studies the hundred little dramas of the woods and meadows, one can never learn all the salient facts about any one of them."
>
> **- Aldo Leopold**

Lack of Species Data

Sometimes the lack of information on a species (e.g. population size, distribution/range, life history details) is considered a threat because it is difficult to determine if a species is secure, rare, or declining. Sometimes narrow endemics are naturally rare and should be monitored but not considered under threat, while other species could be facing extinction and scientists not even know. Another challenge is taxonomic uncertainty arising from the lack of DNA studies to property determine species status and phylogeny. Questions pertaining to speciation include (1) when did two species diverge and (2) was it natural due to niche partitioning or human-induced through fragmentation and subsequent reduced gene flow? Other questions concerning (3) the relatedness to similar species may provide clues as to the best way to manage for a species or guild. In the South Carolina SWAP, taxa



A genetics researcher prepares a sample at the Marine Resources Research Institute. Photo by SCDNR-MRRI.

experts erred on the side of caution and included many data deficient species. As of 2024, only 13.5% of the State has been surveyed (leaving 86.5% unsurveyed) and with a focus in and around public lands (Joe Lemeris, GIS Data Manager, SCDNR, per. comm.). This creates a sampling bias as do records that come from road kills. Where these species would typically inhabit is likely nearby but not at the point of reference. Sometimes areas are surveyed outside of the season or time period when the target species would be using it. At other times, surveys may be conducted when a species is unidentifiable (e.g. juvenile phase instead of adult).

Additionally, especially in the case of insects, museum collections are incomplete in their identification records, requiring additional review by peers before digitization and sharing online with researchers. It is critical to have this baseline information in place so that when stressors from climate change and habitat fragmentation show faunal shifts, it is noticeable (deMaynadier et al. 2024).

Development and Infrastructure

Infrastructure resulting from modern human society includes homes, stores, factories, schools, healthcare facilities and the network of roads and utilities to link everything together and operate. Unfortunately, the footprint of this infrastructure mars the landscape and fragments, impairs, or outright destroys habitat for other species. Impacts may be direct from equipment maiming or killing animals and plants or indirect from the loss of species or prey habitat, leading to species displacement. For example, some species that require forest interior (e.g. Wood Thrush) or specialized habitats (e.g. Red-cockaded Woodpecker) may be displaced in favor of species more adapted to the urban environment. However, these species may become more concentrated and interact in ways not typically seen in their natural environments. Examples of this include larger than normal populations of Gray Squirrels, Opossums, Raccoons, or White-tailed Deer that are attracted to human dwellings, landscaping, and refuse.

Urban development fragments and degrades habitats. Photo by Morgan Smith.

As habitats become fragmented, especially from poorly planned development, intraspecific interactions, interactions between members of the same species, may be limited or nonexistent, decreasing gene flow and endangering isolated populations with extinction. The isolation of suitable habitats may be most problematic for small mammals, reptiles, and amphibians that have limited dispersal ability and may suffer high mortality when traveling through unsuitable habitats. Habitat fragmentation also hinders the use of prescribed fire. Therefore, most of the SGCN associated with fire-dependent communities decline as development encroaches. Also,

concerns about liability, air quality, social acceptance, and smoke management, as well as the lack of landowners with experience and equipment to conduct prescribed burns, has limited the use of fire on private lands.

Highway 17 cuts across vast marshland in the ACE Basin. Photo by Anna Smith, SCDNR.

Engineered structures over (i.e. bridges) or through (i.e. dams, culverts) waterways may affect the behaviors and movements of aquatic fauna (e.g. hinder fish passage) if not designed appropriately, while impervious surfaces will affect groundwater uptake, aquifer recharge, and other hydrologic processes. For example, fish passage is critical in mussel dispersal, since larval mussels are parasitic on the gills of host fishes and are dispersed by the fish prior to settlement. Impacts from hydropower development have substantially altered and degraded a significant portion of habitat for most native aquatic species with nearly 1,561 km (970 mi.) of streams within South Carolina 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. According to the National Aquatic Barrier Inventory & Prioritization Tool analysis for South Carolina, 18,149 dams have been inventoried but 62,983 culverts or other stream crossings have been identified that could also be potential barriers to aquatic connectivity. Poorly designed culverts can cause downstream scouring and upstream pooling so that the natural movement of sand and gravel is disrupted, impacting aquatic communities.

Piedmont Hydroelectric Project dam located on the Saluda River in the town of Piedmont, SC. Photo by Elizabeth Miller, SCDNR.

Figure 5-1 shows the extent of dams across the State of South Carolina. 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. This favors competitive, and often predacious, species (e.g. Largemouth Bass). 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). Historic migrations of anadromous species (e.g. American Shad) have been disrupted by dams.

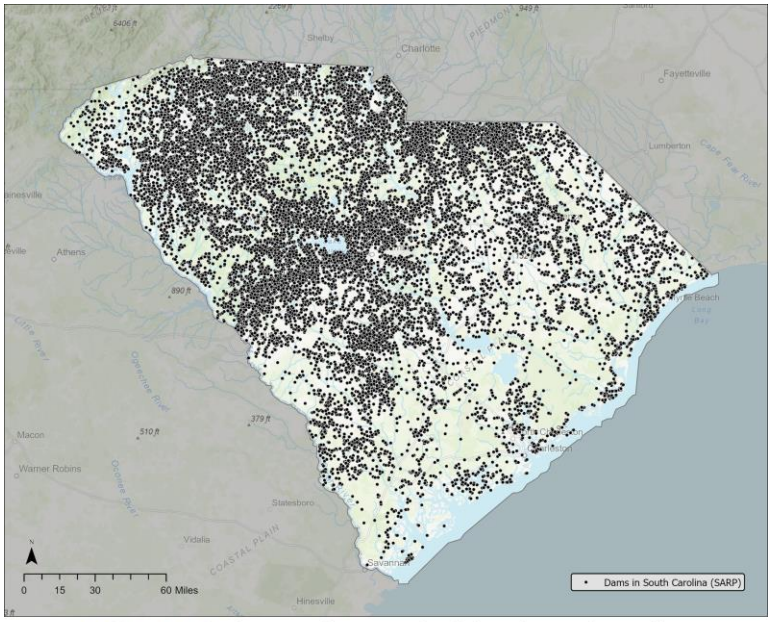
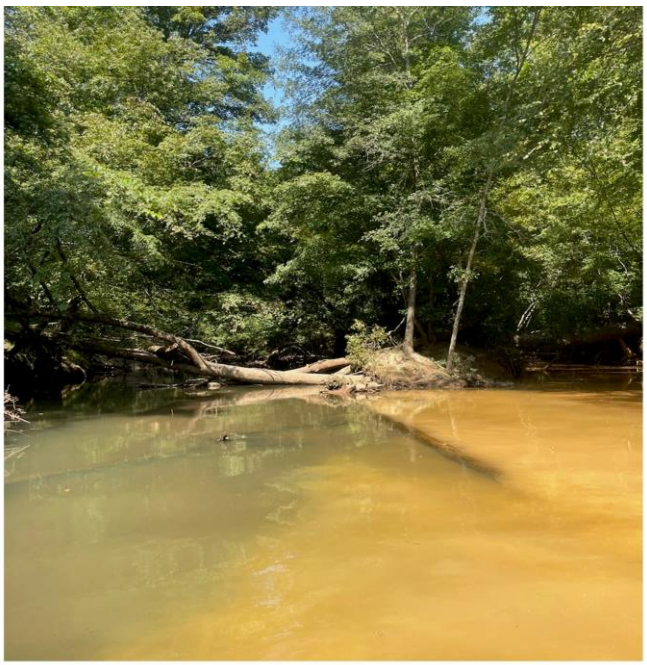


FIGURE 5-1: The extensive network of dams in South Carolina. Map provided by the Southeast Aquatic Research Partnership (SARP).

Destabilized soils from eroded landscapes and earth moving during construction create sedimentation problems in these same waterways. There can be altered sediment regimes where too much sediment enters waterbodies, smothering benthic species or clouding waters which alters photosynthetic processes and visibility. Sediments also can interfere with plankton's absorption of sunlight for nutrients, affecting the food chain. Sometimes sedimentation is blocked from accumulating, degrading downstream habitats that require these depositions as a substrate. Point-source discharges from industrial, municipal, and commercial sources add a variety of pollutants to receiving streams, rivers, and lates. These are in the form of stormwater run-off and releases of effluents, chemicals, and thermal discharges that impact species and habitats where they enter into the aquatic environment but also dissipate to impact other portions of the aquatic system. Non-point source pollution as effluents, sewage from compromised septic systems, and chemicals can leach into



Ineffective silt fencing resulted in stormwater runoff impacts from suspended sediments as the confluence of Six Mile Creek (non-turbid) and Tar Kiln Branch (turbid) in Lancaster County, SC. Photo by Ericah Beason, SCDNR.

waterways for flow overland during rain events. In the case of thermal discharges, expelled water may be colder or warmer than the surrounding water which could have deleterious effects on aquatic life. One such example is the unnatural congregation of warm water species (i.e. Florida Manatee) around warm water discharges so that they become trapped and die from temperature drops when seasonal shifts occur. Polluted waters not only affect wildlife but also human recreation such as swimming and fishing (consumption advisories).

Transportation and Service Corridors

With development comes the infrastructure required to service urban and suburban centers. As highways, bridges, and canals are built, there is direct mortality on plants and animals. Upkeep of human environments such as ditching agricultural fields or forest lands, dredging shipping lanes, removing in-stream structure (e.g. downed logs), and removing shoals and sandbars alters natural habitats, having direct negative impacts on entire communities of plants and animals. For example, as power line rights-of-ways (ROWs) and roadsides are mowed or sprayed through various vegetation management regimes, native species may be lost, directly impacting the associated plants and insects. Equipment that is not properly cleaned can introduce non-native, invasive seeds and other plant parts that can root in once pristine environments and subsequently invade and degrade these landscapes. Routine road maintenance (e.g. repaving, de-icing) uses pollutants including chemicals and salt compounds that are released into the environment. Airport runways must be kept devoid of wildlife to avoid disruption of air traffic while flight paths must avoid bird strikes.

Likewise, shipping lanes within the jurisdictional limit of the State of South Carolina can become lethal to marine mammals and sea turtles that may be struck by boats. In fact, watercraft interactions are the number one cause of mortality for sea turtles in South Carolina (M. Pate, SCDNR, pers. comm.). Coupled with shifts in species distributions from climate changes, whale strikes are expected to increase (Redfern et al. 2020). The mere wave action from passing ships and smaller recreational boat traffic can erode marshes and shorelines.

A cargo ship enters the port of Savannah. Photo by Keith Bradley, SCDNR

Beach Nourishment, Shoreline Stabilization, and Shoreline Modification

Storm surges, subsidence, sea level rise, and altered sedimentation regimes (e.g. lake and dam creation blocking rivers; coastal development) all modify South Carolina's beaches and dunes and cause erosion. Beaches are naturally dynamic ecosystems, and without the ability to move and shift, they can become degraded. When people develop the dune systems by building houses on these shifting sands, beach houses may begin to lose their foundations while important tourist

beaches may shrink in size as hard structures prevent the sand from shifting backwards. In addition to loss of sand under these structures, suitable habitat for beach-dependent species is lost. Beach renourishment from sand pumped from offshore or estuarine sites is frequently required to restore dune systems and beach flats, but renourishment is a temporary solution to a long-term problem. Dredge equipment can injure or kill aquatic organisms through direct uptake in the suction field generated. The spoil that is then deposited on beaches often smothers existing marine invertebrates, thus negatively impacting the system and its inhabitants in the short term (Peterson et al. 2000) and the long term (Jutte et al. 1999). Foraging species may no longer find the habitat or food resources they need on these "improved" stretches of beach until the system recovers. Studies have shown that Piping Plover, which have high site fidelity, suffer nutritional stress when traditional feeding grounds are no longer viable; this stress is manifested in telomere shortening and aging (Chaplin et al. 2024).

Beach renourishment in progress on DeBordieu Beach on Pawley's Island, SC.
Photo by Michelle Pate, SCDNR.

South Carolina's coastline is 187 miles from end-to-end, while its convoluted tidal shoreline is much longer at 2,876 miles (NOAA 2024). Exposed beachfront constitutes around 200 miles, and over 3.5% is estimated to be armored in some way with bulkheads, seawalls, revetment, and riprap (Beauvais and Byers 2024). Other structures include piers, boardwalks, housing and commercial development, jetties, and groins. Hardened structures designed for shoreline and channel protection disrupt the natural processes of sand movement along beaches and can therefore contribute significantly to beach erosion which is already significant in South Carolina. One study (Jackson 2017) found that from the 1930s to 2000s, 44-55% of the State's coast experienced 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. Additionally, private docks and armored shorelines can often change wave action and catch tidewrack which can smother otherwise healthy marsh grasses (Will Doer, SCDNR pers. comm.). Wave abatement structures, although useful in some instances to prevent erosion into

fragile marsh habitats, are another version of man-made hardscaping or "gray" infrastructure. "Soft" or natural solutions typically have fewer negative impacts to species and habitats.

Agriculture

Center point irrigation agriculture is extensive on some South Carolina landscapes, fragmenting wildlife habitat. Photo from Google Maps.

Agriculture can take the form of animal operations like cattle farms, chicken houses, or row crops. Although South Carolina's economy benefits in part from agriculture, the industry still can directly or indirectly threaten wildlife populations. As farm fields have grown in size and field edges and borders are rarely kept in the rough, wildlife has lost habitat or has become blocked from accessing suitable habitat. "Clean" farming, while making farming practices more efficient, has created a loss of diversity in both insects and plants that then sustain other taxa like birds, reptiles, amphibians, small mammals. For example, ground-nesting bees are at risk from extensive ground disturbance (Harmon-Threatt 2020) during agricultural operations and other earth-moving activities. Drainage ditches further divide acreage. During the past century, many streams were channelized to improve drainage of croplands. Channelized streams lead to increased erosion 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. Large farming operations often require water withdrawls from rivers and aquifers for irrigation which can affect water levels, impacting aquatic habitats and drinking water availability, especially in times of drought. During

Extensive agricultural fields representing "clean farming." Photo provided by Billy Dukes, SCDNR.

the 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 to try to maintain aesthetic water levels, thereby dewatering the stream below their dam.

Nationwide, pollution from agricultural sources is the greatest impairment to streams and lakes (EPA 2023). Runoff pollution of herbicides, fungicides, insecticides, and fertilizers can find their way into creeks and other water bodies. Excess nutrients (e.g. fertilizers) can directly kill aquatic organisms or create algal blooms that then cause fish kills. Fecal coliform from chicken houses and cattle and swine farms adds further run-off pollutants to waterbodies sickening wildlife. Tilling of row crops and livestock accessing streams can lead to erosion and sediment run-off into streams, further fouling waterways. Modern soil conservation practices, such as the creation of Streamside Management Zones (SMZs), have reduced those impacts but sedimentation from legacy crop and pasture siltation still continues in South Carolina streams.

Mining Operations

Mining is an intensive practice that removes all vegetation and topsoil from the specified area in order to extract mineral from beneath the ground. Besides direct mortality and habitat destruction from the clearing operation, hydrologic alterations may occur at the aquifer level. Erosion, sinkholes, and contaminants in the form of chemicals, sediments, and heavy metals can degrade the landscape. Pollutants can leave lasting impacts to soils and water, making both uninhabitable or unhealthy to species that would otherwise use these resources. Heavy metals (e.g. mercury) from past and present mining operations can bioaccumulate in fish and other aquatic organisms, impacting food chains and resulting in fish consumption advisories under 303(d) impaired waterways designations. For example, bats can accumulate metal pollutants through their food chain, and heavy metals from industrial waste can also affect the water quality and invertebrates that bats eat (Zuckal and Bandouchova 2015). Sand mining is a common type of mining operation in South Carolina with physical impacts on instream habitat including increasing bedload materials, turbidity, changing substrate type and stability, and altering stream morphology (Nelson 1993).

Sand mining is common in the Coastal Plain of South Carolina and can impact unique habitats such as this Carolina bay in Horry County, SC. Photo provided by the Coastal Conservation League.

Solar Farms

Utility-scale solar has rapidly taken off in South Carolina within the last decade. As of July 31, 2023, according to the South Carolina Energy Office, 1,864 megawatts (MW) of utility-scale solar has been installed in South Carolina. One megawatt of solar production requires approximately five acres of land, which equates to approximately 9,000 acres in solar. In 2014, the General Assembly passed the Distributed Energy Resource Program Act (Act 236) which incentivized utilities to purchase utility-scale solar. Due to Act 236 and the need to reduce carbon footprints and increase renewable energy as a part of utilities' electricity portfolios, the development of utility-scale solar will not slow down anytime soon. The increase in solar generation means a new land use on South Carolina's landscape competing with the needs of natural resources, and while renewable energy is beneficial to natural resources, some solar farms can adversely affect valuable natural resources if not properly planned and constructed. Impacts to natural resources from the construction, operation, and maintenance of solar farms include: the removal of forests and riparian buffers; creation of monotypic habitat; introduction of invasive species; use of herbicides; creation of large, clear open spaces that may be barriers to dispersal; and barriers created from fencing. In South Carolina, agricultural lands are often targeted by solar companies, but in recent years, the State has seen large (4,000-5,000 acre) silviculture tracts being targeted as well. Therefore, the SCDNR worked with Audubon South Carolina to pass the Solar Habitat Act in 2018. This legislation allowed SCDNR to establish guidance for assisting solar developers in establishing their solar site as pollinator friendly habitat and to work with Clemson University to establish a framework for a voluntary solar habitat certification program (Solar Habitat Program). The Solar Habitat Program can help encourage offsets to some negative impacts of solar and provide benefits to wildlife.

In Orangeburg County, a solar farm with its array of panels, can be seen from Interstate 26. Photo from Google Earth.

Wind Energy Facilities

The Carolina Long Bay Area is predominantly off the Coast of North Carolina but close to the South Carolina border. The State of South Carolina has been engaged in conversations as the

Wilmington East Wind Energy Area has been leased to two developers for the development offshore wind. In 2020, due to concerns regarding oil and gas development on the tourism industry and coastal environments in Florida, Georgia, and South Carolina, then President Trump signed a memorandum instructing the Secretary of the Interior to prohibit drilling in these state waters for a period of 10 years (from July 1, 2022 to June 20, 2032). Until this moratorium is lifted, the potential development of offshore wind energy is limited. However, there is always the potential as wind technologies improve that South Carolina could be a target for future land-based wind. Wind development has the potential to cause direct mortality to a variety of bird and bat species, with some studies showing an attraction by bats to wind turbines (Cryan and Barclay 2009). Indirect mortality to bats due to disruption of echolocation is another threat to the species. With offshore wind, similar direct mortality impacts exist above the waves, but underwater the infrastructure and electromagnetic fields associated with those structures can alter and disrupt the behavior of many fish and shellfish species in addition to direct impacts to Essential Fish Habitat and the South Atlantic Fishery Management Council's Habitats of Particular Concern.

Wind turbines have been proposed along the Atlantic Coast, causing concern for impacts on wildlife.
Photo by Nina_Ali, Flickr, public domain

Silviculture

Although timber production is a renewable resource, corporate and private timber managers that fail to follow Best Management Practices (BMPs) – or do so minimally – can have deleterious impacts on landscape diversity through habitat destruction and degradation. There can be initial mortality from timber harvests and site preparation using drum chopping and chemical applications. Often natural phases in the life cycle of pine plantations can be less beneficial to wildlife and understory plants than others. Pine plantations are monocultures that limit diversity, and without proper management, can be biological deserts. Inappropriate stocking rates or thin cycles can stress trees, leading to disease outbreaks or susceptibility to beetle infestations. Planting off-site tree species can result in weak stands or reduced use by native animals. Fire suppression in woodlands that are reliant on fire for seed germination, duff removal, and herbaceous layer heterogeneity can reduce diversity of both plants and animals present. These woodlands also become more at risk for catastrophic wildfires.

Timber harvests are a normal silvicultural practice, but they do alter habitats and can potentially injure or kill wildlife. Photo by SCFC.

Runoff pollution from chemicals and fertilizers can degrade nearby waterbodies with aquatic species impacts. Tree species and density can alter hydrologic regimes as they pull water from the soil. Ditching and bedding can also alter the hydrology. Along with soil disturbance in the stands, inappropriate stream crossings for logging equipment can increase siltation into waterways. Logging equipment, if not cleaned properly, can move invasive plant species into previously unaffected sites. A National Woodland Owners Association study on family forest owners found that only 11% had a forest management plan in place on their properties (Penn State Extension 2023). Without a professional management plan, many of the above-mentioned threats can degrade wildlife habitat instead of enhancing it.

Pollution

Pollution, in general, is discussed as a part of many of the other threat categories. It can take many forms – light, air, sound, water, soil, and thermal – and is also a secondary threat of many other primary threats. Chemicals can cause direct mortality or cellular damage resulting in mutations or reduced fecundity. Trophic cascades, in which contaminants bioaccumulate and are passed up the food chain, can lead to detrimental food web impacts, behavioral abnormalities, and whole life cycle disruptions. Habitats may become degraded to the point of being inhospitable.

Light pollution is evident over urban centers where humans have modified the light levels, causing behavioral disruptions in sensitive species such as sea turtles (Witherington et al. 2014), amphibians, migratory birds, bats, and insects. Navigation, (e.g. hatchling sea turtles and migratory birds) may be impaired and mate recognition through bioluminescence may be compromised (e.g. fireflies).

Light pollution such as that emanating from this gas station on Edisto Island, SC can affect hatchling sea turtles that confuse the lights with moonlight on the ocean.
Photo by Michelle Pate, SCDNR.

Air can become polluted through particulate matter like smoke, byproducts of manufacturing, and vehicle emissions. This can impact the health of both people and wildlife, but it can also damage vegetation like crops and trees. However, some air pollution may be necessary in some instances. In 2024, the Environmental Protection Agency (EPA) instituted a new lower threshold of 12 micrograms per cubic meter of fine particulate matter (PM2.5) to maintain the National Ambient Air Quality Standards (EPA 2024). "Exceptional events" may affect air quality but are still necessary as part of an ecosystem management regime. Prescribed fire is needed on the landscape, to not only mitigate for wildfire risks and maintain resilient landscapes, but to help promote healthy air quality. (S. Cammack, GADNR, pers. comm.). These burns mimic natural events that would have occurred from lightning strikes and allowed to burn unimpeded post-European civilization when the human population was much lower and there were fewer structures on the landscape.

Sound can also be a pollutant in both terrestrial and aquatic systems. Species calling for mates may not be able to hear answering calls; likewise, prey species may not be able to hear predators approaching. In marine environments, sonar and naval weapon discharges can damage or impair the hearing of cetaceans, disrupting behavior.

Runoff from roads can bring oil, gas, and other residues into waterways. Photo generated by AI at www.freepik.com

Threats to aquatic resources in South Carolina include sediments, chemical pollutants, heavy metals, fecal coliform, and microplastics (synthetic polymer fragments and fibers < 5 mm in size). Sediments reaching waterways from

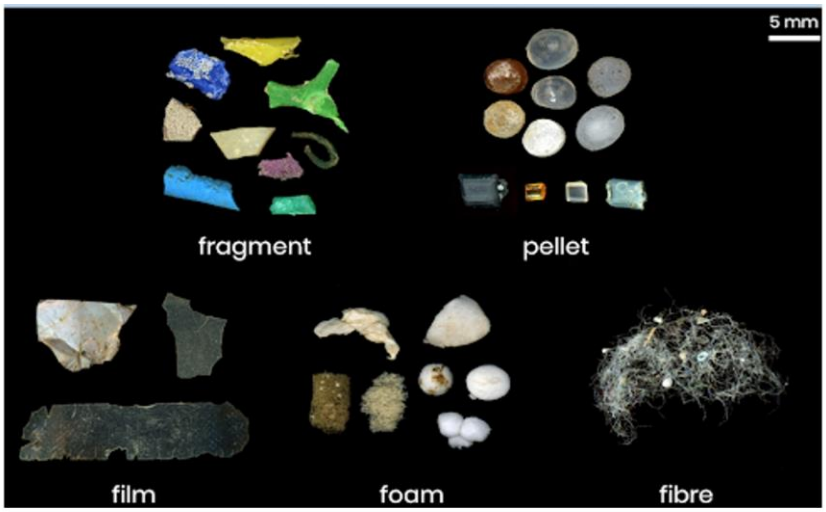
erosion and other ground disturbances can interfere with plankton's absorption of sunlight for nutrients, affecting the food chain. Stormwater runoff carrying chemical pollutants from roads, developments, and agricultural fields can add poisons and excess nutrients (e.g. fertilizers) to aquatic systems, directly killing aquatic organisms or creating algal blooms that then cause fish kills. Native freshwater mussel assemblages across the State are largely dependent on suitable, pollutant-free, stable habitats with adequate access to appropriate host fishes (Ericah Beason, SCDNR, per. comm.). Heavy metals from past and present mining operations can bioaccumulate in fish and other aquatic organisms, impacting food chains and resulting in fish consumption advisories under 303(d) impaired waterways designations. Impervious surfaces disrupt groundwater recharge to aquifers and impact overland flows. Fecal coliform contamination from bacterial runoff from farms (e.g. cattle, swine, and chickens) or from compromised septic systems can sicken wildlife when they contaminate waterways.

Soil can contain the remains of chemicals and other pollutants which can reduce the capacity of plants to thrive, thus creating an impoverished habitat that cannot support higher life forms. The worst examples are brownfields which are abandoned commercial or industrial sites (e.g. gas stations, textile mills) which may require excavation and removal of the toxins. Examples include chlorinated solvents, lead, and petroleum products.

Thermal pollution comes from the discharge of cooled or warmed water into another body of water from power plants, industrial machinery, or even from runoff from host surfaces like pavement. These discharges cause changes to the habitat near the effluent and perhaps beyond as well as the potential for thermal shock in some aquatic animals. Animal behavior can be modified as they either seek the temperature change or avoid it. Whole communities may shift based on these changes in temperature.

Litter

Akin to pollution is the dumping of solid refuse into the environment, collectively called litter. Accumulation of detritus can smother habitats or degrade them. Direct mortality or injury to animals can occur when they become entangled or trapped within litter. Sometimes litter is mistaken for food and ingested, impairing the health of the animal through obstruction, impaired digestive organ function, or absorption of toxins.



There are a wide variety of microplastic contaminants in natural systems. Photo provided by Miriam Boucher (Clemson University) with original information sourced from Alexander Kunz, microplastics researcher in Taiwan.

Abandoned fishing gear, or ghost gear, impacts 45% of all marine mammals on the IUCN Red List of Threatened Species (Ocean Conservancy 2022). A new contaminant, microplastics (synthetic polymer fragments and fibers < 5 mm in size), is being found in waterways in higher and higher concentrations. Trophic transfer occurs in aquatic organisms with unknown health impacts to these species and higher trophic level consumers of these contaminated species (Rochman et al. 2019, Wang et al. 2020).

Invasive Species

The United States Register of Introduced and Invasive Species (US-RIIS) lists 15,264 non-native species in the United States (including Alaska and Hawaii), of which 3,885 (25%) are invasive (Simpson et al. 2021), and the number is steadily increasing. Of this, the conterminous United States has 8,657 non-native species, 2,169 (25%) are invasive (Simpson et al. 2021). The majority of invasive species are plants. Many of these invasive species represent serious threats to agriculture, horticulture, or forestry. Other non-native species are more likely to impact natural communities and individual populations of native wildlife species. Some estimates suggest that 90% of introduced species have resulted in detrimental effects on native wildlife (Hutchins 2011). Invasive and non-native species constitute a significant threat to South Carolina's biological diversity with the exact number unknown. Many native species are declining due to increasing competition or habitat degradation from invasive and non-native species of plants, animals, and pathogens. Some species are still being assessed for their impact severity to South Carolina's ecosystems and if they could be naturally occurring or introduced from abroad.

Kudzu smothering native trees and forbs in rural Oconee County, SC.
Photo by Anna Smith, SCDNR.

What makes a species invasive depends on many things, including its ability to effectively compete for resources and survive the climate of the region such as seasonal temperature changes. The United States Fish and Wildlife Service (2024) categorizes non-native species on their risk of becoming invasive into high, low, or uncertain. A high-risk species is one that already established in one location globally and has a well-documented history of being invasive. A low-risk species is one where there is not evidence of global invasiveness and its establishment is doubtful. An uncertain-risk species needs more study to determine its establishment potential. Risk screening factors may include the species' detectability, ability to reproduce, disperse, carry disease, compete with native species, threaten listed species, impact the economy, and impact human health and safety (FL FWC 2023). An added complication is the definition of "exotic" species which, through range expansion, may naturally move into South Carolina (e.g. Nine-banded Armadillo). This challenges land managers to redefine natural communities and what constitutes "non-native."

Wildlife, water, wind, and humans can act as vectors, inadvertently bringing new species into an area. Sometimes these new species do not compete with the existing community, but often they do. Seeds, tubers, and even animals or parasites can enter South Carolina at ports, hitch a ride on equipment or animal fur, and can come in packing material, dredge spoil, nursery plants, botanical gardens, ballast water, bait buckets, root balls, mulch, and even in the bark of other trees (i.e. Cabbage Palms transplanted from Florida). Sometimes humans deliberately bring them in for landscaping (e.g. Bradford/Callery Pear, Common Periwinkle, Chinese Wisteria), erosion control (e.g. Kudzu), as livestock (e.g. feral hogs and goats), or as pets (e.g. tegu, aquarium fish and plants) which are then released when they are no longer wanted. Sadly, many species once encouraged by wildlife professionals have been found to be deleterious through invasiveness. These include Bicolor Lespedeza, Sawtooth Oaks, and Autumn Olive which were all considered plantings for wildlife forage and are cited in numerous management plans. Even domestic animals can become invasives. Free-ranging cats and feral cat colonies have had enormous impacts on native wildlife with estimates of 1.2 billion birds and 12.3 billion mammals taken by cats annually in the United States (Loss et al. 2013).

Species can escape and become invasive, competing with native wildlife for resources, displacing them, and destroying habitat. Sometimes there is direct mortality (e.g. Hemlock Wooly Adelgid, American Chestnut Blight) on native species as a consequence. New genetic material may be introduced to a

Wild hogs are an invasive species found in many counties in South Carolina. Photo taken by Jeff Blake (OSI) in Florence County, SC.

population resulting in hybridization and a loss of unique genetic lineages. Exotic species bring with them their own pathogens, parasites, and diseases that may enter the local population against which they may have no defenses. Management to recapture sites already affected by non-native, invasive species presents an enormous on-going effort. The economic impact of some common invasive species is profound: $19 billion for rats, $17 billion for feral cats, and $800 million for feral swine (Pimentel et al. 2000). Terrestrial and aquatic plants affecting South Carolina are listed in Appendices 3A and 3B while invasive animals are listed in Appendix 4.

In the case of non-native plants, they can occur in either terrestrial or wetland habitats. Such species can dominate or displace native vegetation and can occur in nearly single-species stands that present a lowered structural diversity and less desirable wildlife habitat. Both tidal low-salinity marshes and wetlands and littoral (shallow water) areas in ponds and impoundments can be densely covered with these species (e.g. Hydrilla and Phragmites). Dense colonies of these plants may restrict hydrological flows and capture sediment, thereby increasing the rate of eutrophication and contributing to low dissolved oxygen (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 Chinese Tallowtree (*Triadica sebiferum*), which quickly becomes established and out-competes more desirable native plants (J.W. McCord, SCDNR, pers. obs.).

Bamboo sold at garden centers can escape from landscaping and degrade native habitats.
Photo by Anna Smith, SCDNR

It isn't always non-native, invasive species that can wreak havoc on the biodiversity and integrity of an ecosystem. Native plants can become a nuisance when their populations increase above normal levels. Examples include Sweet Gum, Rhododendron, and native varieties of *Baccharis* sp. Native pathogens can also be a problem such as Raccoon Roundworm (*Baylisascaris procyonis*) crossing the species boundary to infect the Eastern Woodrat, an SGCN in South Carolina. White-tailed Deer, if overabundant, can over-browse the understory, reducing nesting

habitat for birds and decreasing floristic diversity. Clemson Regulatory Services keeps a list of invasive plants, insects, diseases, mollusks, and nematodes.

Current and Emerging Diseases

Wildlife health is a complex, dynamic topic that can be difficult to define and measure. It is more than just the presence or absence of disease caused by pathogens or contaminants; rather it can be defined by a population's ability to withstand challenges, which may include climate change, habitat loss, or the introduction of a disease-causing agent. Thus, health is the result of interacting biological, social, and environmental determinants (Stephen 2014). Diseases can have significant impacts on wildlife populations. The development of disease depends on factors related to the host organism, its environment, and the disease-causing agent. Pathogens (e.g. bacteria, viruses, parasites, and prions) and contaminants are normally present in wildlife populations, with disease typically occurring at low levels, but becoming more prevalent when hosts are stressed. An emerging disease is defined as "one that has recently been discovered; has recently increased in incidence, geography, or host range; or is newly evolved" (Rachowicz et al. 2005). Two hypotheses can apply to an emerging disease: the novel pathogen hypothesis states that the disease has recently spread into new geographic areas, whereas the endemic pathogen hypothesis suggests that it has been present in the environment but recently has affected new hosts or increased in its ability to cause disease (Rachowicz et al. 2005). For example, in North America, Chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, and White-nose Syndrome, caused by the fungus *Pseudogymnoascus destructans*, (Figure 5-2) have emerged following pathogen introduction and have had devastating impacts on amphibian and bat populations, respectively.

Disease can have direct impacts, such as mortality, or can have indirect impacts, such as reproductive failure; both types of impacts can lead to population declines. As some species disappear from the landscape, others can proliferate, causing an imbalance in predator-prey relationships or overuse of resources. Sometimes these diseases are zoonotic and threaten human health as well. According to the World Health Organization, 70-80% of emerging infectious diseases are zoonotic in origin. Wildlife health is a critical component of One Heath, which is the intersection of human health, animal health, and environmental health. Therefore, discussions of wildlife health must consider connections with humans, domestic animals, and ecosystems. Such connections may include game species as a food source for humans, pathogens that can be transmitted between wildlife and humans or domestic animals, and the habitats needed to support wildlife populations. In addition, healthy ecosystems provide a variety of ecosystem services for humans, including agricultural production and recreation.

A Tricolored Bat (SWAP highest) showing the tale-tell signs of White-nose Syndrome on the muzzle. Photo by Jennifer Kindel, SCDNR.

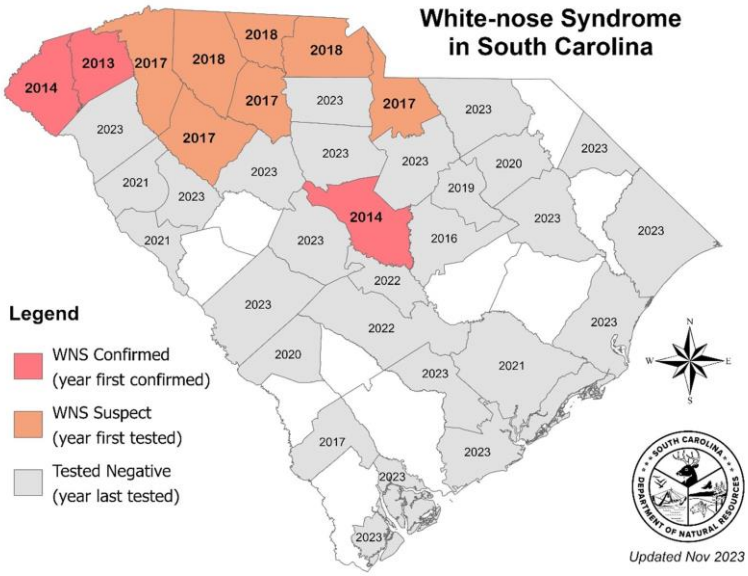


FIGURE 5-2: White-nose Syndrome status in bats in SC from 2013-2023.

Natural Processes

Even natural processes can be a threat or at least a stressor. The changing of the seasons (e.g. frosts, algal blooms/red tide events), weather patterns, food supplies, competition, and predation are all examples. In the case of predation, coyotes and wild hogs are a constant threat to sea turtle nests while crows have had devastating effects on some Least Tern nesting colonies (Mary-Catherine Martin, pers. comm). Even as communities undergo natural successional stages, there is displacement at each step. For example, a grassland may slowly fill with shrubs and trees and then climax as a forest. Species that require different stages will occupy the landscape at different times depending on the habitat present.

> "Harmony with land is like harmony with a friend; you cannot cherish his right hand and chop off his left. That is to say, you cannot love game and hate predators... The land is one organism."
>
> **– Aldo Leopold**

Natural Disasters

Like natural processes, natural disasters can stress species. Examples of natural disasters include hurricanes, tornados, ice storms, droughts, wildfires, and flood events. The severity of the event, how widespread it is, and how long it lasts are all factors contributing to stress on species. Disasters can be especially harsh on rare or declining species that are already in small refuges and thus greatly impacted by even the most localized events. During natural disasters, animals and plants can experience direct mortality, displacement, habitat destruction, or a disruption in their life cycle (e.g. a storm that destroys bird nests and thus reproductive success for that breeding season).

Ice storm damage in Williamsburg County, SC. Photo provided by the SCFC.

Tornado damage in Allendale County, SC. Photo provided by the SCFC.

Climate Change

Climate change is a vast topic that affects a multitude of ecological and biological systems. Our ability to predict the consequences of climate change is limited by uncertainty in climate predictions compounded by complexity in ecological system behavior. Our climate is being impacted not only by natural warming cycles but also by a 40% increase in greenhouse gas emissions into the atmosphere by humans since the 1700s (EPA 2016). The six primary gases defined by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

As the climate warms and moisture regimes change, there can be an array of changes ranging from changes in weather patterns to the resulting habitat changes. Examples of climate change-induced changes include the uncoupling of phenologies (e.g. Vasiliev and Greenwood 2021, Thackeray et al. 2016, Robertson et al. 2024) such as plant bloom windows versus insect emergence, range shifts (expansions and contractions), hybridizations, and changes in food webs/pyramid bases. As sea level rises and ocean waters experience thermal expansion, habitats can become inundated with salt water. According to the National Sea Level Explorer (2024), two locations in South Carolina have been assessed for sea level rise (SLR) changes since 1993; Charleston Harbor (Charleston County) has experienced a 8.2 inch rise while Springmaid Pier (Horry County) has had a 8.3 inch rise. Charleston peninsula will experience even more flooding in the future (Sweet et al. 2022). Salt-sensitive plants species die back in favor of migrating marshes and mangroves. Salinity intrusion into once fresh water sources changes entire communities. Ocean acidification can disrupt the calcium deposition in corals, univalves, and bivalves, leading to collapses in diversity as species die out. As precipitation changes, so do hydrologic regimes (flows). Increased temperatures likewise affect snowmelt patterns and frost-free days as well as land and water temperatures. Heat stress can affect survivability of some species. The severity and timing of weather events may produce droughts, rain bombs, floods, and severe storms. As the climate changes, ecosystems will naturally encroach into new areas with unpredictable consequences. One example of this is mangroves, which are advancing northward through Georgia while simultaneously retreating in Florida, and how their presence will affect salt marshes (Adno 2024). Habitats will migrate, with species experiencing range expansions or contractions. Habitat loss and degradation will occur.

Skeletonized trees in “the boneyard” at Cape Romain National Wildlife Refuge bear witness to rising sea levels. Photo by Keith Bradley, SCDNR.

Chapter 10 provides a regional perspective of climate change impacts in the Southeast. Other documents that address climate changes in South Carolina are the South Carolina Comprehensive Climate Action Plan (CCAP) (2024) and the South Carolina Strategic Statewide Resilience and Risk Reduction Plan (2023). An older document, Climate Change Impacts to Natural Resources in South Carolina (2013), is outdated but provides interesting predictions and case studies for comparison with more recent models.

Overharvesting, Illegal Collecting, and the Exotic Pet Trade

Some species of wildlife are managed through hunting or fishing regulations, but illegal overharvesting or overexploitation can and does occur, negatively affecting populations. Direct mortality can result from humans harassing species in an attempting to capture, transport, and confine South Carolina's native species as "pets". Both animals and plants fall victim to the illegal pet trade as they are collected from their native habitats which often results in degradation of the biological community from their removal. If too many of a species are removed, the depopulation can threaten the continued survival of the species on the landscape. Often humans cannot provide the best accommodations for species so that they suffer from malnutrition, behavioral and physical abnormalities resulting from stress, and loss of vital survival instincts. As humans search for these species across the landscape, the intrusion can spread pathogens and diseases as well as result in habitat destruction. If a pet owner no longer wishes to keep the animal or plant, they are often released back onto the landscape in inappropriate habitats where they are likely to perish. Sometimes they simply escape captivity.

In 2021, poachers at Lewis Ocean Bay Heritage Preserve were caught digging up Yellow Pitcher Plants and issued citations by SCDNR Law Enforcement. The plants were returned to their extraction sites. Photo by SCDNR.

Illegal collecting and poaching of wildlife and plants are threats to SGCN in South Carolina, often requiring intervention by law enforcement. Photo by Joey Frazier, SCDNR.

Non-native species are also kept as pets. Currently, there are over 1,000 species in the exotic pet trade, with the United States being the largest global market for the trade (Scheffers 2024). High-volume, low-cost species are often easy to obtain but naïve buyers, tired of their care or when the animal overgrows its living quarters, release them into native systems. This can alter ecosystems if these released species are able to survive and thrive in these new environments. Climate change is causing temperate systems of the Southeast to transition to tropical environments, making it easier for once cold-sensitive species to survive the winters,

reproduce, and disrupt native food webs (Scheffers 2024). South Carolina falls within a high-risk area for such invasions as it has an overlap in both a high pet ownership culture (popularity) and pet store locations (industry) on top of climate suitability (Scheffers 2024).

Eastern Box Turtles (SGCN High) confiscated from a poacher. Photo by Andrew Grosse, SCDNR.

As an example of the magnitude of the problem, since 2013, SCDNR has compiled over 2,400 reports of nonnative reptile and amphibian species observed and reported throughout South Carolina. Over that time, biologists have visually confirmed, in person or through photographs, 873 reports of over 30 nonnative species. The most frequently reported species include Mediterranean House Geckos, Brown Anoles, Red-eared Sliders, Cuban Tree Frogs, Argentine Black-and-White Tegus, African Spurred Tortoises, and Ball Pythons. SCDNR has also confirmed Burmese Pythons, Green Iguanas, various tortoise and monitor lizard species, and two crocodilian species. The Argentine Black-and-White Tegu, which is prohibited in South Carolina, has been confirmed from 17 counties statewide as of 2024. To date, 18 tegus have been removed from the wild in South Carolina. Releasing nonnative reptiles and amphibians is illegal in South Carolina. The public can report sightings of non-native species on the SCDNR Non-native Animal EDDMapS reporting page.

Broken bottles, campfires, and graffiti spraypainted on the granitic dome at Bald Rock Heritage Preserve has damaged rare plants like Blue Ridge Ragwort (*Packera millefolia*). Photo by SCW staff.

Exploitation can also occur on the habitat level such as when sand is mined or river rocks are removed for landscaping, changing the characteristics and suitability of the habitat. Human activities can completely destroy or seriously degrade habitat properties relied on by species for some stage of their life cycle. In the case of removal of aquatic river stones for landscaping, salamanders, fish, crayfish, and aquatic insect larvae that

utilize this substrate for shade, protection from swift currents, nesting, or hiding are negatively impacted. Even if features or structures are not removed directly, they can be rendered obsolete if degraded. An example would be when reptile collectors cleave rock outcrops and overturn boulder fields in the search for snakes hidden in winter denning sites (Andrew Grosse, SCDNR, pers. comm.). Sometimes outright vandalism affects sensitive habitats like spray-painting on granitic domes.

Persecution by Humans

Snakes are often killed when misidentified as venomous. This Southern (Banded) Watersnake was presumed to be a "cottonmouth." Photo provided by Andrew Grosse, SCDNR

Persecution involves the intentional killing of a species (e.g. snakes) or harassment (e.g. chasing shorebirds and hatchling sea turtles). Indirect persecution may come from the disruption of the equilibrium between predators and their prey. This is best demonstrated through misguided predator removal programs that end up removing top carnivores or mesocarnivores, upsetting the biological balance. Over-browsing by herbivores may occur, resulting in habitat deterioration and food web disruptions. Other indirect impacts on wildlife come from the willful destruction of nests, roosts, dens, or other places of refuge or young-rearing sites. Although some destruction is necessary for human health (e.g. bats in the attic), safety (e.g. geese on airport runways), and sanitation (e.g. vulture roosts on houses) or to prevent infrastructure complications (e.g. nests on cell towers), other destructive behaviors have no basis in sound management and are thus categorized as persecution.

Recreation

Managing agencies face competing demands for access by users whose interests are not always compatible. Impacts of recreational uses on the resource base vary by intensity and type, posing challenges to meeting resource-based management objectives.

Disturbance of seabirds by walking, jogging, or biking through them causes stress. Allowing pets to run through or chase shorebirds is also a stressor. Photo by Janet Thibault, SCDNR.

Perhaps the most unintended threat or stressor is that caused by humans acting benevolently toward or simply independently of wildlife and their habitat needs. The simple presence of a human in a sensitive area (e.g. Wood Stork rookery) may disrupt natural behaviors and lead to abandonment of a site or reduced survivorship. Human traffic can trample nestlings or rare plant species while pets allowed to roam off leash or in restricted areas can directly kill, injure, or harass wildlife. Nest attempts by shorebirds and sea turtles may be aborted when humans disturb a site (Mary Catherine Martin, pers. comm.). Studies have also shown that the sound of human recreating in an area can elicit predator avoidance behavior in wildlife and hypervigilance, a stress reaction (Zeller et al. 2024). Even though nature tourism is an important contributor to local economies, photographers and wildlife watchers that descend on sensitive habitats can disrupt species behavior in the quest for the perfect picture (i.e. use of call playbacks, baiting, drones, and handling) (Davis et al. 2024). Their online posting to social media accounts can bring unwanted attention to rare and declining species by advertising species locations to poachers as well as increasing visitation which can spread disease and a higher risk of predation (Davis et al. 2024).

A game camera captures an unnatural gathering of deer and raccoons around an artificial food source, a corn feeder. Photo by Anna Smith, SCDNR.

Humans also like to feed wildlife under the mistaken belief that they need to supplement the wild diet. Sometimes these additional foods are not as nutritious as the wild variety the species would typically feed upon or can result in health problems for the wildlife through digestive complications. As animals congregate at food sources like feeders or corn piles, unnaturally high concentrations of a species (e.g. deer herds) or assemblages of species (e.g. deer, squirrels, and raccoons) may co-mingle at the same site, increasing the likelihood of disease transmission and altering behavior. Sadly, some humans think that by relocating a species (which is often illegal), they are both ridding themselves of a nuisance but letting it live. However, many species are often placed outside of their territory where they knew where to find food, in inappropriate habitats, or outside of their natural range. This often leads to stress or direct mortality of the animal.

> "Ethical behavior is doing the right thing when no one else is watching- even when doing the wrong thing is legal."
> **- Aldo Leopold**

TABLE 5-1: Primary Threats, Stressors, and Associated Impacts			
Primary Threats and Stressors		**Associated Impacts**	
1	Lack of Species Data	1.1	taxonomic uncertainty
		1.2	population size unknown
		1.3	distribution unknown
		1.4	life history unknown
2	Development & Infrastructure	2.1	direct mortality during construction phase
		2.2	habitat destruction
		2.3	habitat fragmentation (from engineered structures or loss of corridors for dispersal through appropriate habitats)
		2.4	habitat alterations / degradation (including altered sediment regimes)
		2.5	non-point source pollution (chemicals, fertilizers, pathogens); sedimentation
		2.6	point source pollution (effluents, sewage, chemicals, thermal discharges)
		2.7	unnatural species concentrations and interactions
3	Transportation and Service Corridors	3.1	direct mortality or injury from collisions
		3.2	habitat degradation / fragmentation (from engineered structures, the removal of natural structures, and the transmission of invasive species)
		3.3	habitat destruction (through vegetation management regimes or through the use of impervious surfaces)
4	Beach Nourishment/Shoreline Stabilization/ Shoreline Modification	4.1	direct mortality
		4.2	loss of habitat or food resources
		4.3	alterations to sediment regimes and wave action
5	Agriculture (row crops and livestock)	5.1	loss of diversity
		5.2	habitat fragmentation and interrupted gene flow
		5.3	groundwater withdrawals impacts on hydrology
		5.4	habitat destruction / alterations (including loss of food resources)
		5.5	runoff pollution (herbicides, fungicides, insecticides, rodenticides, fertilizers, fecal coliform, sediment)
6	Mining Operations	6.1	direct mortality
		6.2	habitat destruction
		6.3	hydrologic alterations
		6.4	pollution (chemicals, heavy metals, sediments)
7	Solar Farms	7.1	direct mortality
8	Wind Energy Facilities (mainland [A] and offshore [B])	8.1	habitat destruction or alterations (including productivity and temperature regimes)
		8.2	displacement
		8.3	maladaptive behavioral changes
9	Silviculture	9.1	direct mortality from timber operations

		9.2	fire suppression (resulting in plant & animal community changes)
		9.3	artificial habitat creation (inappropriate tree stocking rates or thin cycles; planting of off-site tee species; loss of diversity through monocultures)
		9.4	introduction of invasive plants / seeds
		9.5	runoff pollution from chemicals and/or fertilizers
		9.6	altered hydrologic and sedimentation regimes
10	Pollution (light [A], air [B], sound [C], water [D], soil [E], thermal [F])	10.1	direct mortality
		10.2	mutations /cellular damage
		10.3	disruption of life cycle
		10.4	disruption of behavior; vulnerability to predation
		10.5	habitat destruction / degradation
		10.6	aquatic habitat imbalances
		10.7	trophic cascade leading to food web impacts and disruptions host relationships
11	Litter	11.1	direct mortality or injury from entrapment
		11.2	direct mortality or impaired health from ingestion or absorption (toxicity)
		11.3	habitat degradation
12	Invasive Species (native or non-native/exotic)	12.1	direct mortality
		12.2	displacement and/or competition for resources
		12.3	introduced genetic material / hybridization
		12.4	new pathogens, parasites, diseases, etc.
		12.5	loss of biodiversity
		12.6	habitat degradation (including herbivory impacts from overpopulated native species)
13	Current & Emerging Diseases (pathogens, microbes, viruses, prions)	13.1	direct mortality
		13.2	decreased fitness
		13.3	ecosystem imbalances
		13.4	habitat degradation
14	Natural Processes	14.1	Competition for resources
		14.2	predation
		14.3	normal seasonal shifts in weather patterns and temperature / effects on habitats
		14.4	shifts in communities from natural ecosystem succession
15	Natural Disasters (hurricane, tornado, ice storm, wildfire, drought, flood)	15.1	direct mortality
		15.2	displacement
		15.3	habitat destruction
		15.4	disruption of life cycles
16	Climate Change	16.1	effects of uncoupled phenologies
		16.2	effects of ocean acidification

		16.4	effects on species' habitat utilization patterns and life cycles from changes in snowmelt patterns, frost-free days, precipitation, and flow regimes
		16.5	changes in food web / pyramid bases
		16.6	severity and timing of weather events on life cycles
		16.7	habitat chemical composition changes from increases in water temperatures
		16.8	range shifts and hybridizations
		16.9	direct habitat loss or degradation
		16.10	habitat changes to new steady states: ecosystem encroachment / habitat migration (expansions and contractions); other ecological transformations
17	Overharvesting and Illegal Collecting / Exotic Pet Trade	17.1	direct mortality
		17.2	harassment
		17.3	decreased fitness caused by the spread of pathogens and diseases
		17.4	habitat destruction through human intrusion or manipulation
		17.5	competition from non-native introductions (releases and escapes)
		17.6	depopulation
18	Persecution by Humans (intentional)	18.1	direct mortality through purposeful killing
		18.2	harassment
		18.3	ecological disequilibrium from predator removal
		18.4	indirect effects from willful destruction of nests, roosts, dens, etc.
19	Recreation (unintentional)	19.1	unintentional direct mortality or injury
		19.2	human intrusion / harassment negatively altering behavior
		19.3	negative health and behavior impacts from intentional or unintentional feeding
		19.4	human or pet disturbance / harassment or destruction of sensitive habitats
		19.5	uniformed relocation of species to inappropriate habitats or ranges resulting in mortality or decreased fitness

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CHAPTER 6: SOUTH CAROLINA'S PRIORITY SPECIES (SPECIES OF GREATEST CONSERVATION NEED)

The Southeast North American Coastal Plain is considered a global biodiversity hotspot, and South Carolina contributes to this high species diversity through its topography, latitude, and vast river systems (Jenkinsa et al. 2015, Noss 2016). Habitats in this state range from the mountains to the ocean and include many different taxonomic animal groups. Although all native biota are important to maintain fully functioning ecosystems critical to all life, not all are experiencing declines, and some are actually increasing their populations. As per the federal requirements for State Wildlife Action Plans (SWAPs), prioritization is required. Reasons to prioritize include urgency of conservation efforts needed, funding availability, capacity to implement conservation actions, and feasibility of those actions, among other reasons.

The South Carolina Department of Natural Resources (SCDNR) wanted to address as many native taxa groups as possible for inclusion in the list of priority species—Species of Greatest Conservation Need or SGCN—for the South Carolina SWAP. Therefore, 16 taxonomic groups are included in the Strategy: mammals, birds, reptiles, amphibians, freshwater fish, diadromous fish, marine fish, marine invertebrates, crayfish, freshwater shrimp, freshwater mussels, freshwater snails, freshwater sponges, leeches, insects, and plants. Though not a requirement but encouraged, the inclusion of plants is a proactive response to the need for landscape-level management, wherein plants are an integral component. Plants are not eligible for funding under the State and Tribal Wildlife Grants (SWG) Program or the related Competitive SWG but are of concern nonetheless as they are the basis of the habitats that support vertebrate and invertebrate ("animal") species that are eligible for funding.

Species Selection Process (Methodology)

After the 16 taxonomic groups were identified, a taxa leader was appointed that managed the process for identifying priority species for conservation within that group. This leader formed a committee or team of experts for their specific taxa. First, the committee reviewed a list of all known species within that group that are found in South Carolina to make sure their subnational (state) ranks (S-ranks) were updated and correct. SCDNR's GIS team built a decision support tool ("SWAP Tool") which roughly follows the NatureServe methodology to calculate provisional S-ranks automatically using existing data for a given species, either within the South Carolina Natural Heritage Program's database or the Global Biodiversity Information Facility (GBIF) if applicable. The NatureServe Rank Calculator categorizes species status data based on range extent, area of occupancy, abundance/condition, environmental specificity, threat impact, intrinsic vulnerability, short term trends, and long-term trends. A detailed summary of the official ranking methodology can be found in *NatureServe Conservation Status Assessments: Methodology for Assigning Ranks* (Faber-Langendoen et al. 2012) and is a *Best Practices for State Wildlife Action Plans* (AFWA 2012) recommended tool for SGCN evaluation.

NatureServe definitions of S-ranks are as follows:

- S1 (critically imperiled)
- S2 (imperiled)

- S3 (vulnerable)
- S4 (apparently secure)
- S5 (secure)
- Ranks with 'N' (Nonbreeding), 'M' (Migratory), and 'B' (Breeding) refer to conservation status for a species specifically during that portion of its life history.

These S-ranks then inform the global ranks (G-ranks) created by NatureServe.

Specifically, the SWAP Tool used the 'rarity' factors including range extent, area of occupancy, and number of occurrences. Threats and trends factors are more subjective and relied on expert knowledge of the species. Therefore, SCDNR taxa team leads subsequently reviewed these provisional ranks and changed the threats and trends factors accordingly which shifted the suggested rank up or down. While the methodology only required the rarity factors to produce a rank suggestion, the threats and trends played an important role in shifting the ranks up or down significantly if a species had heavy pressures like habitat loss, disease, significant downward (or upward trends), etc.

Some taxa groups, such as those that included invertebrates, were depauperate in terms of data available, resulting in barriers to conservation management. Examples may include the following knowledge gaps which resulted in some species not being ranked ['not ranked' (SNR)] or 'unrankable' (SU) designations at this time.

<u>Knowledge Gaps</u>

- taxonomic uncertainty
- unknown population status and trends
    - fecundity
    - survival rates (including viability of seed banks over time)
    - recruitment
    - genetic structure
    - sex ratio
    - minimum viable population
- unknown life history needs
    - life cycle
    - food requirements
    - habitat associations by season
- unknown threats
- conservation action outcomes uncertainty

In other cases where some level of knowledge is known about the state of a species' threats, trends, or rarity but there is still uncertainty associated, range ranks and inexact ranks are implemented, which are intended to account for this uncertainty. Examples of inexact ranks include: S3?, S2S3, etc. Additional letters may appear in a species' ranking such as in the status of infraspecific taxa (subspecies or varieties) which are indicated by a "T-rank" (see NatureServe's Conservation Status Categories for further explanations.

The criteria experts considered when deriving their final SGCN lists are shown in Box 6-1, many of which are part of the NatureServe Rank Calculator. Please note that for freshwater fishes, the species selection process was informed by a data-based index quantifying multiple ecological attributes influencing conservation need (Appendix 5).

BOX 6-1: CONSIDERATIONS FOR SGCN INLCUSION

- State and federal protection status: endangered, threatened, at-risk, rare, or special concern; other listings (IUCN, etc.)
- Previous SWAP inclusion as an SGCN
- South Carolina Natural Heritage Program subnational rank as reported to NatureServe
- Degree of exploitation/harvest: high, medium or low
- Feasibility measure: the likelihood that conservation activities in South Carolina can make a difference for this species
- Regional SGCN listing
- Knowledge of the species' population status
- Knowledge of species' distribution in the state
- Knowledge of limiting factors affecting the species
- Population status (trend): population decreasing, stable or increasing
- Keystone species, sentinel species, or major prey base

Some SGCN in South Carolina's SWAP may have funding available elsewhere to address management needs (i.e. Wildlife and Sport Fish Restoration funds), but this did not automatically preclude them from being listed as an SGCN. Instead, funding options are considered when State Wildlife Grant requests are put forth, with preference given to those species for which no other funding sources exist. See Chapter 8 for more details. It should also be noted that some of the species that are included in the current SGCN list are considered game species that are harvested through regulated hunting or fishing. Regulated harvest of game and fish species is not considered a threat to populations. Nonetheless, other threats such as habitat loss and degradation are of concern for certain game species. These populations and their habitats, as well as regulated harvest, are and will be carefully monitored, and efforts should continue to be made to enhance, restore, and acquire additional habitat for SGCN species.

Once all S-ranks were reviewed and confirmed as finalized by staff, the SWAP Tool also automatically calculated a provisional SWAP priority value of Highest, High, Moderate, or Data Deficient based on a rubric developed by the Southeast Association of Fish and Wildlife Agencies, Wildlife Diversity Committee (2022) in the *SGCN Recommendation Report* (funded through a Competitive State Wildlife Grant). This rubric (Figure 6-1) took into consideration not only S-rank and global rank (G-rank) but also the following:

- Endangered Species Act (ESA) status
  - Endangered (E)
  - Threatened (T)
  - Candidate (C)
- State of South Carolina (pg. 54-56) listing status
  - Endangered
  - Threatened

- International Union for Conservation of Nature (IUCN) Red List status
  - Data Deficient (DD)
  - Least Concern (LC)
  - Near Threatened (NT)
  - Vulnerable (VU)
  - Endangered (EN)
  - Critically Endangered (CR)
  - Extinct in the Wild (EW)
  - Extinct (EX)
- Partners In Flight (PIF) Watchlist status
  - Red List
  - Yellow Lists – restricted range (R) and declining populations (D)
  - Common Bird in Steep Decline (CBSD) but criteria not met for listing
- Southeast Regional Species of Greatest Conservation Concern (RSGCN) status for both animals (2019) and plants (2023)
  - Very High
  - High
  - Moderate

Data Deficient species were self-evident, having a lack of data on which to base a solid definition of status yet still of conservation concern based on criteria previously mentioned in Box 6-1. The taxa teams made sure that the automatic sorting process resulted in a prioritized list of species for the SWAP and compared this to the 2015 SGCN list to legitimize changes.

Insects are one of the taxa groups containing many data deficient species. Photo of mating *Habroscelimorpha dorsalis* by Anna Smith, SCDNR at Cape Romain National Wildlife Refuge.

Priority Tier	Definition	Reference Criteria
Highest Conservation Concern	Imperiled species that may become extirpated from the State in the near future unless conservation efforts are continued or enhanced. The population(s) in the State is/are important to the global conservation of the species.	-G1-G2 -RSGCN Very High or High **and** S1-S2 -ESA E -ESA T or C **and** S1-S2 -IUCN CR or EN **and** S1-S2 PIF Red Watchlist Species
High Conservation Concern	Imperiled species that may continue to decline in the State unless conservation efforts are continued or enhanced. The population(s) in the State is/are important to the global or regional conservation of the species.	-G3-G4 **and** S1-S2 -G5 **and** S1 no G-rank but S1 -RSGCN Moderate **and** S1-S2 -RSGCN Very High or High **and** S3 -ESA T or C **and** S3 -IUCN CR or EN **and** S3 -IUCN VU **and** S1-S2 PIF Yellow Watchlist Species
Moderate Conservation Concern	Species that may be currently stable but of long-term conservation concern due to increasing or emerging threats or species that are currently stable but are representative of an ecosystem or community in need of conservation or species that are currently stable but represented by a strong population or unique genetic diversity that is worthy of conservation within the State.	G3 **and** S3 RSGCN Moderate **and** S3 IUCN VU **and** S3 PIF CBSD
Data Deficient	Species that may be imperiled, but lack of information on their conservation status, taxonomy, life history, and threats precludes the identification of conservation actions other than to conduct more research and surveys.	Any G-rank **and** SU SH or SX species that may be rediscovered IUCN Data Deficient

FIGURE 6-1: Rubric used to determine South Carolina's SGCN priority status.

As with the S-ranks, all SWAP priorities calculated by the SWAP Tool were meant to be a suggestion that the taxa team lead could agree with or make manual changes to/override if preferred, which some did. Therefore, the SGCN decision making process can be defined by the flowchart depicted in Figure 6-2.

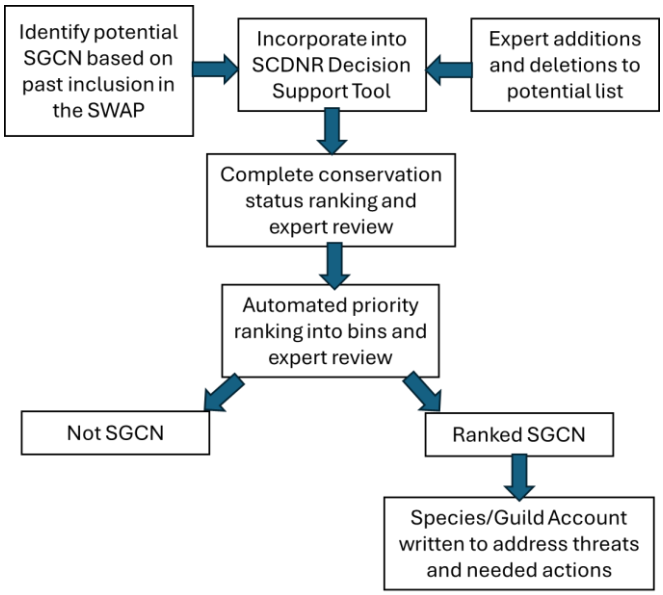

FIGURE 6-2: Flowchart of the SGCN selection process.

Species Listing Format

South Carolina's SGCN list is included in this chapter (Table 6-2). Once the lists were completed by the taxa teams, species or guild (group) accounts were prepared for each animal on South Carolina's SGCN list with the exception of plants and insects. For those SGCN that received a written account, each followed a standardized format to make sure Required Elements 1-6 were included. Authors described the species, their status, population size and distribution, habitat requirements, challenges faced, conservation accomplishments thus far, conservation recommendations for future action, and how to measure success. All accounts are consolidated under separate cover in the **Supplemental Volume: Priority Species and Habitat Accounts** which can be found on the SCDNR SWAP website. The last column in Table 6-2 below references how each individual SGCN was incorporated into the Supplemental Volume—either individually or as part of a guild. However, the last column in the Plants taxa section references an Excel spreadsheet in the Supplemental Volume. It details each species' priority habitat associations as determined by the taxa committee and presented in a format reminiscent of those of Hamel (1992), Trani et al. (2007), and Wilson (1995) in which X's appear in rows and columns. The Insects and Allies taxa's last column contains generalized location and habitat associations if know. These alternative SGCN representations serve as the plant and insect alternative to the species/guild narrative approach as many of these species are so data deficient that there is not enough information to discuss. Although habitat needs and life history traits are

not expounded upon for insects and plants, they are still viable portions of this SWAP as threats and action items are addressed for them in Chapter 4.

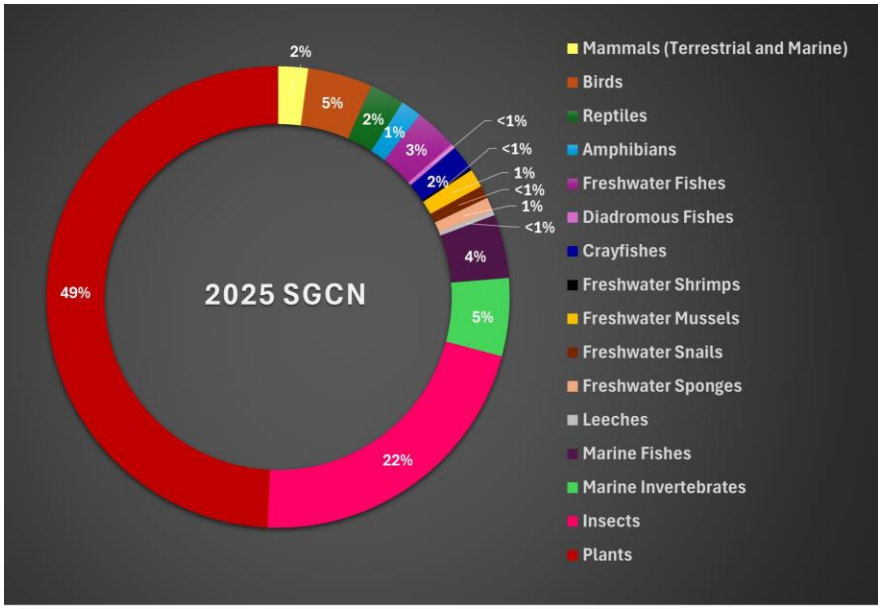

FIGURE 6-3: Proportion of South Carolina SGCN in each taxa group.

TABLE 6-1: Number of South Carolina Species of Greatest Conservation Need by Taxa

	Taxa	No. of Species
1	Mammals (Terrestrial and Marine)	37
2	Birds	80
3	Reptiles	43
4	Amphibians	26
5	Freshwater Fish	53
6	Diadromous Fish	6
7	Crayfish	30
8	Freshwater Shrimp	3
9	Freshwater Mussels	23
10	Freshwater Snails	16
11	Freshwater Sponges	17
12	Leeches	6
13	Marine Fish	79
14	Marine Invertebrates	97
15	Insects	383
16	Plants	874
	Total Number of Animals Species	**889**
	Grand Total of All Species (including plants)	**1,773**

The total number of species included in South Carolina's 2025 SWAP is 889 members of the animal kingdom and 874 plants for a grand total of 1,773. The species representation is almost exactly half animals and half plants. Table 6-1 identifies the number of species included in each taxa group while Figure 6-3 represents this data graphically. Priority rankings for the species resulted in 11% of species in the Highest bin (mostly herpetofauna), 55% High (mostly plants), 9% Moderate (mostly marine invertebrates), and 25% Data Deficient (mostly insects and allies). Interestingly, of the total plant SGCN, the vast majority were in the High or Highest priority bins. Figure 6-4 demonstrates the frequency of bin rankings graphically.

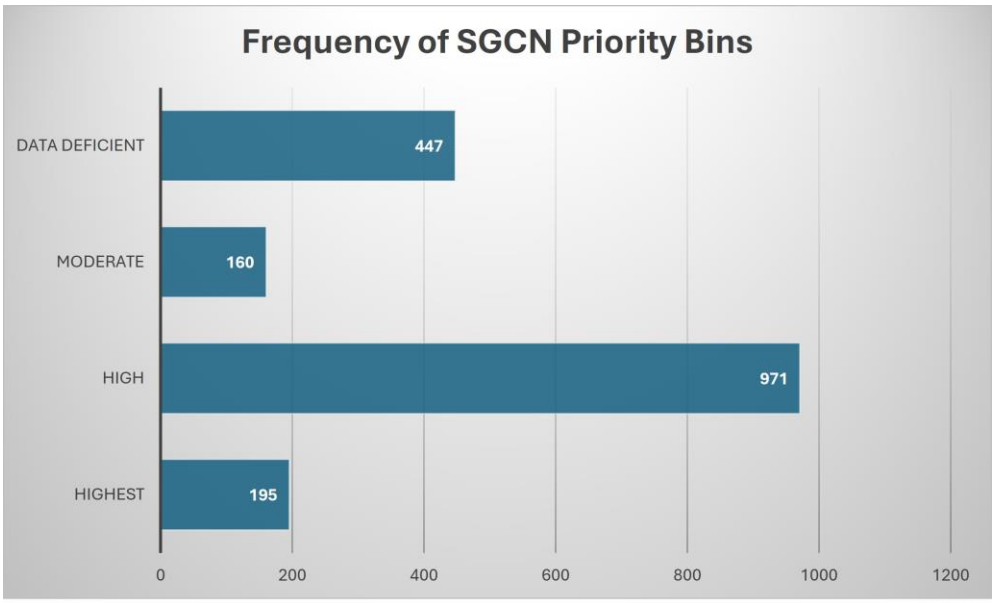

FIGURE 6-4: The frequency of bin rankings of SC's SGCN.

Non-prioritized Species and Urbanized Environments

South Carolina is home to many other species of plants and animals that do not appear in this SWAP. However, the premise of the SWAP is to not only prioritize and assist SGCN but also keep common species common. Although common species such as White-tailed Deer, Eastern Wild Turkey, Mourning Dove, Bobcat, Black Bear, Racoon, Virginia Opossum, Grey Fox, and Red Fox, among others, do not feature in the SWAP, they too will benefit from habitat protection, restoration, and management regimes implemented for SGCN.

Culverts under major roads are manmade structures but do benefit bats and birds by providing roosting and nesting structure, respectively. Photo by Anna Smith, SCDNR.

Additionally, even though urban environments do not feature in this SWAP, they too can provide habitat for both common species and SGCN. Despite their comparatively low habitat value relative to wilderness areas, well-managed urban settings can provide important ecological functions and benefits. Urban trees, shrubs, and grasses provide habitat for many of the more common species of birds, mammals, reptiles, and amphibians. This vegetation cools air temperatures, absorbs noise, filters pollutants from runoff while also controlling volume and velocity.

Treefrogs, like this Squirrel Treefrog, are a common occurrence on structures in the suburban environment. Photo by Anna Smith, SCDNR

Some common species of wildlife even do quite well in urban landscapes, having adapted to the opportunities human modifications provide. These include bridges and culverts utilized by bats and nesting swallows and bird boxes utilized by cavity-nesting species of squirrels and birds. The Purple Martin, a SGCN in the South Carolina SWAP, is now almost completely dependent on humans for the gourds erected for nesting. Likewise, the Chimney Swift, another SGCN, has declined due, in part, from the loss of traditional chimneys as a nesting substrate. In all, over 100 native bird species utilize these areas for breeding or stop-over habitat during migration (NBCI 2013). Eastern Glass Lizards, relatives of the two priority glass lizards in the SWAP—Island and Mimic—also can be quite common in urban and suburban sites. Many homeowners are accustomed to the sight and sound of treefrogs in their yards or clinging to windows and exterior walls.

Barn Swallows (left) often utilize human structures for nesting such as culverts, bridges, or this porch light. A shoe left too long outside may become a home for a Carolina Wren (right)! Photos by Anna Smith, SCDNR.

Residential neighborhoods can still provide habitat for wildlife when homeowners landscape with native plants, provide nesting sites, and provide alternative food and water sources. High-rise office buildings can provide nesting ledges for Peregrine Falcons and Least Terns while the buildings themselves can be built to LEED certification standards (such as using bird-safe exterior glass) to avoid some of the detrimental impacts of the buildings' footprints on the landscape. Nighttime lighting adjustments and encouraging pet owners to keep their cats indoors also help protect native wildlife in the urban environment. In addition, conservation-minded

A herd of urban White-tailed Deer in Mount Pleasant, SC. Photo by Anna Smith, SCDNR.

zoning recommendations can be made to maintain travel corridors and a mosaic of appropriate habitat interspersed with urban or suburban areas.

> "There are some who can live without wild things, and some who cannot."
>
> **- Aldo Leopold**

A family of Barn Swallows nest under a bridge. Photo by Anna Smith, SCDNR.

South Carolina's List of Species of Greatest Conservation Need (SGCN)

TABLE 6-2: South Carolina's 2025 list of Species of Greatest Conservation Need (SGCN). The taxa groups are arranged as follows and in alphabetical order by scientific name with each trouping: ANIMALS – Mammals, Reptiles & Amphibians, Birds, Leeches, Diadromous Fishes, Freshwater Fishes, Freshwater Shrimps, Crayfishes, Freshwater Mussels, Freshwater Snails, Freshwater Sponges, Marine Invertebrates, Marine Fishes; Plants; and Insects & Allies (arranged by major groups). Blanks mean N/A. An icon appears next to those species addressed in Chapter 7 as culturally significant. G- and S-ranks are updated periodically. Therefore, the information presented in this table displays the known rank at the time of publication. Those species with a protection status mean there are laws protecting them in some capacity at either a state or federal level or both. MBTA = Migratory Bird Treaty Act. Plants have a related Excel table in the Supplemental Volume instead of species/guild accounts. Insects and Allies have generalized location and habitat information in the last column and no further appearance in the Supplemental Volume.

SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK	PROTECTION STATUS	SGCN PRIORITY	RSGCN PRIORITY	SUPPLEMENTAL VOLUME INCORPORATION
ANIMALS							
MAMMALS							
Condylura cristata	Star-nosed Mole	G5	S3		High		Moles Guild
Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	G3G4	S2	State Endangered	High	High	Colonial Cavity Roosting Bats Guild
Eptesicus fuscus	Big Brown Bat	G5	S4		Moderate		Colonial Cavity Roosting Bats Guild
Eubalaena glacialis	North Atlantic Right Whale	G1	S1	Federally and State Endangered; Marine Mammal Protection Act	Highest	High	Single Species Account
Globicephala macrorhynchus	Short-finned Pilot Whale	G5	S4	Marine Mammal Protection Act	Moderate	Moderate	Single Species Account
Kogia breviceps	Pygmy Sperm Whale	G4	S4	Marine Mammal Protection Act	Moderate	High	Sperm Whales Guild Account
Kogia sima	Dwarf Sperm Whale	G4	S4	Marine Mammal Protection Act	Data Deficient	High	Sperm Whale Guild Account
Lasionycteris noctivagans	Silver-haired Bat	G3G4	S3		Moderate		Singe Species Account
Lasiurus borealis	Eastern Red Bat	G3G4	S3		Moderate		Foliage Roosting Bats Guild
Lasiurus cinereus	Hoary Bat	G3G4	S2		High	High	Foliage Roosting Bats Guild
Lasiurus intermedius	Northern Yellow Bat	G5	S3		High	High	Foliage Roosting Bats Guild
Lasiurus seminolus	Seminole Bat	G5	S3		Moderate		Foliage Roosting Bats Guild
Megaptera novaeangliae	Humpback Whale	G4	S1	Federally and State Endangered; Marine Mammal Protection Act	High	High	Single Species Account
Microtus pennsylvanicus	Meadow Vole	G5	S3		High		Single Species Account
Mustela nivalis	Least Weasel	G5	S2		Highest		Weasels Guild

Clethrionomys gapperi	Southern Red-backed Vole	G5	S2		High		Single Species Account
Myotis austroriparius	Southeastern Myotis (Bat)	G4	S3		Moderate	Moderate	Colonial Cavity Roosting Bats Guild
Myotis grisescens	Gray Bat	G3G4	S1	Federally Endangered	Highest	Moderate	Colonial Cavity Roosting Bats Guild
Myotis leibii	Eastern Small-footed Myotis	G4	S2	State Threatened	High	High	Colonial Cavity Roosting Bats Guild
Myotis lucifugus	Little Brown Bat	G3G4	S2		Highest	Very High	Colonial Cavity Roosting Bats Guild
Myotis septentrionalis	Northern Long-eared Bat	G2G3	S1	Federally Endangered	Highest	Very High	Colonial Cavity Roosting Bats Guild
Napaeozapus insignis	Woodland Jumping Mouse	G5	S2S3		Moderate		Single Species Account
Neogale frenata	Long-tailed Weasel	G5	S2		High		Weasels Guild
Neogale vison	American Mink	G5	S3		Moderate		Single Species Account
Neotoma floridana	Eastern Woodrat	G5	S3S4		Moderate		Single Species Account
Parascalops breweri	Hairy-tailed Mole	G5	S2		High		Moles Guild
Perimyotis subflavus	Tricolored Bat	G3G4	S3	Federally Endangered	Highest	High	Colonial Cavity Roosting Bats Guild
Sciurus niger niger	Southern Fox Squirrel	G5T5	S3S4		Moderate		Single Species Account
Sorex cinereus	Masked Shrew	G5	S2		High		Shrews Guild
Sorex fumeus	Smoky Shrew	G5	S3		Moderate		Shrews Guild
Sorex hoyi	American Pygmy Shrew	G5	S2		Moderate		Shrews Guild
Spilogale putorius	Eastern Spotted Skunk	G4	S2		High	High	Single Species Account
Sylvilagus aquaticus	Swamp Rabbit	G5	S3		Moderate		Single Species Account
Sylvilagus obscurus	Appalachian Cottontail	G4	S2		High	Moderate	Single Species Account
Trichechus manatus latirostris	Florida Manatee	G2G3T2	S2	Federally Threatened (proposed); State Endangered; Marine Mammal Protection Act	High	High	Single Species Account
Tursiops erebennus	Tamanend's Dolphin	GNR	S4	Marine Mammal Protection Act	High		Single Species Account
Tursiops truncatus	Common Bottlenose Dolphin	G5	S5	Marine Mammal Protection Act	Moderate	High	Single Species Account
REPTILES & AMPHIBIANS							
Alligator mississippiensis	American Alligator	G5	S5	Federally and State Threatened; State Regulated	Moderate		Single Species Account
Acris crepitans	Eastern Cricket Frog (coastal population)	G5	S5		Moderate		Isolated Wetland-breeding Amphibians Guild

Ambystoma cingulatum	Frosted Flatwoods Salamander	G2	S1	Federally Threatened; State Endangered	Highest	Very High	Isolated Wetlands-breeding Amphibians Guild
Ambystoma mabeei	Mabee's Salamander	G4	S3		High	High	Isolated Wetlands-breeding Amphibians Guild
Ambystoma tigrinum	Eastern Tiger Salamander	G5	S2		Highest		Isolated Wetlands-breeding Amphibians Guild
Anaxyrus quercicus	Oak Toad	G5	S3		High	Moderate	Isolated Wetlands-breeding Amphibians Guild
Aneides aeneus	Green Salamander	G3G4	S1		Highest	High	Blue Ridge Reptiles and Amphibians Guild
Apalone ferox	Florida Softshell Turtle	G5	S4	State Regulated	High		Freshwater Turtles Guild
Apalone spinifera	Gulf Coast Spiny Softshell Turtle	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Caretta Caretta	Loggerhead Sea Turtle	G3	S3	Federally Endangered; State Threatened	Highest		Single Species Account
Chelonia mydas	Green Sea Turtle	G3	S3	Federally Endangered; State Threatened	Highest		Resident Juvenile Sea Turtles Guild
Chelydra serpentina	Snapping Turtle	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Chrysemys picta	Eastern Painted Turtle	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Clemmys guttata	Spotted Turtle	G5	S2	State Threatened; State Regulated	Highest	High	Freshwater Turtles Guild
Crotalus adamanteus	Eastern Diamondback Rattlesnake	G3	S2		Highest	High	Longleaf Pine Reptile Guild
Crotalus horridus	Timber Rattlesnake (mountain population) Timber (Canebreak) Rattlesnake (coastal population)	G4 G4	S2 S4		High Moderate	Moderate	Blue Ridge Reptiles and Amphibians Guild (coastal population also mentioned)
Deirochelys recticularia	Eastern Chicken Turtle	G5T5	S3	State Regulated	High	High	Freshwater Turtles Guild
Dermochelys coriacea	Leatherback Sea Turtle	G2	S2	Federally & State Endangered	Highest		Single Species Account
Desmognathus aeneus	Seepage Salamander	G4	S2		Highest	Moderate	Blue Ridge Reptiles and Amphibians Guild
Desmognathus aureatus	Shovel-nosed Salamander	G3	S2		Highest	High	Blue Ridge Reptiles and Amphibians Guild
Desmognathus bairdi	Baird's Dusky Salamander	G2G3	S3		Data Deficient		Miscellaneous Amphibians Guild
Desmognathus folkersti	Dwarf Black-bellied Salamander	G2	S2		Highest	Moderate	Blue Ridge Reptiles and Amphibians Guild
Eretmochelys imbricata	Hawksbill Sea Turtle	G3	S1N	Federally & State Endangered	Highest		Resident Juvenile Sea Turtle Guild
Eurycea chamberlaini	Chamberlain's Dwarf Salamander	G4	S3		High	Moderate	Miscellaneous Amphibians Guild
Farancia abacura	Red-Bellied Mud Snake	G5	S4		Data Deficient	Moderate	Aquatic Snakes Guild
Farancia erytrogramma	Rainbow Snake	G4	S3		Data Deficient	High	Aquatic Snakes Guild

Glyptemys muhlenbergii	Bog Turtle	G2G3	S1	Federally & State Threatened	Highest	Very High	Blue Ridge Reptiles and Amphibians Guild
Gopherus polyphemus	Gopher Tortoise	G3	S1	State Endangered	Highest	High	Longleaf Pine Reptiles Guild
Hemidactylium scutatum	Four-toed Salamander	G5	S3		High		Miscellaneous Amphibians Guild
Heterodon simus	Southern Hognose Snake	G2	S1	State Threatened; State Regulated	Highest	High	Longleaf Pine Reptiles Guild
Dryophytes andersonii	Pine Barrens Treefrog	G4	S2	State Threatened	Highest	Very High	Miscellaneous Amphibians Guild
Dryophytes avivoca	Bird-voiced Treefrog	G5	S3		High		Miscellaneous Amphibians Guild
Kinosternon baurii	Striped Mud Turtle	G4	S3	State Regulated	High	Moderate	Freshwater Turtles Guild
Kinosternon subrubrum	Eastern Mud Turtle	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Lampropeltis getula	Eastern Kingsnake	G5	S4		Moderate		Miscellaneous Reptiles Guild
Lampropeltis rhombomaculata	Northern Mole Kingsnake	G5	S4		High		Miscellaneous Reptiles Guild
Lampropeltis triangulum	Eastern Milk Snake	G5	S2		High		Blue Ridge Reptiles and Amphibians Guild
Lepidochelys kempii	Kemp's Ridley Sea Turtle	G1	S1N	Federally & State Endangered	High		Resident Juvenile Sea Turtles Guild
Liodytes pygaea paludis	Carolina Swampsnake	G5T4	S3		Data Deficient	Moderate	Aquatic Snakes Guild
Liodytes rigida	Glossy Swampsnake	G5	S3		Data Deficient	Moderate	Aquatic Snakes Guild
Lithobates capito	Carolina Gopher Frog	G2G3	S1	State Endangered	Highest	Very High	Isolated Wetland-breeding Amphibians Guild
Lithobates heckscheri	River Frog	G5	S4		Data Deficient	High	Miscellaneous Amphibians Guild
Lithobates palustris	Pickerel Frog	G5	S3		High		Miscellaneous Amphibians Guild
Lithobates sylvaticus	Wood Frog	G5	S3		High		Blue Ridge Reptiles and Amphibians Guild
Malaclemys terrapin	Carolina Diamondback Terrapin	G4	S3		High	High	Miscellaneous Reptiles Guild
Micrurus fulvius	Harlequin Coral Snake	G5	S2		Highest	High	Longleaf Pine Reptiles Guild
Necturus punctatus	Dwarf Waterdog	G5	S4		Data Deficient	Moderate	Miscellaneous Amphibians Guild
Nerodia floridana	Florida Green Watersnake	G5	S2		High	Moderate	Aquatic Snakes Guild
Ophisaurus attenuatus	Slender Glass Lizard	G5	S4		Moderate	High	Longleaf Pine Reptiles Guild
Ophisaurus compressus	Island Glass Lizard	G3G4	S2		Highest	High	Miscellaneous Reptiles Guild
Ophisaurus mimicus	Mimic Glass Lizard	G2	S1		Highest	High	Longleaf Pine Reptiles Guild
Pituophis melanoleucus melanoleucus	Northern Pine Snake	G4T3	S2		Highest	High	Blue Ridge Reptiles and Amphibians Guild

Pituophis melanoleucus mugitus	Florida Pine Snake	G4T3	S2		Highest	High	Longleaf Pine Reptiles Guild
Plestiodon anthracinus	Coal Skink	G5	S1	State Threatened	Highest	High	Blue Ridge Reptiles and Amphibians Guild
Plethodon websteri	Webster's Salamander	G3G4	S2	State Endangered	Highest	High	Miscellaneous Amphibians Guild
Pseudacris feriarum	Upland Chorus Frog (coastal population)	G5	S5		Moderate		Isolated Wetland-breeding Amphibians Guild
Pseudacris ornata	Ornate Chorus Frog	G4	S3		High	High	Isolated Wetland-breeding Amphibians Guild
Pseudemys concinna concinna	Eastern River Cooter	G5	S4	State Regulated	Moderate		Freshwater Turtles Guild
Pseudemys concinna floridana	Coastal Plain Cooter	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Pseudobranchus striatus striatus	Broad-striped Dwarf Siren	G5T1T3	S1	State Threatened	Highest	High	Isolated Wetland-breeding Amphibians Guild
Pseudotriton montanus flavissimus	Gulf Coast Mud Salamander	G5T4	S3		Data Deficient	Moderate	Miscellaneous Amphibians Guild
Regina septemvittata	Queen Snake	G5	S4		Data Deficient		Aquatic Snakes Guild
Rhadinaea flavilata	Pine Woods Littersnake	G4	S3		Data Deficient	High	Longleaf Pine Reptiles Guild
Sistrurus miliarius	Pygmy Rattlesnake	G5	S3		High	Moderate	Miscellaneous Reptiles Guild
Stereochilus marginatus	Many-lined Salamander	G5	S3		Data Deficient	Moderate	Miscellaneous Amphibians Guild
Sternotherus odoratus	Eastern Musk Turtle	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Terrapene carolina	Eastern Box Turtle	G5	S3	State Regulated	High	Moderate	Miscellaneous Reptiles Guild
Trachemys scripta	Yellow-Bellied Slider	G5	S5	State Regulated	Moderate		Freshwater Turtles Guild
Urspelerpes brucei	Patch-Nosed Salamander	G1	S1		Highest	Very High	Blue Ridge Reptiles and Amphibians Guild
BIRDS							
Ammodramus savannarum	Grasshopper Sparrow	G5	S3	MBTA	High	High	Grassland Birds Guild
Ammospiza caudacuta	Saltmarsh Sparrow	G2	S3N	MBTA	Highest	Very High	Marsh Birds Guild
Ammospiza maritima macgillivraii	MacGillivray's Seaside Sparrow	G4T3	S2	MBTA	Highest	High	Single Species Account (Marsh Birds Guild)
Ammospiza nelsoni	Nelson's Sparrow	G5	S3S4N	MBTA	High	High	Marsh Birds Guild
Antrostomus carolinensis	Chuck-will's-widow	G5	S4B	MBTA	High	Moderate	Nightjars Guild
Antrostomus vociferus	Eastern Whip-poor-will	G5	S3S4	MBTA	High	High	Nightjars Guild
Aquila chrysaetos	Golden Eagle	G5	S1N	Bald & Golden Eagle Protection Act; MBTA	High		Eagles Guild
Arenaria interpres	Ruddy Turnstone	G5	S3N	MBTA	High		Migratory Shorebirds Guild

Bonasa umbellus	Ruffed Grouse	G5	S2	State Regulated	Highest		Single Species Account (Mountain Birds Guild)
Butorides virescens	Green Heron	G5	S4	MBTA	Moderate		Colonial Nesting Wading Birds and Allies Guild
Calidris alba	Sanderling	G5	S3S4N	MBTA	Moderate		Migratory Shorebirds Guild
Calidris alpina	Dunlin	G5	S4N	MBTA	Moderate		Migratory Shorebirds Guild
Calidris canutus rufa	Red Knot	G4T2	S2N	Federally Endangered	Highest	High	Migratory Shorebirds Guild
Calidris pusilla	Semipalmated Sandpiper	G5	S3M	MBTA	High		Migratory Shorebirds Guild
Calonectris diomedea	Cory's Shearwater	G5	S4?N	MBTA	High		Single Species Account (Pelagic Seabirds Guild)
Centronyx henslowii	Henslow's Sparrow	G4	S1?N	MBTA	Highest	High	Pine Savanna Birds Guild
Chaetura pelagica	Chimney Swift	G4G5	S4B	MBTA	High	Moderate	Miscellaneous Birds Guild
Charadrius melodus	Piping Plover	G3	S2N	Federally Threatened & State Endangered; MBTA	Highest	High	Migratory Shorebirds Guild
Charadrius wilsonia	Wilson's Plover	G5	S3	State Threatened; MBTA	High	High	Nesting Shorebirds Guild
Chordeiles minor	Common Nighthawk	G5	S4S5	MBTA	Moderate		Nightjars Guild
Cistothorus palustris griseus	Worthington's Marsh Wren	G5T3	SU	MBTA	Data Deficient		Marsh Birds Guild
Coccothraustes vespertinus	Evening Grosbeak	G5	S3?N	MBTA	High		Miscellaneous Birds Guild
Coccyzus americanus	Yellow-billed Cuckoo	G5	S4S5B	MBTA	Moderate	High	Deciduous Forest Interior Birds Guild
Coccyzus erythropthalmus	Black-billed Cuckoo	G5	S3	MBTA	High		Deciduous Forest Interior Birds Guild
Colinus virginianus	Northern Bobwhite	G4G5	S4	State Regulated	Moderate	High	Single Species Account (Early- to Mid-Successional Guild)
Columbina passerina	Common Ground Dove	G5	S3	State Threatened	Highest		Grassland Birds Guild
Coturnicops noveboracensis	Yellow Rail	G4	S3N	MBTA	High	High	Marsh Birds Guild
Dolichonyx oryzivorus	Bobolink	G5	S3?	MBTA	High		Grassland Birds Guild
Dryobates borealis	Red-cockaded Woodpecker	G3	S2	Federally Threatened & State Endangered; MBTA	Highest	Very High	Single Species Account (Pine Savanna Birds Guild)
Egretta caerulea	Little Blue Heron	G5	S2S3	MBTA	High	Moderate	Colonial Nesting Wading Birds and Allies Guild
Egretta rufescens	Reddish Egret	G4	S1S2	MBTA	Highest	High	Colonial Nesting Wading Birds and Allies Guild
Egretta thula	Snowy Egret	G5	S2S3	MBTA	High	High	Colonial Nesting Wading Birds and Allies Guild
Elanoides forficatus	Swallow-tailed Kite	G5	S2	State Endangered; MBTA	Highest	Very High	Single Species Account (Forested Wetlands Birds

							Guild)
Eremophila alpestris	Horned Lark	G5	S3S4	MBTA	Moderate		Grassland Birds Guild
Euphagus carolinus	Rusty Blackbird	G4	S3N	MBTA	High	High	Forested Wetlands Birds Guild
Falco peregrinus anatum	American Peregrine Falcon	G4T4	S1B,S1N	State Threatened; MBTA	High		Single Species Account (Mountain Birds Guild)
Falco sparverius paulus	Southeastern American Kestrel	G5T4	SU	MBTA	Data Deficient	High	Pine Savannah Birds Guild
Gelochelidon nilotica	Gull-billed Tern	G5	S3B	MBTA	High	High	Colonial Nesting Seabirds Guild
Grus americana	Whooping Crane	G1	S1N	Federally Endangered; MBTA	Highest		Single Species Account (Marsh Birds Guild)
Haematopus palliatus	American Oystercatcher	G5	S3		High	High	Single Species Account (Nesting Shorebirds Guild)
Haliaeetus leucocephalus	Bald Eagle	G5	S3B,S3N	Bald & Golden Eagle Protection Act; State Threatened; MBTA	Moderate		Eagle Guild
Hylocichla mustelina	Wood Thrush	G4	S3S4B	MBTA	High	Moderate	Deciduous Forest Interior Birds Guild
Ixobrychus exilis	Least Bittern	G4G5	S3	MBTA	Moderate	Moderate	Marsh Birds Guild
Lanius ludovicianus	Loggerhead Shrike	G4	S3	MBTA	High	High	Grassland Birds Guild
Laterallus jamaicensis	Black Rail	G3	S1	Federally Threatened; MBTA	Highest	Very High	Single Species Account (Marsh Birds Guild)
Limnodromus griseus	Short-billed Dowitcher	G5	S3S4N	MBTA	High		Migratory Shorebirds Guild
Limosa fedoa	Marbled Godwit	G5	S4N	MBTA	High		Migratory Shorebirds Guild
Melanerpes erythrocephalus	Red-headed Woodpecker	G5	S4S5	MBTA	High		Pine Savanna Birds Guild
Mycteria americana	Wood Stork	G4	S2	Federally Threatened; State Endangered; MBTA	Highest	High	Single Species Account (Colonial Nesting Wading Birds Guild)
Nannopterum auritum	Double-crested Cormorant	G5	S1S2B,S4 S5N	MBTA	High		Colonial Nesting Wading Birds and Allies Guild
Numenius americanus	Long-billed Curlew	G5	S2S3N	MBTA	Highest		Migratory Shorebirds Guild
Numenius phaeopus	Whimbrel	G5	S2S3N	MBTA	Highest	High	Migratory Shorebirds Guild
Nyctanassa violacea	Yellow-crowned Night-Heron	G5	S2S3	MBTA	High	Moderate	Colonial Nesting Wading Birds and Allies Guild
Passerina ciris	Painted Bunting	G5	S3B	MBTA	High	High	Single Species Account (Early- to Mid-Successional Guild)
Pelecanus occidentalis	Brown Pelican	G4	S4B,S4N	MBTA	High		Colonial Nesting Seabirds Guild
Peucaea aestivalis	Bachman's Sparrow	G3	S3	MBTA	High	Very High	Pine Savanna Birds Guild
Platalea ajaja	Roseate Spoonbill	G5	S2S3	MBTA	Highest	High	Colonial Nesting Wading Birds and Allies Guild

Pluvialis squatarola	Black-bellied Plover	G5	S3N	MBTA	Moderate		Migratory Shorebirds Guild
Protonotaria citrea	Prothonotary Warbler	G5	S3S4	MBTA	High	Moderate	Forested Wetlands Bird Guild
Pterodroma hasitata	Black-capped Petrel	G1	S1?N	Federally Endangered; MBTA	Highest		Single Species Account (Pelagic Seabirds Guild)
Rallus elegans	King Rail	G4	S2S3	MBTA	Highest	High	Marsh Birds Guild
Riparia riparia	Bank Swallow	G5	S3	MBTA	Moderate		Miscellaneous Birds Guild
Rynchops niger	Black Skimmer	G5	S2	MBTA	Highest	High	Colonial Nesting Seabirds Guild
Scolopax minor	American Woodcock	G5	S4	MBTA	Moderate	Moderate	Single Species Account (Early- to Mid-Successional Guild)
Setophaga cerulea	Cerulean Warbler	G4	S1	MBTA	Highest	High	Mountain Birds Guild
Setophaga discolor	Prairie Warbler	G5	S4B	MBTA	High	Moderate	Single Species Account (Early- to Mid-Successional Guild)
Setophaga striata	Blackpoll Warbler	G5	S4?M	MBTA	Moderate		Deciduous Forest Interior Birds Guild
Setophaga virens waynei	Wayne's Black-throated Green Warbler	G5T1	S1S2B	MBTA	Highest	High	Single Species Account (Deciduous Forest Birds Guild)
Spinus pinus	Pine Siskin	G5	S4S5N	MBTA	Moderate		Pine Savannah Birds Guild
Spiza americana	Dickcissel	G5	S2S3B	MBTA	Moderate		Grassland Birds Guild
Spizella pusilla	Field Sparrow	G5	S4S5	MBTA	Moderate		Grassland Birds Guild
Sterna forsteri	Forster's Tern	G5	S4B,S4N	MBTA	High		Colonial Nesting Seabirds Guild
Sterna hirundo	Common Tern	G5	S3B	MBTA	Moderate		Colonial Nesting Seabirds Guild
Sternula antillarum	Least Tern	G4	S2B	State Threatened; MBTA	Highest	High	Colonial Nesting Seabirds Guild
Sturnella magna	Eastern Meadowlark	G5	S4	MBTA	Moderate	High	Grassland Birds Guild
Thalasseus maximus	Royal Tern	G5	S4	MBTA	High	Moderate	Colonial Nesting Seabirds Guild
Thalasseus sandvicensis	Sandwich Tern	G5	S4B	MBTA	High	High	Colonial Nesting Seabirds Guild
Tringa flavipes	Lesser Yellowlegs	G5	S3N	MBTA	High		Migratory Shorebirds Guild
Tringa semipalmata	Willet	G5	S4	MBTA	High	High	Nesting Shorebirds Guild
Vermivora chrysoptera	Golden-winged Warbler	G4	S1	MBTA	Highest	High	Mountain Birds Guild
LEECHES							
Brachellion ravenelii	"a marine leech"	GNR	SNR		Data Deficient		Leeches Guild
Haemopis septagon	"a terrestrial leech"	GNR	SNR		Data Deficient		Leeches Guild

Macrobdella sestertia	New England Medicinal Leech	G2	SH		Data Deficient		Leeches Guild
Placobdella biannulata	Appalachian Leech	GNR	SNR		Data Deficient		Leeches Guild
Placobdella nuchalis	Nuchal Leech	GNR	SNR		Data Deficient		Leeches Guild
Placobdella translucens	Translucent Leech	GNR	SNR		Data Deficient		Leeches Guild
DIADROMOUS FISHES							
Acipenser brevirostrum	Shortnose Sturgeon	G3	S1	Federally & State Endangered	Highest	Very High	Sturgeons Guild
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	G3T3	S1S2	Federally Endangered	Highest	High	Sturgeons Guild
Alosa aestivalis	Blueback Herring	G3G4	S4S5	State Regulated	Moderate	NA	Alosines Guild
Alosa mediocris	Hickory Shad	G4	S4?	State Regulated	Data Deficient	High	Alosines Guild
Alosa sapidissima	American Shad	G5	S4S5	State Regulated	Moderate	Very High	Alosines Guild
Anguilla rostrata	American Eel	G4	S2S3	State Regulated	Highest	NA	Single Species Account
FRESHWATER FISHES							
Alburnops chalybaeus	Ironcolor Shiner	G4	S3		High	High	Single Species Account
Ameiurus brunneus	Snail Bullhead	G4	S3S4		Moderate		Single Species Account
Ameiurus catus	White Catfish	G5	S3S4		Moderate		Single Species Account
Ameiurus platycephalus	Flat Bullhead	G4	S3S4		Moderate		Single Species Account
Campostoma anomalum	Central Stoneroller	G5	S3		Moderate	Moderate	Single Species Account
Carpiodes sp. cf. cyprinus	"Carolina" Quillback	G5	S2S3		High	High	Single Species Account
Carpiodes sp. cf. velifer	"Atlantic" Highfin Carpsucker	G4G5	S3		Moderate	High	Single Species Account
Chologaster cornuta	Swampfish	G5	S3		Moderate	Moderate	Single Species Account
Clinostomus funduloides	Rosyside Dace	G5	S4		Moderate		Single Species Account
Coccotis coccogenis	Warpaint Shiner	G5	S3		Moderate	Moderate	Single Species Account
Cottus bairdii	Mottled Sculpin	G5	S2S3		High	High	Single Species Account
Cyprinella analostana	Satinfin Shiner	G5	S3		Moderate	Moderate	Single Species Account
Cyprinella galactura	Whitetail Shiner	G5	S3		Moderate		Single Species Account
Cyprinella labrosa	Thicklip Chub	G4	S2S3		Moderate	Moderate	Single Species Account
Cyprinella leedsi	Bannerfin Shiner	G4	S3		Moderate		Single Species Account
Cyprinella leptocheilus	Siouan Thinlip Chub	G2Q	S1S2		Highest	High	Single Species Account

Cyprinella pyrrhomelas	Fieryblack Shiner	G4	S3		Moderate	Moderate	Single Species Account
Cyprinella zanema	Santee Chub	G4	S3		High	High	Single Species Account
Elassoma boehlkei	Carolina Pygmy Sunfish	G2	S1	State Threatened	Highest	Very High	Single Species Account
Elassoma evergladei	Everglades Pygmy Sunfish	G5	S4		Moderate		Single Species Account
Elassoma okatie	Bluebarred Pygmy Sunfish	G2G3	S1S2		Highest	Very High	Single Species Account
Enneacanthus chaetodon	Blackbanded Sunfish	G3G4	S2S3		High	High	Single Species Account
Enneacanthus obesus	Banded Sunfish	G5	S3		Moderate	Moderate	Single Species Account
Etheostoma brevispinum	Carolina Fantail Darter	G4	S2		Highest	High	Single Species Account
Etheostoma collis	Carolina Darter	G3	S3		High	High	Single Species Account
Etheostoma fricksium	Savannah Darter	G4	S3		High	High	Single Species Account
Etheostoma hopkinsi	Christmas Darter	G4G5	S2		Highest	Very High	Single Species Account
Etheostoma inscriptum	Turquoise Darter	G4	S2S3		High	Moderate	Single Species Account
Etheostoma mariae	Pinewoods Darter	G3	SH	State Endangered	Data Deficient	High	Single Species Account
Etheostoma serrifer	Sawcheek Darter	G5	S4		Moderate		Single Species Account
Etheostoma thalassinum	Seagreen Darter	G4	S3		Moderate	Moderate	Single Species Account
Fundulus diaphanus	Banded Killifish	G5	S1		High		Single Species Account
Hudsonius altipinnis	Highfin Shiner	G5	S3S4		Moderate		Single Species Account
Hybopsis hypsinotus	Highback Chub	G4	S3		Moderate	Moderate	Single Species Account
Hybopsis rubrifrons	Rosyface Chub	G4	S3		Moderate	Moderate	Single Species Account
Hydrophlox chiliticus	Redlip Shiner	G4	S2S3		Moderate		Single Species Account
Lepisosteus platyrhincus	Florida Gar	G5	S1S2		Moderate		Single Species Account
Micropterus sp. 1 (cf. *coosae*)	"Bartram's" Bass	GNR	S1	State Regulated	Highest	Very High	Single Species Account
Miniellus alborus	Whitemouth Shiner	G4	S2S3		Moderate	Moderate	Single Species Account
Miniellus procne	Swallowtail Shiner	G5	S3		Moderate	Moderate	Single Species Account
Morone saxatilis	Striped Bass	G5	S1	State Regulated	Highest		Single Species Account
Moxostoma pappillosum	V-Lip Redhorse	G4	S3		Moderate	Moderate	Single Species Account
Moxostoma robustum	Robust Redhorse	G1	S1	State Regulated	Highest	Very High	Single Species Account
Moxostoma sp. 4	"Brassy Jumprock"	G4	S3		Moderate	Moderate	Single Species Account
Moxostoma sp. 3 (cf. *erythrurum*)	"Carolina" Redhorse	G1G2Q	S1		Highest	Very High	Single Species Account

Notropis bifrenatus	Bridle Shiner	G3	SH		Data Deficient	High	Single Species Account
Noturus sp. 2 (cf. *insignis*)	"Broadtail" Madtom	G2	S1	State Threatened	Highest	Very High	Single Species Account
Paranotropis leuciodus	Tennessee Shiner	G5	S3		Moderate		Single Species Account
Paranotropis spectrunculus	Mirror Shiner	G4	S3		Moderate		Single Species Account
Percina crassa	Piedmont Darter	G4	S3		Moderate	Moderate	Single Species Account
Rhinichthys obtusus	Western Blacknose Dace	G5	S2		Moderate		Single Species Account
Salvelinus fontinalis	Eastern Brook Trout	G5	S1S2	State Regulated	Highest	High	Single Species Account
Semotilus lumbee	Sandhills Chub	G3G4	S2		Highest	High	Single Species Account
FRESHWATER SHRIMPS							
Macrobrachium acanthurus	Cinnamon River Shrimp	G5	S3		Data Deficient		Single Species Account
Macrobrachium ohione	Ohio Shrimp	G4	S2		Moderate		Single Species Account
Palaemon paludosus	Eastern Grass Shrimp	G5	S4		Data Deficient		Single Species Account
CRAYFISHES							
Cambarus acuminatus	Acuminate Crayfish	GNR	S2		Moderate		Single Species Account
Cambarus aldermanorum	Carolina Needlenose Crayfish	GNR	S2		Moderate	Moderate	Single Species Account
Cambarus carolinus	Red Burrowing Crayfish	G4	S2?		Highest		Single Species Account
Cambarus chaugaensis	Chauga Crayfish	G2	S2?		High	High	Single Species Account
Cambarus hobbsorum	Rocky River Crayfish	G3G4	S3		Moderate		Single Species Account
Cambarus howardi	Chattahoochee crayfish ("sp. A")	G3	S2		Moderate		Single Species Account
Cambarus nodosus	Knotty Burrowing Crayfish	G4	S1?		High		Single Species Account
Cambarus reflexus	Pine Savannah Crayfish	G4	S3		Highest		Single Species Account
Cambarus sp. B cf. longirostis	"Keowee Crayfish"	G5	S1		Highest		Single Species Account
Cambarus spicatus	Broad River Spiny Crayfish	G3	S2		High	Moderate	Single Species Account
Cambarus strigosus	Lean Crayfish	G2	S1		High		Single Species Account
Creaserinus fodiens	Digger Crayfish	G5	S4		Moderate		Single Species Account
Distocambarus carlsoni	Mimic Crayfish	G2G3	S2		Highest	Moderate	Single Species Account
Distocambarus crockeri	Piedmont Prairie Burrowing Crayfish	G3	S3		High	Moderate	Single Species Account
Distocambarus hunteri	Saluda Burrowing Crayfish	G1	S1		Highest	High	Single Species Account
Distocambarus youngineri	Newberry Burrowing Crayfish	G1	S1		Highest	Very High	Single Species Account

Faxonella clypeata	Ditch Fencing Crayfish	G5	S2		Moderate		Single Species Account
Procambarus ancylus	Coastal Plain Crayfish	G4G5	S3		High		Single Species Account
Procambarus barbatus	Wandering Crayfish	G5	S2		High		Single Species Account
Procambarus blandingii	Santee Crayfish	G4	S3		Moderate		Single Species Account
Procambarus chacei	Cedar Creek Crayfish	G4	S3		Moderate	High (for previous Waccamaw Crayfish)	Single Species Account
Procambarus echinatus	Edisto Crayfish	G3	S3		Highest		Single Species Account
Procambarus enoplosternum	Black Mottled Crayfish	G4G5	S3		Moderate		Single Species Account
Procambarus hirsutus	Shaggy Crayfish	G4	S4		Moderate		Single Species Account
Procambarus lepidodactylus	Pee Dee Lotic Crayfish	G4	S3		Moderate		Single Species Account
Procambarus lunzi	Hummock Crayfish	G4	S1S2		Highest		Single Species Account
Procambarus pearsei	Carolina Sandhills Crayfish	G4	S1		High	Moderate	Single Species Account
Procambarus pubescens	Brushnose Crayfish	G4G5	S3		Moderate		Single Species Account
Procambarus troglodytes	Eastern Red Swamp Crayfish	G5	S3		Moderate		Single Species Account
FRESHWATER MUSSELS							
Alasmidonta arcula	Altamaha Arcmussel	G2	S1	State Regulated	Highest		Single Species Account
Alasmidonta undulata	Triangle Floater	G4	S1?	State Regulated	Data Deficient		Single Species Account
Alasmidonta varicosa	Brook Floater	G3	S1S2	State Regulated	High	High	Single Species Account
Atlanticoncha ochracea	Tidewater Mucket	G3G4	S2S3	State Regulated	High		Single Species Account
Elliptio congaraea	Carolina Slabshell	G3	S4	State Regulated	Moderate		Single Species Account
Elliptio folliculata	Pod Lance	G2G3	S1S3	State Regulated	High	High	Single Species Account
Elliptio fraterna	Brother Spike	G1G2	S1?	State Endangered	Data Deficient	Very High	Single Species Account
Elliptio hopetonensis	Altamaha Slabshell	G4	SU	State Regulated	Data Deficient		Single Species Account
Elliptio producta	Atlantic Spike	G3	S3	State Regulated	Moderate		Single Species Account
Elliptio roanokensis	Roanoke Slabshell	G3	S2S3	State Regulated	Moderate		Single Species Account
Fusconaia masoni	Atlantic Pigtoe	G1	SH	Federally Threatened (proposed); State Endangered	Data Deficient	Very High	Single Species Account
Lampsilis cariosa	Yellow Lampmussel	G3G4	S3?	State Regulated	Moderate		Single Species Account

Lampsilis radiata	Eastern Lampmussel	G5	S2?	State Regulated	Moderate		Combined Species Account
Lampsilis splendida	Rayed Pink Fatmucket	G3	S2?	State Regulated	High	High	Combined Species Account
Lasmigona decorata	Carolina Heelsplitter	G1	S1	Federally Endangered	Highest	Very High	Single Species Account
Sagittunio nasutus	Eastern Pondmussel	G4	S2S3	State Regulated	Moderate		Single Species Account
Sagittunio vaughanianus	Carolina Creekshell	G2G3	S1	State Regulated	Highest	High	Single Species Account
Strophitus undulatus	Creeper	G5	S2S3	State Regulated	Moderate		Single Species Account
Toxolasma pullus	Savannah Lilliput	G2	S1S3	State Regulated	Highest	High	Single Species Account
Utterbackiana couperiana	Barrel Floater	G4	S1S2	State Regulated	High	High	Single Species Account
Utterbackiana implicata	Alewife Floater	G5	SU	State Regulated	Data Deficient		Single Species Account
Venustaconcha constricta	Notched Rainbow	G3	S1	State Regulated	Highest		Single Species Account
Villosa vibex	Southern Rainbow	G5	S2?	State Regulated	Moderate		Single Species Account
FRESHWATER SNAILS							
Callinina intertexta	Rotund Mysterysnail	G4	S2S3		High		Single Species Account
Elimia dislocata	Lapped Elimia	G4Q	S3S5		Moderate		Single Species Account
Galba cubensis	Carib Fossaria	G5	S2S3		Moderate		Single Species Account
Galba humilis	Marsh Fossaria	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Galba obrussa	Golden Fossaria	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Gyraulus deflectus	Flexed Gyro	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Littoridinops tenuipes	Henscomb Hydrobe	G5	S1S3		High		Single Species Account
Lyogyrus retromargo	Indented Duskysnail	G4Q	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Physella carolinae	Carolina Physa	GNR	S3S5		Moderate		Single Species Account
Physella gyrina	Tadpole Physa	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Planorbula armigera	Thicklip Rams-horn	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Pomatiopsis lapidaria	Slender Walker	G5	SU		Data Deficient		Data Deficient Freshwater Snails Guild
Promenetus exacuous	Sharp Sprite	G5	S1S3		High		Single Species Account
Somatogyrus virginicus	Panhandle Pebblesnail	G2G3	S2S4		High		Single Species Account
Valvata bicarinata	Two-ridge Valvata	G5	S1S2		High		Single Species Account

Valvata tricarinata	Threeridge Valvata	G5	SH		Data Deficient		Single Species Account
FRESHWATER SPONGES							
Corvospongilla becki	"a freshwater sponge"	GNR	S4		Data Deficient		Freshwater Sponges Guild
Corvospongilla novaeterrae	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Corvospongilla sp. 1	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Ephydatia fluviatilis	"a freshwater sponge"	GNR	S3		Data Deficient		Freshwater Sponges Guild
Eunapius fragilis	"a freshwater sponge"	G5	S3S4		Data Deficient		Freshwater Sponges Guild
Heteromeyenia baileyi	"a freshwater sponge"	G5	S3S4		Data Deficient		Freshwater Sponges Guild
Heteromeyenia latitenta	"a freshwater sponge"	G3G5	S3		Data Deficient		Freshwater Sponges Guild
Heteromeyenia longistylus	"a freshwater sponge"	G1G3	S3		Data Deficient		Freshwater Sponges Guild
Racekiela ryderi	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Racekiela sp. 1	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Radiospongilla cerebellata	"a freshwater sponge"	GNR	S3		Data Deficient		Freshwater Sponges Guild
Radiospongilla sp. 1	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Spongilla lacustris	"a freshwater sponge"	G5	S3		Data Deficient		Freshwater Sponges Guild
Trochospongilla horrida	"a freshwater sponge"	G5	S3S4		Data Deficient		Freshwater Sponges Guild
Trochospongilla latouchiana	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Trochospongilla leidii	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
Trochospongilla pennsylvanica	"a freshwater sponge"	GNR	S3S4		Data Deficient		Freshwater Sponges Guild
MARINE INVERTEBRATES							
Acanthohaustorius intermedius	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Acanthohaustorius millsi	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Acanthohaustorius pansus	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Acanthohaustorius shoemakeri	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild

Acanthohaustorius similis	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Achelous gibbesii	Iridescent Swimming Crab	GNR	SNR		Moderate		Portunid Crab Guild
Achelous spinimanus	Blotched Swimming Crab	GNR	SNR		Moderate		Portunid Crab Guild
Alitta succinea	Common Southern Clamworm	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Alpheus angulosus	"a snapping shrimp"	GNR	SNR		Moderate		Intertidal Alpheid Guild
Alpheus estuariensis	Estuarine Snapping Shrimp	GNR	SNR		Moderate		Intertidal Alpheid Guild
Alpheus heterochaelis	Big Claw Snapping Shrimp	GNR	SNR		Moderate		Intertidal Alpheid Guild
Alpheus normanni	Green Snapping Shrimp	GNR	SNR		Moderate		Intertidal Alpheid Guild
Ampelisca abdita	"an amphipod"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Aphelochaeta sp.	"a polychaete"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Arabella mutans	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrates Guild
Arenaeus cribrarius	Speckled Swimming Crab	GNR	SNR		Moderate		Portunid Crab Guild
Austinixa cristata	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrates Guild
Balanoglossus aurantiacus	"an acorn worm"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Brachidontes exustus	Scorched Mussel	G5	SNR		Moderate		Intertidal Marine Invertebrate Guild
Busycon carica	Knobbed Whelk	GNR	SNR	State Regulated	Moderate		Whelk Guild
Busycotypus canaliculatus	Channeled Whelk	GNR	SNR	State Regulated	Moderate		Whelk Guild
Callinectes exasperatus	Rugose Swimming Crab	GNR	SNR		Moderate		Portunid Crab Guild
Callinectes ornatus	Ornate Swimming Crab	GNR	SNR		Moderate		Portunid Crab Guild
Callinectes sapidus	Blue Crab	GNR	SNR	State Regulated	High		Portunid Crab Guild
Callinectes similis	Lesser Blue Crab	GNR	SNR		Moderate		Portunid Crab Guild
Capitella capitata	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Caulleriella sp.	"a polychaete"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Cerebratulus lacteus	Nemertean Worm	GNR	SNR		Moderate		Intertidal Marine Invertebrates Guild
Chiropsalmus quadrumanus	Four-handed Box Jellyfish	GNR	SNR		Moderate		Single Species Account
Crassostrea virginica	Eastern Oyster	G3G4	SNR	State Regulated	High		Single Species Account
Cyathura sp.	"an isopod"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild

Diopatra cuprea	Plumed Worm	GNR	SNR		Moderate		Single Species Account
Dissodactylus mellitae	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Donax variabilis	Coquina Clam	GNR	SNR		Moderate		Single Species Account; Intertidal Marine Invertebrate Guild
Drilonereis longa	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Emerita talpoida	Atlantic Sand Crab	GNR	SNR		Moderate		Single Species Account
Exosphaeroma diminutum	"an isopod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Fulguropsis spirata	Pear Whelk	GNR	SNR	State Regulated	Moderate		Whelk Guild
Gammarus palustris	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Gammarus mucronatus	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Geukensia demissa	Ribbed Mussel	GNR	SNR		Moderate		Single Species Account
Glycera americana	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Glycera dibranchiata	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Haustorius canadensis	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Haustorius jayneae	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Laeonereis culveri	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Lepidactylis dytiscus	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Leptogorgia virgulata	Colorful Sea Whip	G4	SNR		Moderate		Single Species Account
Leptuca pugilator	Atlantic Sand Fiddler Crab	G4	SNR		Moderate		Fiddler Crab Guild
Limulus polyphemus	American Horseshoe Crab	G5	SNR	State Regulated	High		Single Species Account; Intertidal Marine Invertebrate Guild
Littoraria irrorata	Marsh Periwinkle	GNR	SNR		Moderate		Single Species Account
Lolliguncula brevis	Atlantic Brief Squid	G5	SNR		Moderate		Single Species Account
Mediomastus sp.	"a polychaete"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Menippe mercenaria	Florida Stone Crab	GNR	SNR	State Regulated	Moderate		Single Species Account
Mercenaria campechiensis	Southern Quahog	GNR	SNR	State Regulated	Moderate		Hard Clam Guild
Mercenaria mercenaria	Northern Quahog	G5	SNR	State Regulated	Moderate		Hard Clam Guild

Minuca minax	Red-jointed Fiddler Crab	G4	SNR		Moderate		Fiddler Crab Guild
Minuca pugnax	Mud Fiddler Crab	G5	SNR		Moderate		Fiddler Crab Guild
Mnemiopsis leidyi	Sea Walnut	GNR	SNR		Moderate		Single Species Account
Monticellina sp.	"a polychaete"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Mulinia lateralis	Dwarf Surf Clam	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Neohaustorius schmitzi	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Neverita duplicata	Shark Eye	GNR	SNR		Moderate		Single Species Account
Ocypode quadrata	Atlantic Ghost Crab	GNR	SNR		Moderate		Single Species Account
Oliva sayana	Lettered Olive	GNR	SNR		Moderate		Single Species Account
Ostrea stentina	Crested Oyster	G5	SNR		Moderate		Single Species Account
Palaemon mundusnovus	Brackish Grass Shrimp	GNR	SNR		Moderate		Grass Shrimp Guild
Palaemon pugio	Daggerblade Grass Shrimp	GNR	SNR		Moderate		Grass Shrimp Guild
Palaemon vulgaris	Marsh Grass Shrimp	GNR	SNR		Moderate		Grass Shrimp Guild
Panopeus herbstii	Atlantic Mud Crab	GNR	SNR		Moderate		Single Species Account
Parahaustorius longimerus	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Parahaustorius holmesi	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Paraonis fulgens	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Penaeus aztecus	Brown Shrimp	GNR	SNR		Moderate		Penaeid Shrimp Guild
Penaeus duorarum	Pink Shrimp	GNR	SNR	State Regulated	Moderate		Penaeid Shrimp Guild
Penaeus setiferus	Atlantic White Shrimp	GNR	SNR	State Regulated	Moderate		Penaeid Shrimp Guild
Petricolaria pholadiformis	False Angel Wing	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Pinninxa lunzi	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Protohaustorius bousfieldi	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Protohaustorius deichmannae	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Protohaustorius wigleyi	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Pseudohaustorius caroliniensis	"an amphipod"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild

Rathbunixa sayana	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Rhepoxynius hudsoni	"an amphipod"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Scolelepis sp.	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Saccoglossus kowalevskii	"an acorn worm"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Sesarma reticulatum	Purple Marsh Crab	GNR	SNR		Moderate		Single Species Account
Sinistrofulgur perversum	Lightning Whelk	GNR	SNR	State Regulated	Moderate		Whelk Guild
Squilla empusa	Common Mantis Shrimp	GNR	SNR		Moderate		Single Species Account
Stomolophus meleagris	Cannonball Jellyfish	GNR	SNR		Moderate		Single Species Account
Streblospio benedicti	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Tellin spp.	"a tellin clam"	G5	SNR		Moderate		Estuarine Sensitive Taxa Guild
Tharyx acutus	"a polychaete"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Tubificoides spp.	"an oligochaete"	GNR	SNR		Moderate		Estuarine Sensitive Taxa Guild
Tubicolixa chaetopterana	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Tumidotheres maculatus	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
Zaops ostreum	"a pinnotherid crab"	GNR	SNR		Moderate		Intertidal Marine Invertebrate Guild
MARINE FISHES							
Acanthocybium solandri	Wahoo	GNR	SU	Federally and State Regulated	Data Deficient		Single Species Account
Aetobatus narinari	Spotted Eagle Ray	G4	S3		High		Single Species Account
Archosargus probatocephalus	Sheepshead	G5	S4	State Regulated	Moderate		Single Species Account
Ariopsis felis	Hardhead Catfish	G5	S1	State Regulated	Highest	High	Marine Catfishes Guild
Bagre marinus	Gafftopsail Catfish	G5	S2	State Regulated	Highest		Marine Catfishes Guild
Balistes capriscus	Gray Triggerfish	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Brevoortia tyrannus	Atlantic Menhaden	G5	S4	State Regulated	Moderate		Single Species Account
Carcharhinus acronotus	Blacknose Shark	GNR	S3	Federally and State Regulated	Moderate		Single Species Account
Carcharhinus altimus	Bignose Shark	GNR	SU	Federally and State Regulated	Data Deficient		Ridge-back Sharks Guild
Carcharhinus brevipinna	Spinner Shark	GNR	S3	Federally and State Regulated	Moderate	Moderate	Single Species Account

Carcharhinus falciformis	Silky Shark	G3	S3	Federally and State Regulated	Moderate		Single Species Account
Carcharhinus isodon	Finetooth Shark	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Carcharhinus longimanus	Oceanic Whitetip Shark	GNR	S2	Federally Threatened	Highest		Single Species Account
Carcharhinus obscurus	Dusky Shark	G3	S2	Federally and State Regulated	High		Ridge-back Sharks Guild
Carcharhinus plumbeus	Sandbar Shark	G4	S4	Federally and State Regulated	Moderate		Ridge-back Sharks Guild
Carcharhinus signatus	Night Shark	G3	S3	Federally and State Regulated	High		Single Species Account
Carcharias taurus	Sand Tiger Shark	G3G4	S3	Federally and State Regulated	Moderate		Single Species Account
Carcharodon carcharias	Great White Shark (White Shark)	G2	S3	Federally and State Regulated	Moderate		Single Species Account
Caulolatilus microps	Blueline Tilefish	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Centropomus undecimalis	Common Snook	G5	S3		Data Deficient		Single Species Account
Centropristis striata	Black Sea Bass	GNR	S3	Federally and State Regulated	High		Single Species Account
Coryphaena hippurus	Dolphin Fish (Mahi Mahi)	GNR	S4	Federally and State Regulated	Data Deficient		Single Species Account
Cynoscion nebulosus	Spotted Seatrout	G5	S5	State Regulated	Moderate		Single Species Account
Cynoscion regalis	Weakfish	GNR	S3	State Regulated	High		Single Species Account
Epinephelus drummondhayi	Speckled Hind	G3	S2	Federally and State Regulated	Highest		Single Species Account
Epinephelus morio	Red Grouper	GNR	S3	Federally and State Regulated	High		Single Species Account
Fundulus heteroclitus	Mummichog	G5	S3	Federally and State Regulated	Moderate		Single Species Account
Haemulon plumierii	White Grunt	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Hyperoglyphe perciformis	Barrelfish	GNR	SU	Federally and State Regulated	Data Deficient		Single Species Account
Hyporthodus nigritus	Warsaw Grouper	G3	S2	Federally and State Regulated	Highest		Single Species Account
Hyporthodus niveatus	Snowy Grouper	G4G5	S4	Federally and State Regulated	Moderate		Single Species Account
Istiophorus platypterus	Atlantic Sailfish	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Billfishes Guild
Isurus oxyrinchus	Shortfin Mako	GNR	S2	Federally and State Regulated	High		Combined Species Account
Isurus paucus	Longfin Mako	G2G3	S2	Federally and State Regulated	High		Combined Species Account

Kajikia albida	Atlantic White Marlin	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Billfishes Guild
Lachnolaimus maximus	Hogfish	GNR	S3	Federally and State Regulated	Data Deficient		Single Species Account
Leiostomus xanthurus	Spot	G5	S3	State Regulated	Moderate		Single Species Account
Lobotes surinamensis	Atlantic Tripletail	GNR	S4	State Regulated	Data Deficient		Single Species Account
Lopholatilus chamaeleonticeps	Tilefish (Golden Tilefish)	GNR	S3	Federally and State Regulated	Moderate		Single Species Account
Lutjanus analis	Mutton Snapper	GNR	S3	Federally and State Regulated	Data Deficient		Single Species Account
Lutjanus campechanus	Red Snapper	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Lutjanus griseus	Gray Snapper	G5	SU	Federally and State Regulated	Data Deficient		Single Species Account
Makaira nigricans	Blue Marlin	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Billfishes Guild
Megalops atlanticus	Tarpon	G5	S3	State Regulated	High		Single Species Account
Menticirrhus americanus	Southern Kingfish	GNR	S5	State Regulated	Moderate		Single Species Account
Micropogonias undulatus	Atlantic Croaker	G5	S4	State Regulated	Moderate		Single Species Account
Mobula birostris	Giant Oceanic Manta Ray (Giant Manta Ray)	G3G4	S2	Federally Threatened	High	High	Mobulidae Guild
Mobula hypostoma	Lesser Devil Ray	GNR	S3		Moderate		Mobulidae Guild
Mobula mobular	Devil Fish (Giant Devil Ray)	GNR	S3		Moderate		Mobulidae Guild
Mugil cephalus	Striped Mullet	G5	S4		Moderate		Single Species Account
Mugil curema	White Mullet	G5	S4		Data Deficient		Single Species Account
Mycteroperca interstitialis	Yellowmouth Grouper	GNR	S3	Federally and State Regulated	Data Deficient		Combined Species Account
Mycteroperca microlepis	Gag	GNR	S3	Federally and State Regulated	Highest		Single Species Account
Mycteroperca phenax	Scamp	GNR	S3	Federally and State Regulated	Moderate		Combined Species Account
Negaprion brevirostris	Lemon Shark	G3G4	S3	Federally and State Regulated	Moderate	Moderate	Single Species Account
Orthopristis chrysoptera	Pigfish	G5	S4		Data Deficient		Single Species Account
Pagrus pagrus	Red Porgy	GNR	S3	Federally and State Regulated	Moderate		Single Species Account
Paralichthys albigutta	Gulf Flounder	G5	S4	State Regulated	Data Deficient		Large Tooth Flounders Guild
Paralichthys dentatus	Summer Flounder	GNR	S4	State Regulated	Data Deficient		Large Tooth Flounders Guild

Paralichthys lethostigma	Southern Flounder	G5	S3	State Regulated	Highest	High	Single Species Account
Pogonias cromis	Black Drum	GNR	S4	State Regulated	Moderate		Single Species Account
Polyprion americanus	Wreckfish	G5	S4	Federally and State Regulated	Data Deficient		Single Species Account
Pomatomus saltatrix	Bluefish	G5	S4	State Regulated	Moderate		Single Species Account
Pristis pectinata	Smalltooth Sawfish	G1G3	S1	Federally Endangered	Highest	Very High	Single Species Account
Rachycentron canadum	Cobia	GNR	S2	State Regulated	High	Moderate	Single Species Account
Rhomboplites aurorubens	Vermilion Snapper	GNR	S4	Federally and State Regulated	Moderate		Single Species Account
Sciaenops ocellatus	Red Drum	G5	S3	State Regulated	High		Single Species Account
Scomberomorus cavalla	King Mackerel	GNR	S3	Federally and State Regulated	Moderate		Single Species Account
Scomberomorus maculatus	Spanish Mackerel	G5	S4	Federally and State Regulated	Moderate		Single Species Account
Sphyrna gilberti	Carolina Hammerhead	GNR	S2	Federally and State Regulated	Highest	Highest	Hammerhead Sharks Guild
Sphyrna lewini	Scalloped Hammerhead	G4	S2	Federally and State Regulated	High	Highest	Hammerhead Sharks Guild
Sphyrna mokarran	Great Hammerhead	G3G4	S2	Federally and State Regulated	High		Hammerhead Sharks Guild
Sphyrna tiburo	Bonnethead	GNR	S3	Federally and State Regulated	High	High	Hammerhead Sharks Guild
Sphyrna zygaena	Smooth Hammerhead	G3G4	S2	Federally and State Regulated	Moderate		Hammerhead Sharks Guild
Tetrapturus pfluegeri	Longbill Spearfish	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Billfishes Guild
Thunnus albacares	Yellowfin Tuna	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Tunas Guild
Thunnus atlanticus	Blackfin Tuna	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Tunas Guild
Thunnus thynnus	Atlantic Bluefin Tuna	GNR	SU	Federally and State Regulated	Data Deficient		Atlantic Tunas Guild
Xiphias gladius	Swordfish	G5	SU	Federally and State Regulated	Data Deficient		Atlantic Billfishes Guild
SCIENTIFIC NAME	**COMMON NAME**	**G-RANK**	**S-RANK**	**PROTECTION STATUS**	**SGCN PRIORITY**	**RSGCN PRIORITY**	**SUPPLEMENTAL VOLUME INCORPORATION**
PLANTS							
Abdra aprica	Flatrock Draba, Open-ground Whitlow-grass, Sun-loving Draba, Granite Whitlow-wort	G3	S1		High	Moderate	Plants Excel Spreadsheet
Acer spicatum	Mountain Maple	G5	SH		High		Plants Excel Spreadsheet

Acmispon helleri	Carolina Prairie-trefoil	G5T3	S2		High		Plants Excel Spreadsheet
Aconitum uncinatum	Eastern Blue Monkshood, Appalachian Blue Monkshood	G4	S2		High		Plants Excel Spreadsheet
Actaea podocarpa	Mountain Black-cohosh, Late Black-cohosh	G4	S1		High		Plants Excel Spreadsheet
Aesculus parviflora	Bottlebrush Buckeye	G3	S1		High	Moderate	Plants Excel Spreadsheet
Agalinis aphylla	Scale-leaf Agalinis	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Agalinis auriculata	Earleaf Foxglove	G3	S1		High	Moderate	Plants Excel Spreadsheet
Agalinis decemloba	Sandplain Agalinis	G3G4	S1		High		Plants Excel Spreadsheet
Agalinis laxa	Long-pedicelled Agalinis	G3G4	S1		High		Plants Excel Spreadsheet
Agalinis maritima var. grandiflora	Southern Saltmarsh Agalinis	G5T5	S1		High		Plants Excel Spreadsheet
Agalinis plukenetii	Plukenet's Agalinis	G3G5	SH		High		Plants Excel Spreadsheet
Agalinis tenella	Delicate Agalinis	G4	S1		High		Plants Excel Spreadsheet
Agarista populifolia	Agarista, Pipestem	G4G5	S1		High		Plants Excel Spreadsheet
Agastache nepetoides	Yellow Giant-hyssop	G5	SX		High		Plants Excel Spreadsheet
Agastache scrophulariifolia	Purple Giant-Hyssop	G4	SH		High		Plants Excel Spreadsheet
Agrimonia incisa	Pineland Agrimony	G3	S2		High	Moderate	Plants Excel Spreadsheet
Agrostis altissima	Coastal Bog Bentgrass	G4	S1		High		Plants Excel Spreadsheet
Aletris obovata	Southern White Colic-root	G4G5	S1		High		Plants Excel Spreadsheet
Allium cuthbertii	Cuthbert's Onion	G4	S2		High		Plants Excel Spreadsheet
Allium mobilense	Mobile Onion	G5T4T5	S1S2		High		Plants Excel Spreadsheet
Amaranthus pumilus	Seabeach Amaranth, Dwarf Amaranth	G2	S1	Federally Threatened	Highest	Very High	Plants Excel Spreadsheet
Ambrosia porcheri	Outcrop Ragweed	G1	S1		Highest		Plants Excel Spreadsheet
Ammannia latifolia	Pink Redstem	G5	S1		High		Plants Excel Spreadsheet
Amorpha confusa	Savanna Indigo-bush	G2G3	SX		Highest		Plants Excel Spreadsheet
Amorpha georgiana	Georgia Indigo-bush	G1	S1		Highest	Very High	Plants Excel Spreadsheet
Amorpha nitens	Dark Indigo-bush, Shining Indigo-bush	G4	S1		High		Plants Excel Spreadsheet
Amorpha schwerinii	Piedmont Indigo-bush	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Andropogon brachystachyus	Shortspike Bluestem	G4	S1		High		Plants Excel Spreadsheet
Andropogon longiberbis	Longbeard Bluestem	G5	S1		High		Plants Excel Spreadsheet

Andropogon mohrii	Tawny Bluestem, Bog Bluestem	G4?	S2		High		Plants Excel Spreadsheet
Andropogon tracyi	Tracy's Bluestem	G4?	S2		High		Plants Excel Spreadsheet
Andropogon virginicus var. 1	Smooth Bluestem	G5TNR	S1S2		High		Plants Excel Spreadsheet
Anemone berlandieri	Eastern Prairie Anemone, Ten-petal Anemone	G4G5	S1		High	Moderate	Plants Excel Spreadsheet
Anemone caroliniana	Prairie Anemone, Carolina Anemone	G5	S1		High		Plants Excel Spreadsheet
Aneura sharpii	Sharp's Greasewort	GNR	S1		High		Plants Excel Spreadsheet
Apocynum androsaemifolium	Spreading Dogbane	G5	S1		High		Plants Excel Spreadsheet
Aralia nudicaulis	Wild Sarsaparilla	G5	S1		High		Plants Excel Spreadsheet
Arethusa bulbosa	Dragon's-mouth, Bog-rose, Arethusa	G5	S1		High		Plants Excel Spreadsheet
Aristida mohrii	Mohr's Three-awn	G3	S1		Highest	Very High	Plants Excel Spreadsheet
Aristida simpliciflora	Southern Three-awn, Chapman's Three-awn	G3G4	S1		High		Plants Excel Spreadsheet
Aristida spiciformis var. spiciformis	Bottlebrush Three-awn, Spike Three-awn	G4TNR	S1		High		Plants Excel Spreadsheet
Aristida tenuispica	Southern Arrowfeather	G5T5	S1?		High		Plants Excel Spreadsheet
Arnoglossum ovatum var. ovatum	Broadleaf Indian-Plantain	G4G5	S1S2		High		Plants Excel Spreadsheet
Arnoglossum reniforme	Great Indian-plantain	G4	S1		High	Moderate	Plants Excel Spreadsheet
Aronia prunifolia	Purple Chokeberry	GNA	SH		High		Plants Excel Spreadsheet
Asclepias cinerea	Ashy Milkweed, "Carolina Milkweed"	G4?	S1		High		Plants Excel Spreadsheet
Asclepias connivens	Largeflower Milkweed	G4?	S1		High		Plants Excel Spreadsheet
Asclepias pedicellata	Stalked Milkweed, Savanna Milkweed	G4	S2		High		Plants Excel Spreadsheet
Asclepias rubra	Purple Savanna Milkweed, "Red Milkweed"	G4G5	S2		High		Plants Excel Spreadsheet
Asclepias viridis	Green Antelope-horn, Spider Milkweed	G4G5	SX		High		Plants Excel Spreadsheet
Asimina angustifolia	Slimleaf Pawpaw	G4	S1		High		Plants Excel Spreadsheet
Asplenium bradleyi	Bradley's Spleenwort	G4	S1		High	Moderate	Plants Excel Spreadsheet
Asplenium heterochroum	Bicolored Spleenwort	G3G5	SX		High		Plants Excel Spreadsheet
Asplenium heteroresiliens	Marl Spleenwort, Carolina Spleenwort, Wagner's Spleenwort, Morzenti's Spleenwort	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Asplenium monanthes	Single-sorus Spleenwort	G4	S1		High		Plants Excel Spreadsheet

Asplenium pinnatifidum	Lobed Spleenwort	G4	S1		High		Plants Excel Spreadsheet
Asplenium resiliens	Blackstem Spleenwort	G5	S1		High		Plants Excel Spreadsheet
Astilbe biternata	Appalachian Astilbe, Appalachian False Goat's-beard	G4G5	S2		High		Plants Excel Spreadsheet
Astragalus canadensis var. canadensis	Canada Milkvetch	G5T5	SH		High		Plants Excel Spreadsheet
Astragalus michauxii	Sandhill Milkvetch, Michaux's Milkvetch	G3	S2		High	Moderate	Plants Excel Spreadsheet
Astragalus villosus	Bearded Milkvetch, Southern Milkvetch	G4	S1		High		Plants Excel Spreadsheet
Astrolepis sinuata ssp. sinuata	Wavy Cloak Fern	G5?T5?	S1		High		Plants Excel Spreadsheet
Avenella flexuosa	Common Hairgrass, Wavy Hairgrass	G5	S1		High		Plants Excel Spreadsheet
Bacopa innominata	Tropical Water-hyssop	G3G5	S1		High		Plants Excel Spreadsheet
Bacopa rotundifolia	Midwestern Water-hyssop	G5	S1		High		Plants Excel Spreadsheet
Balduina atropurpurea	Bog Honeycomb-head, Purple Honeycomb-head, Purple Balduina	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Balduina uniflora	Savanna Honeycomb-head, Yellow Balduina	G4	S2		High		Plants Excel Spreadsheet
Baptisia cinerea	Carolina Wild Indigo	G3G4	S3S4		Moderate		Plants Excel Spreadsheet
Berberis canadensis	American Barberry, Allegheny Barberry	G3G4	S1		High		Plants Excel Spreadsheet
Betula alleghaniensis	Yellow Birch	G5	S1		High		Plants Excel Spreadsheet
Bidens cernua	Nodding Bur-marigold	G5	S1		High		Plants Excel Spreadsheet
Bidens connata	Purplestem Beggar-ticks	G5	S1S2		High		Plants Excel Spreadsheet
Bidens trichosperma	Northern Tickseed-sunflower	G4	S1?		High		Plants Excel Spreadsheet
Bidens vulgata	Tall Beggar-ticks	G5	S1		High		Plants Excel Spreadsheet
Bommeria hispida	Hispid Bommer Fern, Copper Fern, Hairy Bommer	G4	S1		High		Plants Excel Spreadsheet
Borodinia missouriensis	Missouri Rockcress	G5	S1		High		Plants Excel Spreadsheet
Boykinia aconitifolia	Brook-saxifrage, Aconite-saxifrage, Eastern Boykinia, Allegheny Brookfoam	G4	S2		High		Plants Excel Spreadsheet
Bromus nottowayanus	Satin Brome, Nottoway River Brome, Virginia Brome	G4G5	S1		High		Plants Excel Spreadsheet
Brunnichia ovata	Buckwheat-vine, Eardrop-vine, Ladies'-eardrops, Redvine	G4G5	S2		High		Plants Excel Spreadsheet
Bryocrumia vivicolor	Gorge Moss	G1G2	S1		Highest		Plants Excel Spreadsheet
Bulbostylis warei	Ware's Hairsedge	G3G4	S1		High		Plants Excel Spreadsheet

Burmannia biflora	Violet Burmannia	G4G5	S2		High		Plants Excel Spreadsheet
Calamagrostis porteri	Porter's Reedgrass	G4T4	S1		High		Plants Excel Spreadsheet
Calamovilfa brevipilis	Pinebarren Sandreed	G4	S1		High		Plants Excel Spreadsheet
Calicium carolinianum	Carolina stubble lichen	GNR	SH		High		Plants Excel Spreadsheet
Callirhoe triangulata	Sand Poppy-mallow, Clustered Poppy-mallow	G3	SH		High		Plants Excel Spreadsheet
Callitriche peploides	Matted Water-Starwort	G4G5	S2		High		Plants Excel Spreadsheet
Calopogon barbatus	Bearded Grass-pink	G4?	S2		High		Plants Excel Spreadsheet
Calopogon multiflorus	Many-flowered Grass-pink	G2G3	S1		Highest	High	Plants Excel Spreadsheet
Calopogon oklahomensis	Oklahoma Grass-pink	G2	SX		Highest		Plants Excel Spreadsheet
Campanulastrum americanum	Tall Bellflower	G5	S1		High		Plants Excel Spreadsheet
Canna flaccida	Golden Canna, Yellow Canna	G4?	S2		High		Plants Excel Spreadsheet
Capnoides sempervirens	Rock Harlequin, Tall Corydalis, Pink Corydalis, Pale Corydalis	G5	S1		High		Plants Excel Spreadsheet
Cardamine angustata	Eastern Slender Toothwort	G5	S1		High		Plants Excel Spreadsheet
Cardamine flagellifera var. flagellifera	Large Flowered Blue Ridge Bittercress	G3TNR	S1		High		Plants Excel Spreadsheet
Cardamine longii	Long's Bittercress	G3	S1		High		Plants Excel Spreadsheet
Carex aestivalis	Summer Sedge	G4	S2		High		Plants Excel Spreadsheet
Carex appalachica	Appalachian Sedge	G5?	S2		High	Moderate	Plants Excel Spreadsheet
Carex austrodeflexa	Canebrake Sedge	G3G4	S2		High		Plants Excel Spreadsheet
Carex austrolucorum	Appalachian Woodland Sedge	G5T3T4	S3		Moderate		Plants Excel Spreadsheet
Carex barrattii	Barratt's Sedge	G4	S1		High		Plants Excel Spreadsheet
Carex bicknellii	Bicknell's Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex biltmoreana	Biltmore Sedge	G3	S1		High	Moderate	Plants Excel Spreadsheet
Carex bromoides ssp. montana	Blue Ridge Brome Sedge	G5T3?	S3?		Moderate		Plants Excel Spreadsheet
Carex bullata var. bullata	Button Sedge	G5?T3T4	S1		High		Plants Excel Spreadsheet
Carex bullata var. greenei	Greene's Sedge	G5?T4	S1S2		High		Plants Excel Spreadsheet
Carex bushii	Bush's Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex buxbaumii	Brown Bog Sedge, Buxbaum's Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex calcifugens	Halfsweet Sedge	G3	S2		High		Plants Excel Spreadsheet

Carex chapmanii	Chapman's Sedge	G3	S2		High	Moderate	Plants Excel Spreadsheet
Carex collinsii	Collins's Sedge	G4	S2		High		Plants Excel Spreadsheet
Carex dasycarpa	Velvet Sedge	G4?	S2		High		Plants Excel Spreadsheet
Carex decomposita	Cypress-knee Sedge, Epiphytic Sedge	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Carex disjuncta	Silvery Sedge	G5T5	S1		High		Plants Excel Spreadsheet
Carex eburnea	Ebony Sedge, Bristleleaf Sedge	G5	SX		High		Plants Excel Spreadsheet
Carex echinata ssp. echinata	Star Sedge	G5T5	S1		High		Plants Excel Spreadsheet
Carex elliottii	Elliott's Sedge	G4?	S2		High		Plants Excel Spreadsheet
Carex fissa var. aristata	Hammock Sedge	G4?T4?	S1		High		Plants Excel Spreadsheet
Carex flexuosa	Flexuous White-edge Sedge, Rudge's White-edge Sedge	G5T5	S1		High		Plants Excel Spreadsheet
Carex folliculata	Northern Long Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex gholsonii	Gholson's Sedge	G4G5	S2S3		High		Plants Excel Spreadsheet
Carex gracilescens	Slender Loose-flowered Sedge	G5?	S1?		High		Plants Excel Spreadsheet
Carex granularis	Limestone Meadow Sedge, Corncob Sedge	G5	S1S2		High		Plants Excel Spreadsheet
Carex hyalinolepis	Shoreline Sedge	G4G5	S2		High		Plants Excel Spreadsheet
Carex impressinervia	Ravine Sedge	G3	S1		Highest		Plants Excel Spreadsheet
Carex jamesii	James's Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex lupuliformis	Umbo Sedge, False Hop Sedge	G4	S2?		High		Plants Excel Spreadsheet
Carex lutea	Golden Sedge	G2	S1	Federally Endangered	Highest		Plants Excel Spreadsheet
Carex manhartii	Blue Ridge Purple Sedge, Manhart's Sedge	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Carex meadii	Mead's Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex mesochorea	Midland Sedge	G4G5	S1S2		High		Plants Excel Spreadsheet
Carex normalis	Greater Straw Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex oligocarpa	Eastern Few-fruited Sedge	G5	S2		High		Plants Excel Spreadsheet
Carex planispicata	Flat-spiked Sedge	G4Q	S2		High		Plants Excel Spreadsheet
Carex projecta	Necklace Sedge	G5	S1S2		High		Plants Excel Spreadsheet
Carex radfordii	Radford's Sedge	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Carex reniformis	Kidney Sedge	G4?	S2		High		Plants Excel Spreadsheet

Carex rugosperma	Parachute Sedge	G5T5	S1		High		Plants Excel Spreadsheet
Carex ruthii	Ruth's Sedge	G3G4	S1		High		Plants Excel Spreadsheet
Carex socialis	Low Woodland Sedge	G4	S2		High	Moderate	Plants Excel Spreadsheet
Carex species 5	"a sedge"	G3	S1		High		Plants Excel Spreadsheet
Carex stricta	Tussock Sedge, Upright Sedge	G5	S1		High		Plants Excel Spreadsheet
Carex turgescens	Pinebarren Sedge	G4G5	S2		High		Plants Excel Spreadsheet
Carex willdenowii	Willdenow's Sedge	G5?	S1		High		Plants Excel Spreadsheet
Carex woodii	Wood's Sedge	G4	S1		High		Plants Excel Spreadsheet
Carphephorus corymbosus	Flatwood Chaffhead	G4	S1		High		Plants Excel Spreadsheet
Carya myristiciformis	Nutmeg Hickory	G4	S2		High		Plants Excel Spreadsheet
Castanea dentata	American Chestnut	G3	S3		Moderate		Plants Excel Spreadsheet
Cayaponia quinqueloba	Five-lobe-cucumber	G4	S2		High	Moderate	Plants Excel Spreadsheet
Celastrus scandens	American Bittersweet, Waxwork	G5	SH		High		Plants Excel Spreadsheet
Ceratiola ericoides	Rosemary, Florida Rosemary, Sandhill Rosemary, Sand Heath	G4	S1		High		Plants Excel Spreadsheet
Ceratophyllum echinatum	Spineless Hornwort	G4	S1		High		Plants Excel Spreadsheet
Cetradonia linearis	Rock Gnome Lichen	G3	S1	Federally Endangered	Highest		Plants Excel Spreadsheet
Chaerophyllum procumbens var. procumbens	Common Spreading Chervil	G5T5	S1		High		Plants Excel Spreadsheet
Chaerophyllum procumbens var. shortii	Short's Spreading Chervil	G5T3T4Q	S1?		High		Plants Excel Spreadsheet
Chasmanthium nitidum	Shiny Spanglegrass	G3G4	S2S3		High	Moderate	Plants Excel Spreadsheet
Cheilolejeunea evansii	Evan's Cheilolejeunea	G2	S1		Highest		Plants Excel Spreadsheet
Chelone cuthbertii	Cuthbert's Turtlehead	G3	SX		High		Plants Excel Spreadsheet
Chelone lyonii	Appalachian Turtlehead	G4	S2		High		Plants Excel Spreadsheet
Chelone obliqua var. erwiniae	Mountain Purple Turtlehead, Erwin's Turtlehead	G4T2T4Q	S1S2		High		Plants Excel Spreadsheet
Chelone obliqua var. obliqua	Purple Turtlehead	G4T3T4Q	S1S2		High		Plants Excel Spreadsheet
Chimaphila umbellata var. cisatlantica	Prince's-pine	G5T5	SX		High		Plants Excel Spreadsheet
Chrysoma pauciflosculosa	Woody Goldenrod	G4G5	S1S2		High		Plants Excel Spreadsheet
Chrysosplenium americanum	Golden-saxifrage, Water-mat, Water-carpet	G5	S1		High		Plants Excel Spreadsheet
Cicuta mexicana	Southern Water-hemlock	G3G5	S1?		High		Plants Excel Spreadsheet

Cirsium discolor	Field Thistle	G5	S1		High		Plants Excel Spreadsheet
Cirsium horridulum var. vittatum	Southern Yellow Thistle, Pineland Thistle	G5T3T4	S2S3		High		Plants Excel Spreadsheet
Cirsium lecontei	LeConte's Thistle	G3	S1		High		Plants Excel Spreadsheet
Cirsium pumilum	Pasture Thistle	G4G5	S1?		High		Plants Excel Spreadsheet
Cirsium virginianum	Virginia Thistle	G3	S3S4?		Moderate		Plants Excel Spreadsheet
Cladina evansii	Powder-puff Lichen	G3G5	S2		High		Plants Excel Spreadsheet
Cladium mariscoides	Twig-rush, Fen-sedge, Smooth Sawgrass	G5	S1		High		Plants Excel Spreadsheet
Cladonia psoromica	Prostrate Thorn Cladonia	G1	S1		High		Plants Excel Spreadsheet
Cladrastis kentukea	Yellow-wood	G4	S1		High	Moderate	Plants Excel Spreadsheet
Claytosmunda claytoniana	Interrupted Fern	G5	S1		High		Plants Excel Spreadsheet
Cleistesiopsis bifaria	Appalachian Dragonhead Pogonia	G3G4	S1S2		High		Plants Excel Spreadsheet
Cleistesiopsis oricamporum	Small Dragonhead Pogonia	G3?	S3		Moderate		Plants Excel Spreadsheet
Cliftonia monophylla	Black Titi, Buckwheat-tree	G4G5	S1		High		Plants Excel Spreadsheet
Coleataenia longifolia ssp. combsii	Combs's Panic Grass	G5T5?	S1S2		High		Plants Excel Spreadsheet
Coleataenia tenera	Southeastern Panic Grass	G4	S2		High		Plants Excel Spreadsheet
Collinsonia punctata	Florida Horsebalm	G3?	S1		High	Moderate	Plants Excel Spreadsheet
Collinsonia tuberosa	Stoneroot	G3G4	S2S3		High		Plants Excel Spreadsheet
Collinsonia verticillata	Whorled Horsebalm	G3G4	S3		Moderate	Moderate	Plants Excel Spreadsheet
Comptonia peregrina	Sweet-fern	G5	S1		High		Plants Excel Spreadsheet
Convallaria pseudomajalis	American Lily-of-the-Valley	G4?	S1		High		Plants Excel Spreadsheet
Convolvulus catesbyanus	Catesby's Bindweed	G4	S1S2		High		Plants Excel Spreadsheet
Convolvulus sericatus	Silky Bindweed, Blue Ridge Bindweed	G4T3	S2S3		High		Plants Excel Spreadsheet
Corallorhiza maculata var. maculata	Eastern Spotted Coralroot, Summer Coralroot	G5T5	SH		High		Plants Excel Spreadsheet
Coreopsis delphiniifolia	Larkspur Coreopsis	G3?	S3?		Moderate		Plants Excel Spreadsheet
Coreopsis integrifolia	Chipola Dye-flower	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Coreopsis latifolia	Broadleaf Coreopsis	G3	S1		High	Moderate	Plants Excel Spreadsheet
Coreopsis palustris	Beadle's Coreopsis	G3G4Q	S1		High		Plants Excel Spreadsheet
Coreopsis pubescens var. robusta	Mountain Hairy Coreopsis	G5?T3T5	S1?		High		Plants Excel Spreadsheet

Coreopsis rosea	Pink Coreopsis	G3	S1		Highest	High	Plants Excel Spreadsheet
Crataegus aemula	Rome Hawthorn	G2	S1		Highest		Plants Excel Spreadsheet
Crataegus berberifolia var. berberifolia	Barberry Hawthorn	G5T4	S1		High		Plants Excel Spreadsheet
Crataegus berberifolia var. engelmannii	Engelmann's Hawthorn	G5T4	S1		High		Plants Excel Spreadsheet
Crataegus calpodendron	Pear Hawthorn	G5	SH		High		Plants Excel Spreadsheet
Crataegus dispar	Aiken Hawthorn	G3G5Q	S1S2		High		Plants Excel Spreadsheet
Crataegus florens	Mississippi Hawthorn	GNR	S1?		High		Plants Excel Spreadsheet
Crataegus lepida	Pygmy Hawthorn	GNR	S1?		High		Plants Excel Spreadsheet
Crataegus mendosa	Albertville Hawthorn	G3Q	S1		High		Plants Excel Spreadsheet
Crataegus pexa	Woolly Dwarf Hawthorn	G4G5TNR	S1?		High		Plants Excel Spreadsheet
Crataegus phaenopyrum	Washington Hawthorn	G4?	S2		High		Plants Excel Spreadsheet
Crataegus senta	Rough Hawthorn	G2	S3S4		Highest		Plants Excel Spreadsheet
Crepidomanes intricatum	Grotto-felt, Appalachian Trichomanes, Weft Fern	G4G5	S1		High		Plants Excel Spreadsheet
Crinum americanum var. americanum	Swamp-lily, String-lily, Seven-sisters	G5T5	S1		High		Plants Excel Spreadsheet
Crocanthemum corymbosum	Pinebarren Sunrose	G4G5	S2		High		Plants Excel Spreadsheet
Crocanthemum georgianum	Georgia Sunrose	G4	S2		High		Plants Excel Spreadsheet
Crocanthemum nashii	Florida Scrub Sunrose, Nash's Sunrose	G3G4	S1		High		Plants Excel Spreadsheet
Crotalaria maritima	Low Rattlebox, Rabbitbells	GNR	S1?		High		Plants Excel Spreadsheet
Croton elliottii	Pondshore Croton, Elliott's Croton	G3	S1S2		Highest	High	Plants Excel Spreadsheet
Cuphea viscosissima	Clammy Cuphea, Blue Waxweed	G5	S1		High		Plants Excel Spreadsheet
Cuscuta cephalanthi	Buttonbush Dodder	G5	S1		High		Plants Excel Spreadsheet
Cuscuta coryli	Hazel Dodder	G4	S1		High		Plants Excel Spreadsheet
Cuscuta indecora	Bigseed Alfalfa Dodder	G5	S1		High		Plants Excel Spreadsheet
Cuscuta rostrata	Appalachian Dodder, Beaked Dodder	G4	S1		High		Plants Excel Spreadsheet
Cyperus articulatus	Chintúl	G4G5	SX		High		Plants Excel Spreadsheet
Cyperus distinctus	Swamp Flatsedge	G4	S1		High		Plants Excel Spreadsheet
Cyperus granitophilus	Granite Flatsedge	G3G4	S1?		High	Moderate	Plants Excel Spreadsheet
Cyperus grayi	Gray's Flatsedge	G4G5	S2		High		Plants Excel Spreadsheet

Cyperus hystricinus	Bristly Flatsedge	G4	S2?		High		Plants Excel Spreadsheet
Cyperus lecontei	Le Conte's Flatsedge	G4?	S1		High		Plants Excel Spreadsheet
Cyperus tetragonus	Four-angled Flatsedge	G4	S2		High		Plants Excel Spreadsheet
Cystopteris bulbifera	Bulblet Fern, Bulblet Bladder Fern	G5	S1		High		Plants Excel Spreadsheet
Danthonia epilis	Bog Oat-grass	G4	S2		High		Plants Excel Spreadsheet
Dasistoma macrophyllum	Mullein Foxglove	G4	SH		High	Moderate	Plants Excel Spreadsheet
Delphinium carolinianum ssp. carolinianum	Ozark Larkspur, Prairie Larkspur, Carolina Larkspur, Blue Larkspur	G5T5	S1		High		Plants Excel Spreadsheet
Delphinium tricorne	Dwarf Larkspur	G5	S1?		High		Plants Excel Spreadsheet
Dendrolycopodium hickeyi	Delicate Tree-clubmoss, Pennsylvania Groundpine, Hickey's Tree-clubmoss	G5	S1		High		Plants Excel Spreadsheet
Dermiscellum oulocheila	Catawbar River Buttons	GNR	S1		High		Plants Excel Spreadsheet
Desmodium fernaldii	Fernald's Tick-trefoil	G4	S1S2		High		Plants Excel Spreadsheet
Desmodium floridanum	Florida Tick-trefoil	G4	S1		High		Plants Excel Spreadsheet
Desmodium paniculatum var. epetiolatum	Panicledleaf Ticktrefoil	G5T1Q	S1?		High		Plants Excel Spreadsheet
Desmodium sessilifolium	Sessile-leaf Tick-trefoil	G5	S1?		High		Plants Excel Spreadsheet
Dicentra canadensis	Squirrel Corn	G5	S1		High		Plants Excel Spreadsheet
Dicentra cucullaria	Dutchman's Britches, Dutchman's Breeches	G5	S1		High		Plants Excel Spreadsheet
Dicentra eximia	Wild Bleeding Heart	G4	S1		High		Plants Excel Spreadsheet
Dicerandra odoratissima	Harper's Scrub-balm	G4G5	S1		High		Plants Excel Spreadsheet
Dichanthelium annulum	Ringed Witchgrass	G4	SH		High		Plants Excel Spreadsheet
Dichanthelium bicknellii	Bicknell's Witch Grass	G4?Q	S1		High		Plants Excel Spreadsheet
Dichanthelium caerulescens	Blue Witchgrass	G3	S1		High		Plants Excel Spreadsheet
Dichanthelium columbianum	American Witchgrass	G5T5	S1		High		Plants Excel Spreadsheet
Dichanthelium cryptanthum	Hidden-flowered Witchgrass	G3Q	S1		High		Plants Excel Spreadsheet
Dichanthelium curtifolium	Short-leaved Witchgrass	G4T3?	SX		High		Plants Excel Spreadsheet
Dichanthelium fusiforme	Spindle-fruited Witchgrass	G5?	S1?		High		Plants Excel Spreadsheet
Dichanthelium glabrifolium	Smooth-leaved Witchgrass	G5TNR	S1		High		Plants Excel Spreadsheet
Dichanthelium latifolium	Broad-leaved Witchgrass	G5	S1?		High		Plants Excel Spreadsheet
Dichanthelium linearifolium	Slimleaf Panicgrass	G5	SH		High		Plants Excel Spreadsheet

Dichanthelium malacon	Dehiscent Witch Grass	G3	S2		High		Plants Excel Spreadsheet
Dichanthelium neuranthum	Nerved Witchgrass	G5T3	S1		High		Plants Excel Spreadsheet
Dichanthelium roanokense	Roanoke Witchgrass	G4?	S1		High		Plants Excel Spreadsheet
Dichanthelium scribnerianum	Scribner's Witchgrass	G5T5	SH		High		Plants Excel Spreadsheet
Dichanthelium spretum	Eaton's Witchgrass	G5	S1		High		Plants Excel Spreadsheet
Dichanthelium strigosum var. glabrescens	Hairless Witchgrass	G5T4T5	S1		High		Plants Excel Spreadsheet
Didiplis diandra	Water-purslane	G3G4	SH		High		Plants Excel Spreadsheet
Didymoglossum petersii	Dwarf Filmy Fern	G4	S2		High		Plants Excel Spreadsheet
Diervilla sessilifolia	Smooth Southern Bush-honeysuckle	G4?	S2		High		Plants Excel Spreadsheet
Dinebra panicea ssp. brachiata	Red Sprangletop	GNRT5	S1		High		Plants Excel Spreadsheet
Diodia harperi	Harper's Buttonweed	G4	S2		High		Plants Excel Spreadsheet
Dionaea muscipula	Venus Flytrap, Meadow Clam, Tippitiwitchet	G2	S1	State Regulated	Highest	Very High	Plants Excel Spreadsheet
Dioscorea floridana	Florida Wild Yam	G3G4	S1S2		High		Plants Excel Spreadsheet
Diphasiastrum tristachyum	Blue Running-cedar, Ground-cedar	G5	S1		High		Plants Excel Spreadsheet
Diphylleia cymosa	Umbrella-leaf, Pixie-parasol	G4	S1		High		Plants Excel Spreadsheet
Diplaziopsis pycnocarpa	Glade Fern	G5	S1		High		Plants Excel Spreadsheet
Doellingeria sericocarpoides	Pocosin Flat-topped Aster, Southern Flat-topped Aster, Southern Tall Flat-topped Aster	G3G5	S2		High		Plants Excel Spreadsheet
Doellingeria umbellata var. umbellata	Northern Flat-topped White Aster, Northern Tall Flat-topped Aster	G5T5	S1		High		Plants Excel Spreadsheet
Donrichardsia pringlei	Pringle's Water Feathermoss	G4	S1		High		Plants Excel Spreadsheet
Drosera filiformis var. filiformis	Northern Threadleaf Sundew	G4T4	SX		High		Plants Excel Spreadsheet
Drosera rotundifolia	Roundleaf Sundew	G5	S1		High		Plants Excel Spreadsheet
Dryopteris australis	Southern Woodfern, Southern Shieldfern	GNA	S1		High		Plants Excel Spreadsheet
Dryopteris carthusiana	Spinulose Woodfern, Toothed Woodfern	G5	S1		High		Plants Excel Spreadsheet
Dryopteris goldieana	Goldie's Woodfern, Giant Woodfern	G5	S1		High		Plants Excel Spreadsheet
Duravia species 2	Glade Knotweed, Slender Knotweed	G5	S1?		High		Plants Excel Spreadsheet
Dyschoriste humistrata	Swamp Twinflower, Swamp Dyschoriste	G4G5	S1		High		Plants Excel Spreadsheet
Echinacea laevigata	Smooth Purple Coneflower	G2G3	S2	Federally Threatened	Highest	High	Plants Excel Spreadsheet

Elatine minima	Tiny Waterwort	G5	S1		High		Plants Excel Spreadsheet
Eleocharis ambigens	Creeping Spikerush	G4G5	S1		High		Plants Excel Spreadsheet
Eleocharis atropurpurea	Purple Spikerush	G4G5	S2		High		Plants Excel Spreadsheet
Eleocharis brittonii	Britton's Spikerush	G4G5	S1		High		Plants Excel Spreadsheet
Eleocharis cellulosa	Gulf Coast Spikerush	G4G5	S1		High		Plants Excel Spreadsheet
Eleocharis engelmannii	Engelmann's Spikerush	G5	S1S2		High		Plants Excel Spreadsheet
Eleocharis microcarpa var. microcarpa	Smallfruit Spikerush	G5T3T4	S1?		High		Plants Excel Spreadsheet
Eleocharis montevidensis	Sand Spikerush	G5	S1		High		Plants Excel Spreadsheet
Eleocharis nigrescens	Black Spikerush	G3G5	S1?		High		Plants Excel Spreadsheet
Eleocharis palustris	Common Spikerush, Small's Spikerush	G5	S1		High		Plants Excel Spreadsheet
Eleocharis parvula	Dwarf Spikerush, Small Spikerush	G5	S1S2		High		Plants Excel Spreadsheet
Eleocharis robbinsii	Robbins's Spikerush	G4	S2		High		Plants Excel Spreadsheet
Eleocharis rostellata	Beaked Spikerush	G5	S1		High		Plants Excel Spreadsheet
Eleocharis verrucosa	Slender Spikerush	G5T5?	S1		High		Plants Excel Spreadsheet
Eleocharis vivipara	Viviparous Spikerush	G5	S1		High		Plants Excel Spreadsheet
Elliottia racemosa	Elliottia, Southern-plume, Georgia-plume, 'Laurel'	G2?	SX		Highest	Very High	Plants Excel Spreadsheet
Elymus trachycaulus ssp. trachycaulus	Slender Wheatgrass	G5T5	S1		High		Plants Excel Spreadsheet
Enemion biternatum	Isopyrum, False Rue-anemone	G5	S1		High		Plants Excel Spreadsheet
Ephebe solida	Rockshag Lichen, Thick-branched rockshag	G3G4	S3		Moderate		Plants Excel Spreadsheet
Epilobium ciliatum ssp. ciliatum	American Willow-herb	G5T5	SH		High		Plants Excel Spreadsheet
Epilobium coloratum	Bronze Willow-herb, Eastern Willow-herb	G5	S1S2		High		Plants Excel Spreadsheet
Eragrostis frankii	Lacegrass, Sandbar Lovegrass	G5	S1?		High		Plants Excel Spreadsheet
Eriocaulon ravenelii	Ravenel's Pipewort	G3G4	SX		High		Plants Excel Spreadsheet
Eriocaulon texense	Texas Hatpins	G4	S1		High	Moderate	Plants Excel Spreadsheet
Eriochloa michauxii var. michauxii	Longleaf Cupgrass	G3G4T3T4	SH		High	Moderate	Plants Excel Spreadsheet
Eriophorum virginicum	Tawny Cottonsedge, Tawny Cottongrass, Cat's-paw	G5	S1?		High		Plants Excel Spreadsheet
Eryngium baldwinii	Baldwin's Eryngo	G5	S1		High		Plants Excel Spreadsheet

Eryngium ravenelii	Ravenel's Eryngo	G4T2T3	S1		Highest	High	Plants Excel Spreadsheet
Eubotrys recurvus	Mountain Fetterbush	G4G5	S2		High		Plants Excel Spreadsheet
Euonymus atropurpureus	American Wahoo, Burning Bush, Bleeding Heart, Waahoo	G5	S1		High		Plants Excel Spreadsheet
Euonymus obovatus	Running Strawberry-bush	G5	S1		High		Plants Excel Spreadsheet
Eupatorium altissimum	Tall Thoroughwort	G5	S1		High		Plants Excel Spreadsheet
Eupatorium anomalum	Anomalous Eupatorium	G2G3	S2		Highest	High	Plants Excel Spreadsheet
Eupatorium cordigerum	Clasping Roundleaf Eupatorium	G5TNR	SH		High		Plants Excel Spreadsheet
Eupatorium fernaldii	Fernald's Eupatorium	GNR	S1		High		Plants Excel Spreadsheet
Eupatorium leptophyllum	Limesink Dog-fennel	G5	S1S2		High		Plants Excel Spreadsheet
Eupatorium paludicola	Bay Boneset	G2	S1		Highest		Plants Excel Spreadsheet
Eupatorium recurvans	Recurved Eupatorium	G3G4Q	S2?		High	Moderate	Plants Excel Spreadsheet
Eupatorium resinosum	Resinous Boneset, Pinebarren Eupatorium	G3	SH		High	Moderate	Plants Excel Spreadsheet
Euphorbia bombensis	Southern Seaside Spurge, Dixie Sandmat	G4G5	S2		High		Plants Excel Spreadsheet
Euphorbia discoidalis	Summer Spurge	G4	S1		High		Plants Excel Spreadsheet
Eurybia avita	Alexander's Rock Aster	G3	S1		High	Moderate	Plants Excel Spreadsheet
Eurybia compacta	Slender Aster	G4G5	S1		High		Plants Excel Spreadsheet
Eurybia macrophylla	Big-leaved Aster	G5	S1		High		Plants Excel Spreadsheet
Eurybia mirabilis	Piedmont Aster	G3	S2S3?		High		Plants Excel Spreadsheet
Eurybia spectabilis	Low Showy Aster	G5	S1		High		Plants Excel Spreadsheet
Euthamia graminifolia	Northern Smooth Goldentop	G5	S1		High		Plants Excel Spreadsheet
Fellhanera hybrida	Piedmont Crustose Lichen	G2?	S2?		Highest		Plants Excel Spreadsheet
Fimbristylis decipiens	Tricky Fimbry	G4	S1		High		Plants Excel Spreadsheet
Fimbristylis perpusilla	Harper's Fimbry	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Fimbristylis vahlii	Vahl's Fimbry	G5	S1		High		Plants Excel Spreadsheet
Forestiera godfreyi	Godfrey's Forestiera	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Forestiera ligustrina	Glade Forestiera, Southern-privet	G4G5	S2		High		Plants Excel Spreadsheet
Forestiera segregata	Florida Forestiera, Florida-privet	G4	S1		High		Plants Excel Spreadsheet
Fothergilla major	Large Witch-alder	G3	S2		High	Moderate	Plants Excel Spreadsheet

Fothergilla parvifolia	Kearney's Witch-alder	G2	S1		Highest		Plants Excel Spreadsheet
Fraxinus pauciflora	Swamp White Ash	GNR	S1?		High		Plants Excel Spreadsheet
Fraxinus profunda	Pumpkin Ash	G4	S2S3?		High		Plants Excel Spreadsheet
Gaillardia aestivalis var. aestivalis	Sandhill Gaillardia, Prairie Gaillardia	G5T5	S1S2		High		Plants Excel Spreadsheet
Galactia mollis	Soft Sandhill Milk-pea	G4	S1S2		High		Plants Excel Spreadsheet
Galium lanceolatum	Lanceleaf Bedstraw, Wild-licorice	G5	S1		High		Plants Excel Spreadsheet
Gaylussacia baccata	Black Huckleberry, Crackleberry	G5	S1S2		High		Plants Excel Spreadsheet
Gaylussacia bigeloviana	Northern Dwarf Huckleberry	G4G5	S1		High		Plants Excel Spreadsheet
Gelsemium rankinii	Swamp Jessamine	G5	S1		High		Plants Excel Spreadsheet
Gentiana autumnalis	Pinebarren Gentian	G3	S2S3		High	Moderate	Plants Excel Spreadsheet
Gentiana villosa	Striped Gentian	G4	S2		High		Plants Excel Spreadsheet
Gentianella quinquefolia	Appalachian Gentianella, Eastern Agueweed	G5	S1S2		High		Plants Excel Spreadsheet
Geobalanus oblongifolius	Gopher-apple, Ground-oak	G4G5	S1		High		Plants Excel Spreadsheet
Geocarpon glabrum	Appalachian Sandwort	G4	S2S3		High		Plants Excel Spreadsheet
Geum vernum	Spring Avens, Heartleaf Avens	G5	S1		High		Plants Excel Spreadsheet
Gillenia stipulata	Midwestern Indian-physic	G5	SH		High		Plants Excel Spreadsheet
Glandularia canadensis	Rose Vervain, Rose Verbena, Creeping Vervain	G5	S1S2		High		Plants Excel Spreadsheet
Glyceria obtusa	Coastal Mannagrass	G5	S1		High		Plants Excel Spreadsheet
Gratiola amphiantha	Pool-sprite, Snorkelwort	G2	S1	Federally Threatened	Highest	Very High	Plants Excel Spreadsheet
Gratiola graniticola	Granite-loving Hedge-hyssop	G3	S1		High		Plants Excel Spreadsheet
Gratiola lutea	Yellow Hedge-hyssop, Golden-pert	G5	S1		High		Plants Excel Spreadsheet
Gratiola viscidula	Viscid Hedge-hyssop, Short's Hedge-hyssop	G4G5	S2		High		Plants Excel Spreadsheet
Habenaria quinqueseta	Michaux's Orchid	G4G5	S1		High		Plants Excel Spreadsheet
Hackelia virginiana	Virginia Stickseed	G5	S1		High		Plants Excel Spreadsheet
Halesia carolina	Little Silverbell	G4G5	S2		High		Plants Excel Spreadsheet
Halesia diptera var. diptera	Common Two-wing Silverbell	G5TNR	S1		High		Plants Excel Spreadsheet
Harperella nodosa	Harperella	G2	S1	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Hedeoma pulegioides	American Pennyroyal	G5	S1		High		Plants Excel Spreadsheet

Helenium brevifolium	Shortleaf Sneezeweed	G4	S1		High	Moderate	Plants Excel Spreadsheet
Helianthus eggertii	Eggert's Sunflower, Tennessee Sunflower	G3	S1		High	Moderate	Plants Excel Spreadsheet
Helianthus floridanus	Florida Sunflower	G3G4	S1		High		Plants Excel Spreadsheet
Helianthus glaucophyllus	Whiteleaf Sunflower	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Helianthus laevigatus	Shale-barren Sunflower, Smooth Sunflower	G4	S2		High		Plants Excel Spreadsheet
Helianthus porteri	Confederate Daisy	G4	S1		High		Plants Excel Spreadsheet
Helianthus radula	Roundleaf Sunflower, Rayless Sunflower	G4G5	S1		High		Plants Excel Spreadsheet
Helianthus schweinitzii	Schweinitz's Sunflower	G3	S3	Federally Endangered	Highest	Moderate	Plants Excel Spreadsheet
Helonias bullata	Swamp Pink	G3	S1	Federally Threatened	Highest	High	Plants Excel Spreadsheet
Heteranthera reniformis	Kidneyleaf Mud-Plantain	G5	S1		High		Plants Excel Spreadsheet
Heuchera pubescens	Marbled Alumroot	G4?	S1		High		Plants Excel Spreadsheet
Hexastylis minor	Little Heartleaf	G4G5Q	S2S3		High		Plants Excel Spreadsheet
Hexastylis naniflora	Dwarf-flower Heartleaf	G3	S3	Federally Threatened	Moderate	Moderate	Plants Excel Spreadsheet
Hexastylis rhombiformis	French Broad Heartleaf	G3	S1		High		Plants Excel Spreadsheet
Hexastylis ruthii	Appalachian Little Brown Jug	G5T4?	S1S2		High		Plants Excel Spreadsheet
Hexastylis sorriei	Sandhill Heartleaf	G3	S1		Highest	Very High	Plants Excel Spreadsheet
Hibiscus grandiflorus	Large-flowered Hibiscus, Swamp Hibiscus	G4?	SX		High		Plants Excel Spreadsheet
Hieracium scabrum	Rough Hawkweed	G5	S1?		High		Plants Excel Spreadsheet
Hottonia inflata	Featherfoil, Water-violet	G4	S1		High	Moderate	Plants Excel Spreadsheet
Houstonia longifolia var. glabra	Granite Dome Bluet	G5T3Q	S1?		High		Plants Excel Spreadsheet
Hudsonia ericoides	Northern Golden-Heather, Pine Barren Heather	G4	S1		High		Plants Excel Spreadsheet
Huperzia porophila	Rock Firmoss, Rock Clubmoss	G4	S1		High	Moderate	Plants Excel Spreadsheet
Hydrangea cinerea	Ashy Hydrangea, Southern Wild Hydrangea	G5	S1		High		Plants Excel Spreadsheet
Hydrastis canadensis	Goldenseal, Tumeric, Orange-root	G3G4	S1		High		Plants Excel Spreadsheet
Hydrocotyle americana	American Water-pennywort	G5	S1		High		Plants Excel Spreadsheet
Hydrolea corymbosa	Skyflower	G5	S1		High		Plants Excel Spreadsheet
Hydrophyllum macrophyllum	Hairy Waterleaf	G5	S1		High		Plants Excel Spreadsheet
Hylotelephium telephioides	Allegheny Live-for-ever	G4	S1		High		Plants Excel Spreadsheet

Hymenocallis coronaria	Shoals Spiderlily, Cahaba Lily	G3?	S2		Highest	High	Plants Excel Spreadsheet
Hymenocallis occidentalis var. occidentalis	Hammock Spiderlily, Woodland Spiderlily, Northern Spiderlily	G4?TNR	S1		High		Plants Excel Spreadsheet
Hymenocallis pygmaea	Pygmy Spiderlily, Waccamaw Spiderlily	G2Q	S3		Highest		Plants Excel Spreadsheet
Hymenophyllum tayloriae	Gorge Filmy Fern	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Hymenophyllum tunbrigense	Tunbridge Filmy Fern, Tunbridge Fern	G4G5	S1		High		Plants Excel Spreadsheet
Hypericum adpressum	Bog St. John's-wort, Creeping St. John's-wort	G3	S1		High	Moderate	Plants Excel Spreadsheet
Hypericum buckleyi	Granite Dome St. John's-wort	G3	SX		High	Moderate	Plants Excel Spreadsheet
Hypericum erythreae	Georgia St. John's-wort, Sparse-leaved St. John's-wort, Grit St. John's-wort	G2	SX		Highest		Plants Excel Spreadsheet
Hypericum harperi	Harper's St. John's-wort	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Hypericum mutilum var. latisepalum	Southern Dwarf St. John's-wort	G5TNR	S1?		High		Plants Excel Spreadsheet
Hypericum myrtifolium	Myrtle-leaf St. John's-wort	G4G5	S1		High		Plants Excel Spreadsheet
Hypericum nitidum	Carolina St. Johnswort	G4	S1S2		High		Plants Excel Spreadsheet
Hypericum pseudomaculatum	Large Spotted St. John's-wort	G5?	S1		High		Plants Excel Spreadsheet
Hypericum suffruticosum	Pineland St. John's-wort	G4G5	S1S2		High		Plants Excel Spreadsheet
Hypericum tenuifolium	Sandhill St. John's-wort	G5	S1		High		Plants Excel Spreadsheet
Hypoxis juncea	Fringed Stargrass	G4?	S1		High		Plants Excel Spreadsheet
Hypoxis rigida	Savanna Stargrass	G4	S1?		High		Plants Excel Spreadsheet
Hypoxis sessilis	Glossy-seed Stargrass	G3	S1?		High		Plants Excel Spreadsheet
Ilex cuthbertii	Cuthbert Holly	G1	S1		Highest		Plants Excel Spreadsheet
Impatiens pallida	Yellow Jewelweed, Yellow Touch-me-not, Pale Touch-me-not	G5	S1		High		Plants Excel Spreadsheet
Ipomoea brasiliensis	Railroad Vine, Goat's-foot, Bay Hops, Bay Winders	G5T5	S1S2		High		Plants Excel Spreadsheet
Ipomoea macrorhiza	Indian-midden Morning-glory, Manroot, Pink Moonvine, Largeroot Morning-glory	G3	S1		High	Moderate	Plants Excel Spreadsheet
Ipomopsis rubra	Standing-cypress, Spanish-larkspur	G4G5	S2		High		Plants Excel Spreadsheet
Iresine rhizomatosa	Bloodleaf	G5	S1		High		Plants Excel Spreadsheet
Iris hexagona	Anglepod Blue Flag	GNR	S1?		High		Plants Excel Spreadsheet
Iris prismatica	Slender Blue Iris, Slender Blue Flag	G4	S1		High		Plants Excel Spreadsheet

Isoetes hyemalis	Wintergreen Quillwort	G2G3	S1		Highest	High	Plants Excel Spreadsheet
Isoetes melanopoda ssp. silvatica	Eastern Blackfoot Quillwort	G5TNR	S1S2		High		Plants Excel Spreadsheet
Isoetes piedmontana	Piedmont Quillwort	G4	S2		High		Plants Excel Spreadsheet
Isoetes species 1	Carolina Quillwort	GNR	S1		High		Plants Excel Spreadsheet
Isoetes valida	Mountain Quillwort, Carolina Quillwort	G4?	S1		High		Plants Excel Spreadsheet
Isotrema tomentosum	Woolly Dutchman's-pipe, Pipevine	G5	S1		High		Plants Excel Spreadsheet
Isotria medeoloides	Small Whorled Pogonia, Little Five-leaves	G2G3	S2	Federally Threatened	Highest	High	Plants Excel Spreadsheet
Iva microcephala	Small-headed Marsh-elder	G5	S1S2		High		Plants Excel Spreadsheet
Juglans cinerea	Butternut, White Walnut	G3	S2		High		Plants Excel Spreadsheet
Juncus anthelatus	Large Path Rush, Greater Poverty Rush	GNR	S1		High		Plants Excel Spreadsheet
Juncus georgianus	Georgia Rush, Flatrock Rush	G3	S2		High		Plants Excel Spreadsheet
Juncus longii	Long's Rush	G3Q	S1S2?		High		Plants Excel Spreadsheet
Juncus paludosus	Swamp Rush	G3G4	SH		High		Plants Excel Spreadsheet
Juncus pylaei	Common Rush	G5T5?	S1		High		Plants Excel Spreadsheet
Juncus secundus	Secund Rush, Lop-sided Rush	G5?	S1		High		Plants Excel Spreadsheet
Juncus subcaudatus	Somewhat-tailed Rush	G5	S1		High		Plants Excel Spreadsheet
Juniperus communis var. depressa	Ground Juniper, Mountain Juniper, Common Juniper	G5T5	S1		High		Plants Excel Spreadsheet
Kalmia cuneata	White Wicky	G3	S1		High	Moderate	Plants Excel Spreadsheet
Krigia montana	Mountain Dwarf-dandelion, Mountain Cynthia	G3	S2		High	Moderate	Plants Excel Spreadsheet
Lachnocaulon minus	Brown Bogbutton	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Lathyrus pusillus	Tiny Pea	G5?	S1		High		Plants Excel Spreadsheet
Lathyrus venosus	Smooth Forest Pea	G5	SH		High		Plants Excel Spreadsheet
Lejeunea blomquistii	Blomquist Leafy Liverwort	G3	S1		High		Plants Excel Spreadsheet
Leptohymenium sharpii	Mount Leconte Moss	G1	S1		Highest		Plants Excel Spreadsheet
Liatris aspera	Rough Blazing-star	G4G5	S2		High		Plants Excel Spreadsheet
Liatris cokeri	Sandhill Blazing-star	G3	S3		Moderate		Plants Excel Spreadsheet
Liatris elegans var. kralii	Kral's Elegant Blazing-star	G5TNR	S1?		High		Plants Excel Spreadsheet
Liatris gracilis	Slender Blazing-star	G5	S1		High		Plants Excel Spreadsheet

Liatris microcephala	Small-head Blazing-star	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Liatris patens	Georgia Blazing-star	G3G4	S2		High		Plants Excel Spreadsheet
Lilaeopsis carolinensis	Carolina Lilaeopsis, Carolina Strapwort	G3G5	S2		High	Moderate	Plants Excel Spreadsheet
Lilium canadense	Canada Lily	G5	S1		High		Plants Excel Spreadsheet
Lilium pyrophilum	Sandhill Bog Lily, Fire Lily	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Lilium superbum	Turk's-cap Lily, Lily-royal, Superb Lily	G5	S1		High		Plants Excel Spreadsheet
Lindera melissifolia	Southern Spicebush, Pondberry	G3	S2	Federally Endangered	Highest	High	Plants Excel Spreadsheet
Lindera subcoriacea	Bog Spicebush	G3	S3		High	Moderate	Plants Excel Spreadsheet
Linum floridanum var. chrysocarpum	Yellow-fruited Yellow Flax	G5?T3?	S1		High		Plants Excel Spreadsheet
Linum intercursum	Bicknell's Yellow Flax, Sandplain Flax	G4	S2?		High		Plants Excel Spreadsheet
Liparis liliifolia	Large Twayblade, Mauve Sleekwort, Russet-witch, Brown Wide-lip Orchid	G5	S1		High		Plants Excel Spreadsheet
Lithospermum canescens	Hoary Puccoon, Indian-paint	G5	S1		High		Plants Excel Spreadsheet
Lithospermum tuberosum	Southern Stoneseed	G4	S1		High		Plants Excel Spreadsheet
Litsea aestivalis	Pondspice	G3?	S3		Moderate	Moderate	Plants Excel Spreadsheet
Lobelia batsonii	Streamhead Lobelia	G3	S2		High	Moderate	Plants Excel Spreadsheet
Lobelia boykinii	Boykin's Lobelia	G2?	S2?		Highest	High	Plants Excel Spreadsheet
Lobelia flaccidifolia	Foldear Lobelia	G5	S1		High		Plants Excel Spreadsheet
Lobelia georgiana	Georgia Lobelia	G4?TNR	S1S2		High		Plants Excel Spreadsheet
Lophocolea appalachiana	Appalachian Crestwort	G2	S1		Highest		Plants Excel Spreadsheet
Ludwigia alata	Winged Seedbox	G3G5	S2		High		Plants Excel Spreadsheet
Ludwigia arcuata	Pondshore Seedbox	G4G5	S1		High		Plants Excel Spreadsheet
Ludwigia brevipes	Long Beach Seedbox, Coastal Plain Water-purslane	G2	S2		Highest	Very High	Plants Excel Spreadsheet
Ludwigia lanceolata	Lanceleaf Seedbox	G3	S1		High	Moderate	Plants Excel Spreadsheet
Ludwigia linifolia	Flaxleaf Seedbox	G4	S2		High		Plants Excel Spreadsheet
Ludwigia ravenii	Raven's Seedbox	G1G2	S1		Highest		Plants Excel Spreadsheet
Ludwigia spathulata	Southern Water-purslane	G2	S2		Highest	Very High	Plants Excel Spreadsheet
Lycium carolinianum	Christmas-berry, Carolina Matrimony-vine, Carolina Wolfberry	G4	SX		High		Plants Excel Spreadsheet
Lycopodium clavatum	Running Clubmoss	G5	S1		High		Plants Excel Spreadsheet

Lycopus cokeri	Coker's Bugleweed, Carolina Bugleweed	G3	S2		High	Moderate	Plants Excel Spreadsheet
Lyonia ferruginea	Crookedwood, Dragonwood, Staggerbush	G5	S1		High		Plants Excel Spreadsheet
Lyonia fruticosa	Staggerbush, Poor-grub	G4	S1		High		Plants Excel Spreadsheet
Lysimachia asperulifolia	Pocosin Loosestrife, 'Roughleaf Loosestrife'	G3	S1	Federally Endangered	Highest	Moderate	Plants Excel Spreadsheet
Lysimachia fraseri	Fraser's Loosestrife	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Lysimachia loomisii	Carolina Loosestrife	G3?	S1		High		Plants Excel Spreadsheet
Lysimachia terrestris	Bog Loosestrife, Bog-candles, Swamp-candles	G5	S1		High		Plants Excel Spreadsheet
Macbridea caroliniana	Carolina Birds-in-a-nest, Carolina Macbridea	G3	S3		Highest	High	Plants Excel Spreadsheet
Magnolia acuminata var. subcordata	Yellow Cucumber-tree, Showy Cucumber Magnolia, Yellow-flowered Magnolia	G5T3Q	S1		High	Moderate	Plants Excel Spreadsheet
Magnolia macrophylla	Bigleaf Magnolia	G5	S1		High		Plants Excel Spreadsheet
Magnolia pyramidata	Pyramid Magnolia	G4	S1		High		Plants Excel Spreadsheet
Malaxis spicata	Florida Adder's-mouth	G4?	S1S2		High		Plants Excel Spreadsheet
Matelea flavidula	Yellow Spinypod	G3?	S2		High		Plants Excel Spreadsheet
Mecardonia acuminata var. microphylla	Pond Axil-flower	G5TNR	S1		High		Plants Excel Spreadsheet
Melanthium parviflorum	Mountain Bunchflower	G4?	S2		High		Plants Excel Spreadsheet
Melanthium woodii	Ozark Bunchflower, Wood's False-hellebore	G5	S1		High		Plants Excel Spreadsheet
Micranthes careyana	Carey Saxifrage	G3	S1		High	Moderate	Plants Excel Spreadsheet
Micranthes petiolaris var. shealyi	Escarpment Saxifrage, Shealy's Saxifrage	G4G5T1	S1		High		Plants Excel Spreadsheet
Mikania cordifolia	Heartleaf Climbing Hempweed	G5	S1		High		Plants Excel Spreadsheet
Mirabilis albida	Wild Four-o'clock, Pale Umbrella-wort, White Four-o'clock	G5	S1		High		Plants Excel Spreadsheet
Mitella diphylla	Two-leaved Miterwort	G5	S1		High		Plants Excel Spreadsheet
Mitreola angustifolia	Narrow-leaved Miterwort	G4G5	S1		High		Plants Excel Spreadsheet
Mnesithea cylindrica	Carolina Jointgrass	G4G5	S1		High		Plants Excel Spreadsheet
Monarda didyma	Scarlet Beebalm, Oswego Tea	G5	S1?		High		Plants Excel Spreadsheet
Monarda fistulosa var. mollis	Eastern Bergamot, Pale Wild Bergamot	G5T5?	S1		High		Plants Excel Spreadsheet
Monotropa brittonii	Scrub Ghost-pipe, Southern Ghost-pipe	GNR	S1?		High		Plants Excel Spreadsheet

Monotropsis odorata	Appalachian Pigmy Pipes, Carolina Beechdrops	G3	S2		High	Moderate	Plants Excel Spreadsheet
Muhlenbergia sylvatica	Woodland Muhly	G5	SH		High		Plants Excel Spreadsheet
Myriophyllum laxum	Loose Water-milfoil	G3	S2		High	Moderate	Plants Excel Spreadsheet
Nabalus autumnalis	Slender Rattlesnake-root	G4G5	S2S3		High		Plants Excel Spreadsheet
Najas canadensis	Northern Naiad	G5	S1		High		Plants Excel Spreadsheet
Najas filifolia	Narrowleaf Naiad	G3	SH		High		Plants Excel Spreadsheet
Najas gracillima	Slender Naiad, Bushy Naiad	G4G5	S1S2		High		Plants Excel Spreadsheet
Narthecium americanum	Yellow Asphodel	G2	SX		Highest	Very High	Plants Excel Spreadsheet
Neottia bifolia	Southern Twayblade	G4	S2		High		Plants Excel Spreadsheet
Neottia smallii	Appalachian Twayblade, Small's Twayblade, Kidneyleaf Twayblade	G4	S1		High		Plants Excel Spreadsheet
Nuphar sagittifolia	Narrowleaf Pondlily, Bonnets	G5T2	S2		Highest		Plants Excel Spreadsheet
Nyssa ogeche	Ogeechee Lime, Ogeechee Tupelo, Ogeechee Plum	G4G5	S1		High		Plants Excel Spreadsheet
Oclemena acuminata	Whorled Aster, Whorled Nodding-aster	G5	S1		High		Plants Excel Spreadsheet
Oclemena reticulata	Pine-barren Aster	G4G5	S2		High		Plants Excel Spreadsheet
Oenothera curtissii	Florida Evening-primrose	G2G4	SH		High		Plants Excel Spreadsheet
Oenothera linifolia	Threadleaf Sundrops, Flaxleaf Sundrops	G5	S1		High		Plants Excel Spreadsheet
Oenothera nutans	Nodding Evening-primrose	G4	SH		High		Plants Excel Spreadsheet
Oenothera perennis	Little Sundrops	G5	S1		High		Plants Excel Spreadsheet
Oenothera riparia	Riverbank Evening-primrose	G2G3	S2S3		Highest		Plants Excel Spreadsheet
Oenothera unguiculata	Coastal Sundrops	G5T2T3	S1		High		Plants Excel Spreadsheet
Oldenlandia boscii	Bosc's Bluet, Bosc's Mille-graines	G5	S1S2		High		Plants Excel Spreadsheet
Ophioglossum crotalophoroides	Bulbous Adder's-tongue	G5	S1		High		Plants Excel Spreadsheet
Ophioglossum nudicaule	Slender Adder's-tongue	G5	S1		High		Plants Excel Spreadsheet
Ophioglossum petiolatum	Long-stem Adder's-tongue	G5	S1		High		Plants Excel Spreadsheet
Orbexilum lupinellus	Lupine Scurfpea, Lupine Leatherroot	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Orbexilum onobrychis	Lanceleaf Scurfpea	G5	SX		High		Plants Excel Spreadsheet
Orbexilum virgatum	Slender Leather-root	G1	SX		Highest		Plants Excel Spreadsheet
Orthochilus ecristatus	Spiked Medusa, Smooth-lipped Eulophia	G4	S2		Highest	High	Plants Excel Spreadsheet

Orthosia scoparia	Leafless Swallowwort	G4	S1		High		Plants Excel Spreadsheet
Oxypolis ternata	Savanna Cowbane	G3	S1		High	Moderate	Plants Excel Spreadsheet
Pachysandra procumbens	Mountain Pachysandra, Allegheny-spurge	G4G5	S2		High		Plants Excel Spreadsheet
Packera millefolium	Blue Ridge Groundsel, Yarrowleaf Groundsel, Blue Ridge Ragwort, Yarrowleaf Ragwort	G3	S2		Highest	High	Plants Excel Spreadsheet
Palhinhaea cernua	Nodding Clubmoss, Staghorn Clubmoss	G5	S1		High		Plants Excel Spreadsheet
Panax quinquefolius	Ginseng, Sang, American Ginseng	G3G4	S3		Moderate	Moderate	Plants Excel Spreadsheet
Panicum dichotomiflorum var. puritanorum	Puritan Panicgrass	G5T4	S1		High		Plants Excel Spreadsheet
Panicum flexile	Wiry Panic Grass	G5	S1		High		Plants Excel Spreadsheet
Pannaria conoplea	Mealy-rimmed Shingle Lichen, Shadowland Luxury	G4G5	S1		High		Plants Excel Spreadsheet
Parietaria pensylvanica	Pennsylvania Pellitory, Rock Pellitory	G5	S1		High		Plants Excel Spreadsheet
Parietaria praetermissa	Coastal Pellitory	G3G4	S2		High		Plants Excel Spreadsheet
Parnassia asarifolia	Appalachian Parnassia, Kidney-leaved Grass-of-Parnassus, Appalachian Grass-of-Parnassus, Brook Parnassia	G4	S2		High		Plants Excel Spreadsheet
Parnassia caroliniana	Savanna Parnassia, Carolina Grass-of-Parnassus, Eyebright	G3	S1		Highest	High	Plants Excel Spreadsheet
Parnassia grandifolia	Limeseep Parnassia, Bigleaf Grass-of-Parnassus	G3	S2		High	Moderate	Plants Excel Spreadsheet
Paronychia americana	American Whitlow-wort	G3G4	S2		High		Plants Excel Spreadsheet
Paronychia canadensis	Canada Whitlow-wort, Forked Chickweed	G5	S1		High		Plants Excel Spreadsheet
Paronychia herniarioides	Michaux's Whitlow-wort	G2G4	S1		High		Plants Excel Spreadsheet
Parthenium integrifolium var. mabryanum	Sandhill Wild Quinine, Mabry's Wild Quinine, Carolina Wild Quinine	G5T3	S2?		High		Plants Excel Spreadsheet
Pavonia spinifex	Gingerbush, Pavonia	G4G5	SX		High		Plants Excel Spreadsheet
Pediomelum canescens	Buckroot, Pineland-Turnip, Eastern Prairie-Turnip, Hoary Scurfpea	G4	S2		High		Plants Excel Spreadsheet
Pediomelum piedmontanum	Piedmont Buckroot	G1	S1		Highest		Plants Excel Spreadsheet
Pelazoneuron ovatum var. ovatum	Ovate Maiden Fern	G3G5T3T4	S1		High	Moderate	Plants Excel Spreadsheet
Pellaea atropurpurea	Purple Cliff-brake	G5	S1		High		Plants Excel Spreadsheet
Pellaea ternifolia ssp. arizonica	Arizona Cliff-brake	G5T2T4	S1		High		Plants Excel Spreadsheet

Pellaea wrightiana	Wright's Cliff-brake	G5	S1		High		Plants Excel Spreadsheet
Pellia appalachiana	Appalachian Pellia	G4	S2		High		Plants Excel Spreadsheet
Peltandra sagittifolia	Spoonflower, White Arrow-arum	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Penstemon calycosus	Long-sepal Beardtongue	G5	S1		High		Plants Excel Spreadsheet
Penstemon canescens	Appalachian Beardtongue	G4	S2		High		Plants Excel Spreadsheet
Penstemon smallii	Blue Ridge Beardtongue	G3	S2		High		Plants Excel Spreadsheet
Persicaria amphibia ssp. laevimarginata	Water Smartweed	G5T5	SH		High		Plants Excel Spreadsheet
Persicaria hirsuta	Hairy Smartweed	G3G4	S2S3		High		Plants Excel Spreadsheet
Persicaria meisneriana var. beyrichiana	Mexican Tearthumb	G5?T5?	S1		High		Plants Excel Spreadsheet
Phacelia bipinnatifida	Fernleaf Phacelia, Forest Phacelia, Purple Phacelia, Purple Bee's Friend	G5	S1		High		Plants Excel Spreadsheet
Phacelia dubia var. dubia	Appalachian Phacelia	G5T5	S1		High		Plants Excel Spreadsheet
Phacelia dubia var. georgiana	Georgia Phacelia	G5T3	S1		High		Plants Excel Spreadsheet
Phacelia dubia var. rionensis	South Carolina Phacelia	G5T3	S3		Moderate		Plants Excel Spreadsheet
Phacelia maculata	Flatrock Phacelia	G3G4	S2S3		High		Plants Excel Spreadsheet
Phaeographis oricola	Carolina Beach Dots	G1	S1S2		Highest		Plants Excel Spreadsheet
Phaseolus sinuatus	Sandhill Bean	G5T3?	S2		High		Plants Excel Spreadsheet
Phemeranthus mengesii	Large-flowered Rock-pink	G3	S1		High		Plants Excel Spreadsheet
Phlox ovata	Mountain Phlox, Appalachian Phlox, Allegheny Phlox	G4	S1		High		Plants Excel Spreadsheet
Physalis lanceolata	Sandhill Ground-cherry	G3	S3		Moderate		Plants Excel Spreadsheet
Physcia pseudospeciosa	Celebration Day	G3	S2S3		Highest		Plants Excel Spreadsheet
Physostegia purpurea	Savanna Obedient-plant	G4G5	S1		High		Plants Excel Spreadsheet
Pieris phillyreifolia	Vine-wicky, Climbing Fetterbush	G4	S1		High		Plants Excel Spreadsheet
Pilularia americana	American Pillwort	G4?	S1		High		Plants Excel Spreadsheet
Pinckneya bracteata	Pinckneya, Fever-tree	G4	S1		High		Plants Excel Spreadsheet
Pinguicula lutea	Yellow Butterwort	G4G5	S2S3		High		Plants Excel Spreadsheet
Pinguicula pumila	Small Butterwort	G4	S1		High		Plants Excel Spreadsheet
Pityopsis pinifolia	Sandhill Goldenaster	G4	S2		High		Plants Excel Spreadsheet
Plagiochila caduciloba	Gorge Leafy Liverwort	G3	S2		High		Plants Excel Spreadsheet

Plagiochila echinata	Spiny featherwort	G3	S1		High		Plants Excel Spreadsheet
Plagiochila retrorsa	Retrorse Leafy Liverwort	G4	S1		High		Plants Excel Spreadsheet
Plagiochila sullivantii	Sullivant's Leafy Liverwort	G3G4	S1		High		Plants Excel Spreadsheet
Plagiomnium rhynchoporum	Mountain Wavy-leaf Moss	G3	S2		High		Plants Excel Spreadsheet
Plantago sparsiflora	Pineland Plantain	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Platanthera integra	Golden Fringeless Orchid, Yellow Fringeless Orchid	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Platanthera integrilabia	Monkey-face Orchid, White Fringeless Orchid	G2	SH	Federally Threatened	Highest	High	Plants Excel Spreadsheet
Platanthera nivea	Snowy Orchid, Bog-spike	G3G4	S1		High		Plants Excel Spreadsheet
Platanthera peramoena	Purple Fringeless Orchid, Purple Spire Orchid, Pride-of-the-peak	G5	SX		High		Plants Excel Spreadsheet
Platanthera psycodes	Small Purple Fringed Orchid, Butterfly Orchid	G5	SH		High		Plants Excel Spreadsheet
Pleea tenuifolia	Rush-featherling	G4	SX		High		Plants Excel Spreadsheet
Poa alsodes	Woodland Bluegrass, Grove Bluegrass	G4G5	S1?		High		Plants Excel Spreadsheet
Poa saltuensis	Weak Speargrass, Old-pasture Bluegrass	G5	SH		High		Plants Excel Spreadsheet
Polygonatum pubescens	Downy Solomon's-seal, Hairy Solomon's-seal	G5	S1		High		Plants Excel Spreadsheet
Polygonella gracilis	Wireweed	G4G5	S1		High		Plants Excel Spreadsheet
Polygonum glaucum	Seabeach Knotweed, Seaside Knotweed	G3	SH		High		Plants Excel Spreadsheet
Polypodium appalachianum	Appalachian Rockcap Fern, Appalachian Rock Polypody	G4G5	S2?		High		Plants Excel Spreadsheet
Porella japonica ssp. appalachiana	Appalachian scalewort	G4T1T2	S1		High		Plants Excel Spreadsheet
Portulaca coronata	Flatrock Portulaca	G5T2	S1		High		Plants Excel Spreadsheet
Portulaca smallii	Small's Portulaca	G3	S1		High	Moderate	Plants Excel Spreadsheet
Potamogeton confervoides	Alga Pondweed, Conferva Pondweed, Tuckerman's Pondweed	G5	S1		High		Plants Excel Spreadsheet
Potamogeton illinoensis	Illinois Pondweed	G5	S1		High		Plants Excel Spreadsheet
Potamogeton nodosus	Longleaf Pondweed, American Pondweed	G5	S1S2		High		Plants Excel Spreadsheet
Potamogeton oakesianus	Oakes's Pondweed	G5	S1		High		Plants Excel Spreadsheet
Prunus alabamensis	Alabama Black Cherry	G4	S1		High		Plants Excel Spreadsheet
Pseudognaphalium helleri	Heller's Rabbit-tobacco	G4G5	S1		High		Plants Excel Spreadsheet

Pseudognaphalium micradenium	Small Rabbit-tobacco, Delicate Rabbit-tobacco	G4G5T3?	SH		High		Plants Excel Spreadsheet
Psilotum nudum	Whiskfern	G5	S1		High		Plants Excel Spreadsheet
Ptilimnium ahlesii	Coastal Bishopweed, Carolina Bishopweed	G2	S1S2		Highest		Plants Excel Spreadsheet
Ptilimnium costatum	Big Bishopweed	G4	S1		High		Plants Excel Spreadsheet
Pycnanthemum beadlei	Beadle's Mountain-mint	G2G3	S2		Highest		Plants Excel Spreadsheet
Pycnanthemum clinopodioides	Basil Mountainmint	G1G2	SX		Highest		Plants Excel Spreadsheet
Pycnanthemum nudum	Smooth Mountain-mint	G5?	S1		High		Plants Excel Spreadsheet
Pyxidanthera barbulata var. barbulata	Savanna Pyxiemoss, Common Pyxiemoss, Big Pyxie	G4	S2		High		Plants Excel Spreadsheet
Pyxidanthera barbulata var. brevifolia	Sandhill Pyxiemoss, Wells's Pyxiemoss, Little Pyxie	G3	S2		Highest	High	Plants Excel Spreadsheet
Quercus austrina	Bluff Oak	G4?	S2		High		Plants Excel Spreadsheet
Quercus bicolor	Swamp White Oak	G5	S1		High		Plants Excel Spreadsheet
Quercus chapmanii	Chapman Oak	G4G5	SH		High		Plants Excel Spreadsheet
Quercus georgiana	Georgia Oak	G3	SH		High	Moderate	Plants Excel Spreadsheet
Quercus myrtifolia	Myrtle Oak	G5	S1		High		Plants Excel Spreadsheet
Quercus oglethorpensis	Oglethorpe Oak	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Quercus similis	Swamp Post Oak, Delta Oak	G4	S1		High		Plants Excel Spreadsheet
Ranunculus fascicularis	Thick-root Buttercup, Early Buttercup	G5	S1		High		Plants Excel Spreadsheet
Ranunculus laxicaulis	Coastal Plain Spearwort, Mississippi Buttercup	G5?	S1		High		Plants Excel Spreadsheet
Ratibida pinnata	Globular Prairie Coneflower, Grey-headed Coneflower, Drooping Coneflower	G5	S1		High		Plants Excel Spreadsheet
Rhapidophyllum hystrix	Needle Palm, Blue Palmetto	G4	S1		High		Plants Excel Spreadsheet
Rhexia aristosa	Awned Meadow-beauty, Bristly Meadow-beauty	G3G4	S3		Moderate	Moderate	Plants Excel Spreadsheet
Rhexia cubensis	West Indian Meadow-beauty	G4G5	S1		High		Plants Excel Spreadsheet
Rhododendron catawbiense	Pink Laurel, Catawba Rhododendron, Rose Bay, Oval-leaf laurel	G5	S1		High		Plants Excel Spreadsheet
Rhododendron coryi	Swamp Azalea	G5	S1		High		Plants Excel Spreadsheet
Rhododendron eastmanii	May White Azalea, Eastman's Azalea	G3	S2		Highest	High	Plants Excel Spreadsheet
Rhododendron flammeum	Oconee Azalea	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Rhus michauxii	Michaux's Sumac, Dwarf Sumac	G2G3	SX	Federally Endangered	Highest	High	Plants Excel Spreadsheet

Rhus typhina	Staghorn Sumac	G5	S1		High		Plants Excel Spreadsheet
Rhynchosia minima	Little Snoutbean	GNR	S1		High		Plants Excel Spreadsheet
Rhynchospora alba	Northern White Beaksedge	G5	SX		High		Plants Excel Spreadsheet
Rhynchospora brachychaeta	West Indian Beaksedge	GNR	S1		High		Plants Excel Spreadsheet
Rhynchospora cephalantha var. attenuata	Small Bunched Beaksedge	G5T3?	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora compressa	Pagoda Beaksedge	G4	S1		High		Plants Excel Spreadsheet
Rhynchospora decurrens	Swamp-forest Beaksedge	G3G4	S2		High		Plants Excel Spreadsheet
Rhynchospora divergens	White-seeded Beaksedge	G4	S1		High		Plants Excel Spreadsheet
Rhynchospora galeana	Short-bristle Beaksedge	G3?	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora harperi	Harper's Beaksedge	G4	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora inundata	Narrow-fruit Horned Beaksedge	G4	S2?		High		Plants Excel Spreadsheet
Rhynchospora leptocarpa	Slender-fruited Beaksedge	G3	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora macra	Southern White Beaksedge	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora odorata	Fragrant Beaksedge	G4	S1		High		Plants Excel Spreadsheet
Rhynchospora oligantha	Feather-bristled Beaksedge	G4	S2		High		Plants Excel Spreadsheet
Rhynchospora pallida	Pale Beaksedge	G3	S1		High	Moderate	Plants Excel Spreadsheet
Rhynchospora pinetorum	Small's Beaksedge	G5?T3T4	S1S2		High	Moderate	Plants Excel Spreadsheet
Rhynchospora pleiantha	Coastal Beaksedge	G2G3	S1		Highest	High	Plants Excel Spreadsheet
Rhynchospora saxicola	Stone Mountain Beaksedge	G3Q	S1		High		Plants Excel Spreadsheet
Rhynchospora scirpoides	Long-beak Beaksedge	G4	S2S3		High	Moderate	Plants Excel Spreadsheet
Rhynchospora solitaria	Autumn Beaksedge	G1	SH		Highest		Plants Excel Spreadsheet
Rhynchospora stenophylla	Coastal Bog Beaksedge	G4	S2		High		Plants Excel Spreadsheet
Rhynchospora sulcata	Grooved Beaksedge	G2G4Q	S2		High		Plants Excel Spreadsheet
Rhynchospora thornei	Thorne's Beaksedge	G3	S1		High		Plants Excel Spreadsheet
Ribes echinellum	Miccosukee Gooseberry	G1	S1	Federally Threatened	Highest	Very High	Plants Excel Spreadsheet
Robinia hartwigii	Granite Dome Locust, Highlands Locust, Hartwig's Locust	G3T2	S3?		High		Plants Excel Spreadsheet
Robinia hispida var. kelseyi	Kelsey's Locust	G4T1	S2?		Highest		Plants Excel Spreadsheet
Robinia hispida var. rosea	Boynton's Locust	G4T3?	S3S4		Moderate		Plants Excel Spreadsheet
Rorippa teres	Southern Marsh Yellowcress	G5	S1		High		Plants Excel Spreadsheet

Rubus canadensis	Smooth Blackberry, Thornless Blackberry	G5	S1?		High		Plants Excel Spreadsheet
Rudbeckia heliopsidis	Sunfacing Coneflower, Pineywoods Coneflower	G2	S1S2		Highest	Very High	Plants Excel Spreadsheet
Rudbeckia hirta var. angustifolia	Coastal Plain Black-eyed Susan	G5TNR	S1?		High		Plants Excel Spreadsheet
Rudbeckia mollis	Woolly Coneflower	G3G5	S1		High		Plants Excel Spreadsheet
Ruellia ciliosa	Sandhill Wild-petunia, Dwarf Wild-petunia	G5T3T5	S1		High		Plants Excel Spreadsheet
Ruellia humilis	Low Wild-petunia, Hairy Wild-petunia, Fringeleaf Ruellia	G5	S1		High		Plants Excel Spreadsheet
Ruellia pinetorum	Pineland Wild-petunia	G5T3T4	SH		High		Plants Excel Spreadsheet
Ruellia purshiana	Pursh's Wild-petunia	G3	S1?		High		Plants Excel Spreadsheet
Ruellia strepens	Limestone Wild-petunia, Limestone Ruellia	G4G5	S1		High		Plants Excel Spreadsheet
Rumex altissimus	Pale Dock, Tall Dock, Peachleaf Dock	G5	SH		High		Plants Excel Spreadsheet
Rumex floridanus	Florida Dock	GNR	S1		High		Plants Excel Spreadsheet
Sabatia brevifolia	Savanna White Rose-gentian	G3G4	S3S4		Moderate		Plants Excel Spreadsheet
Sabatia decandra	Bartram's Rose-gentian	G4G5	S1		High		Plants Excel Spreadsheet
Sabatia gentianoides	Pinewoods Sabatia, Spider Sabatia	G4G5	S2		High		Plants Excel Spreadsheet
Sabatia kennedyana	Plymouth Gentian	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Sabatia quadrangula	Four-angled Sabatia	G4G5	S2S3?		High		Plants Excel Spreadsheet
Sabulina paludicola	Godfrey's Sandwort	G1	SX		Highest	Very High	Plants Excel Spreadsheet
Sageretia minutiflora	Small-flowered Buckthorn	G3G4	S3		Moderate		Plants Excel Spreadsheet
Sagittaria chapmanii	Chapman's Arrowhead	G3?	S2		High		Plants Excel Spreadsheet
Sagittaria fasciculata	Bunched Arrowhead	G2	S2	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Sagittaria filiformis	Threadleaf Arrowhead	G4G5	S2		High		Plants Excel Spreadsheet
Sagittaria isoetiformis	Quillwort Arrowhead	G3	S3		Moderate		Plants Excel Spreadsheet
Sagittaria lancifolia var. lancifolia	Bulltongue Arrowhead	G5?TNR	S1?		High		Plants Excel Spreadsheet
Sagittaria macrocarpa	Bunched Arrowhead	G2	S1		Highest		Plants Excel Spreadsheet
Sagittaria subulata	Dwarf Arrowhead, Awl-leaf Arrowhead	G4	S2S3?		High		Plants Excel Spreadsheet
Sagittaria weatherbiana	Weatherby's Arrowhead	G3G4	S3		Moderate	Moderate	Plants Excel Spreadsheet
Salix humilis	Upland Willow, Prairie Willow	G5	SH?		High		Plants Excel Spreadsheet

Salvia urticifolia	Nettle-leaf Sage	G5	S2		High		Plants Excel Spreadsheet
Sanguisorba canadensis	Canada Burnet, American Burnet, White Burnet	G5	S1		High		Plants Excel Spreadsheet
Sanicula canadensis var. grandis	Large Sanicle, Long-styled Canada Sanicle	G5T3T5	SH		High		Plants Excel Spreadsheet
Sanicula trifoliata	Beaked Sanicle, Large-fruited Sanicle	G4	S1		High		Plants Excel Spreadsheet
Sapindus marginatus	Florida Soapberry	G5	SX		High		Plants Excel Spreadsheet
Sarracenia jonesii	Mountain Sweet Pitcherplant	G2	S1S2	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Sarracenia psittacina	Parrot Pitcherplant	G4	S1		High		Plants Excel Spreadsheet
Sarracenia purpurea var. montana	Southern Appalachian Purple Pitcherplant	G5T1T2	S1		Highest		Plants Excel Spreadsheet
Sarracenia rubra ssp. rubra	Carolina Sweet Pitcherplant, Carolina Redflower Pitcherplant	G3G4T3T4	S3S4		Moderate		Plants Excel Spreadsheet
Sarracenia rubra ssp. viatorum	Georgia Sweet Pitcherplant, Georgia Redflower Pitcherplant	G3G4T2T3Q	S1		High		Plants Excel Spreadsheet
Sceptridium jenmanii	Alabama Grapefern	G3G4	S1		High		Plants Excel Spreadsheet
Sceptridium lunarioides	Winter Grapefern	G4?	S1		High	Moderate	Plants Excel Spreadsheet
Schisandra glabra	Bay Starvine, Climbing-magnolia, Magnolia-vine	G3	SH		High	Moderate	Plants Excel Spreadsheet
Schlotheimia lancifolia	Highlands Moss	G1	S1		Highest		Plants Excel Spreadsheet
Schoenolirion croceum	Yellow Sunnybell	G4	S1		High		Plants Excel Spreadsheet
Schoenoplectiella erecta ssp. raynalii	Weakstalk Bulrush	G4G5T4T5	SH		High		Plants Excel Spreadsheet
Schoenoplectus californicus	Giant Bulrush, Southern Bulrush, Tule, California Bulrush	G5	S1		High		Plants Excel Spreadsheet
Schoenoplectus etuberculatus	Swamp Bulrush, Canby's Bulrush	G3G4	S2		High		Plants Excel Spreadsheet
Schwalbea americana	Chaffseed	G2	S2	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Scirpus divaricatus	Spreading Bulrush	G4	S2S3		High		Plants Excel Spreadsheet
Scleria bellii	Smooth-seeded Hairy Nutrush	G3	S1		High		Plants Excel Spreadsheet
Scleria reticularis	Netted Nutrush	G4	S1		High		Plants Excel Spreadsheet
Scleria verticillata	Savanna Nutrush, Low Nutrush	G5	S1		High		Plants Excel Spreadsheet
Sclerolepis uniflora	Sclerolepis	G3	S2		High		Plants Excel Spreadsheet
Scrophularia lanceolata	American Figwort	G5	S1S2		High		Plants Excel Spreadsheet
Scutellaria altamaha	Altamaha Skullcap	G2G3	S1		Highest		Plants Excel Spreadsheet
Scutellaria australis	Southern Skullcap	G5T5?	S1		High		Plants Excel Spreadsheet

Scutellaria incana var. punctata	Hoary Skullcap	G5T4T5	S1		High		Plants Excel Spreadsheet
Scutellaria mellichampii	Mellichamp's Skullcap	G3	S2		High		Plants Excel Spreadsheet
Scutellaria multiglandulosa	Small's Skullcap	G4?	S1		High		Plants Excel Spreadsheet
Scutellaria nervosa	Bottomland Skullcap, Veined Skullcap	G5	S1		High		Plants Excel Spreadsheet
Scutellaria ocmulgee	Ocmulgee Skullcap	G2	S1	Federally Endangered	Highest		Plants Excel Spreadsheet
Scutellaria serrata	Showy Skullcap, Serrate Skullcap	G4G5	SX		High		Plants Excel Spreadsheet
Sedum pusillum	Puck's Orpine	G3	S2		High	Moderate	Plants Excel Spreadsheet
Senega aquilonia	Northern Drumheads	G5T4	S1?		High		Plants Excel Spreadsheet
Senega brevifolia	Shortleaf Milkwort, Little-leaf Milkwort	G4G5	S1		High		Plants Excel Spreadsheet
Senega hookeri	Hooker's Milkwort	G3	S1		High	Moderate	Plants Excel Spreadsheet
Senega nana	Dwarf Milkwort, Candyroot	G5	S1		High		Plants Excel Spreadsheet
Senega officinalis var. 2	Southern Senega Snakeroot	G4G5TNR	S1S2?		High		Plants Excel Spreadsheet
Senna hebecarpa	Northern Wild Senna	G5	S1S2		High		Plants Excel Spreadsheet
Seymeria pectinata ssp. pectinata	Comb Seymeria, Combleaf Blacksenna	G4G5TNR	S1S2		High		Plants Excel Spreadsheet
Shortia galacifolia	Southern Shortia, Oconee Bells	G2G3	S3		Highest		Plants Excel Spreadsheet
Sideroxylon lanuginosum ssp. lanuginosum	Eastern Gum Bumelia, Eastern Gum Bully, Gum-elasticChittamwoodFalse Buckthorn,Gum Bully Gum, Bumelia Gum, Woollybucket, Shittamwood, Wooly Buckthorn	G4G5TNR	S1		High		Plants Excel Spreadsheet
Sideroxylon reclinatum ssp. reclinatum	Smooth Bumelia, Florida Bully	G4G5TNR	S1		High		Plants Excel Spreadsheet
Sideroxylon tenax	Tough Buckthorn, Tough Bumelia, Tough Bully	G3?	S3		Moderate		Plants Excel Spreadsheet
Silene ovata	Mountain Catchfly	G3	S1		High	Moderate	Plants Excel Spreadsheet
Silphium compositum var. ovatifolium	Florida Rosinweed	G5T5	S1?		High		Plants Excel Spreadsheet
Silphium compositum var. venosum	Georgia Rosinweed	G5T3T4	S1?		High		Plants Excel Spreadsheet
Silphium reniforme	Kidneyleaf Rosinweed	G5T3T5	S1		High		Plants Excel Spreadsheet
Silphium simpsonii	Simpson's Rosinweed	G3?Q	S1		High		Plants Excel Spreadsheet
Silphium terebinthinaceum	Prairie-dock	G4G5	S1		High		Plants Excel Spreadsheet
Sisyrinchium capillare	Wiry Blue-eyed-grass	G3	S1		High		Plants Excel Spreadsheet

Sisyrinchium dichotomum	White Irisette, Isothermal Irisette	G2	S1	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Smilax biltmoreana	Biltmore Carrionflower	G4	S2		High		Plants Excel Spreadsheet
Smilax lasioneura	Midwestern Carrionflower	G5	S1		High		Plants Excel Spreadsheet
Smilax pseudochina	Coastal Carrionflower	G4G5	S2		High		Plants Excel Spreadsheet
Solanum pseudogracile	Dune Nightshade	G4	S2?		High		Plants Excel Spreadsheet
Solenostoma fossombronioides	Bronze Ditch Flapwort	G4	S1		High		Plants Excel Spreadsheet
Solidago auriculata	Eared Goldenrod	G4	S1		High	Moderate	Plants Excel Spreadsheet
Solidago brachyphylla	Dixie Goldenrod	G3G4	S2		High		Plants Excel Spreadsheet
Solidago faucibus	Gorge Goldenrod	G3G4	S1		High		Plants Excel Spreadsheet
Solidago flaccidifolia	Appalachian Goldenrod	G5	S1S2		High		Plants Excel Spreadsheet
Solidago gracillima	Southern Bog Goldenrod, Graceful Goldenrod	G4?	S1		High		Plants Excel Spreadsheet
Solidago jacksonii	Southeastern Bold Goldenrod	G5T3T4	S1		High		Plants Excel Spreadsheet
Solidago kralii	Kral's Goldenrod	G2G3	S2?		Highest		Plants Excel Spreadsheet
Solidago pinetorum	Pineywoods Goldenrod	G5	S1S2		High		Plants Excel Spreadsheet
Solidago ptarmicoides	White Prairie-goldenrod, Upland White Aster	G5	S1		High		Plants Excel Spreadsheet
Solidago puberula	Downy Goldenrod	G5	S1S2		High		Plants Excel Spreadsheet
Solidago pulchra	Beautiful Goldenrod, Carolina Goldenrod	G3	S1		High	Moderate	Plants Excel Spreadsheet
Solidago radula	Rough Goldenrod	G5?	S1		High		Plants Excel Spreadsheet
Solidago rigida	Midwestern Bold Goldenrod	G5	S1		High		Plants Excel Spreadsheet
Solidago rigidiuscula	Narrowleaf Showy Goldenrod	G5T4	S1		High		Plants Excel Spreadsheet
Solidago roanensis	Roan Mountain Goldenrod	G4G5	S2		High		Plants Excel Spreadsheet
Solidago salicina	Southern Roughleaf Goldenrod	G5T5	S1S2		High		Plants Excel Spreadsheet
Solidago sphacelata	Limestone Goldenrod, Heartleaved Goldenrod	G4G5	S1		High		Plants Excel Spreadsheet
Solidago verna	Spring-flowering Goldenrod	G3	S1		High	Moderate	Plants Excel Spreadsheet
Spermacoce glabra	Smooth Buttonweed	G4G5	SH		High		Plants Excel Spreadsheet
Sphenopholis filiformis	Longleaf Wedgescale	G4	S2		High		Plants Excel Spreadsheet
Spiranthes brevilabris	Short-lipped Ladies'-tresses	G1G2	SU		Highest		Plants Excel Spreadsheet
Spiranthes eatonii	Eaton's Ladies'-tresses	G3Q	S1		High		Plants Excel Spreadsheet

Spiranthes floridana	Florida Ladies'-tresses	G1	SX		Highest		Plants Excel Spreadsheet
Spiranthes laciniata	Lace-lip Ladies'-tresses	G4G5	S1S2		High		Plants Excel Spreadsheet
Spiranthes longilabris	Giant Spiral Orchid, Longhorn Ladies'-tresses	G3	S1		High	Moderate	Plants Excel Spreadsheet
Spiranthes ochroleuca	Yellow Nodding Ladies'-tresses	G4	S1		High		Plants Excel Spreadsheet
Sporobolus compositus var. compositus	Tall Dropseed	G5T5	S1		High		Plants Excel Spreadsheet
Sporobolus compositus var. drummondii	Drummond's Dropseed	G5TNR	S1		High		Plants Excel Spreadsheet
Sporobolus curtissii	Curtiss's Dropseed	G3	S1		High	Moderate	Plants Excel Spreadsheet
Sporobolus floridanus	Florida Dropseed	G3	S1		High	Moderate	Plants Excel Spreadsheet
Sporobolus pinetorum	Carolina Dropseed, Savanna Dropseed	G3	S2		High	Moderate	Plants Excel Spreadsheet
Sporobolus teretifolius	Wireleaf Dropseed	G2	S1		Highest	Very High	Plants Excel Spreadsheet
Stachys caroliniana	Carolina Hedge-nettle	G1	S1		Highest		Plants Excel Spreadsheet
Stachys crenata	Mouse's-ear, Shade Betony	G5	S1		High		Plants Excel Spreadsheet
Stachys latidens	Broad-toothed Hedge-nettle	G4G5	S2		High		Plants Excel Spreadsheet
Stachys tenuifolia	Smooth Hedge-nettle	G5	S1		High		Plants Excel Spreadsheet
Steironema tonsum	Southern Loosestrife, Appalachian Loosestrife	G4	SH		High		Plants Excel Spreadsheet
Stewartia ovata	Mountain Camellia, Mountain Stewartia	G4	S2		High		Plants Excel Spreadsheet
Sticta limbata	Powdered Moon Lichen	G3G4	S1		High		Plants Excel Spreadsheet
Stillingia aquatica	Corkwood, Water Toothleaf	G4G5	S2		High		Plants Excel Spreadsheet
Stokesia laevis	Stokesia, Stokes Aster, Blue Stokesia	G4	S1		High		Plants Excel Spreadsheet
Stromatella bermudana	"a lichen"	GNR	S1		High		Plants Excel Spreadsheet
Stylisma aquatica	Water Dawnflower	G4	S2S3		High		Plants Excel Spreadsheet
Stylisma pickeringii var. pickeringii	Pickering's Dawnflower	G4T3	S1		High		Plants Excel Spreadsheet
Symphyotrichum concolor var. devestitum	Gulf Coast Silvery Aster	G5T2	S1?		High		Plants Excel Spreadsheet
Symphyotrichum dumosum var. subulifolium	Rice Button Aster	G5T3T5	S1?		High		Plants Excel Spreadsheet
Symphyotrichum georgianum	Georgia Aster	G3	S3S4		Moderate	Moderate	Plants Excel Spreadsheet
Symphyotrichum laeve	Smooth Blue Aster	G5	S1S2		High		Plants Excel Spreadsheet
Symphyotrichum lanceolatum var. latifolium	Broad-leaved White Panicled Aster	G5T5	S1S2?		High		Plants Excel Spreadsheet

Symphyotrichum lowrieanum	Smooth Heart-leaved Aster	G3G5Q	S1?		High		Plants Excel Spreadsheet
Symphyotrichum novae-angliae	New England Aster, Michaelmas-daisy	G5	S1		High		Plants Excel Spreadsheet
Symphyotrichum phlogifolium	Appalachian Clasping Aster	G4	S1		High		Plants Excel Spreadsheet
Symphyotrichum simmondsii	Simmonds's Aster	G4G5	S2?		High		Plants Excel Spreadsheet
Teloschistes exilis	Slender Orangebush Lichen	G3G5	S2		High		Plants Excel Spreadsheet
Teloschistes flavicans	Powdered Orangebush Lichen	G4G5	S1		High		Plants Excel Spreadsheet
Thalia dealbata	Powdery Thalia, Powdery Alligator-flag	G4	S2		High		Plants Excel Spreadsheet
Thalictrum coriaceum	Appalachian Meadowrue, Maid-of-the-Mist	G4	S1		High		Plants Excel Spreadsheet
Thalictrum macrostylum	Small-leaved Meadowrue	G3G4	S1S2		High	Moderate	Plants Excel Spreadsheet
Thermopsis fraxinifolia	Ashleaf Golden-banner	G3?	S2		High		Plants Excel Spreadsheet
Thermopsis mollis	Appalachian Golden-banner	G3G4	S1		High		Plants Excel Spreadsheet
Tiedemannia canbyi	Canby's Cowbane	G2	S2	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Tofieldia glabra	Carolina Bog Asphodel, White Asphodel	G4	S1S2		High		Plants Excel Spreadsheet
Tomostima reptans	Carolina Draba	G5	S1		High		Plants Excel Spreadsheet
Torreyochloa pallida	Pale Mannagrass	G5	S1		High		Plants Excel Spreadsheet
Tradescantia hirsutiflora	Hairyflower Spiderwort	G5	S1		High		Plants Excel Spreadsheet
Tradescantia roseolens	Sandhill Spiderwort	G3	S1?		High		Plants Excel Spreadsheet
Tradescantia virginiana	Virginia Spiderwort	G5	S1		High		Plants Excel Spreadsheet
Trautvetteria applanata	Ozark Tassel-rue	GNR	S1		High		Plants Excel Spreadsheet
Trepocarpus aethusae	White-nymph	G4G5	S1		High		Plants Excel Spreadsheet
Triadenum tubulosum	Southern Marsh St. John's-wort	G4?	SH		High		Plants Excel Spreadsheet
Trichophorum cespitosum	Deergrass, Deerhair Bulrush	G5	S1		High		Plants Excel Spreadsheet
Trichostema coeruleum	Glade Blue Curls, False Pennyroyal	G5	S1		High		Plants Excel Spreadsheet
Trichostema nesophilum	Dune Blue Curls, Carolina Blue Curls	G2	S2		Highest		Plants Excel Spreadsheet
Tridens carolinianus	Carolina Triodia, Carolina Fluffgrass	G3G4	S2		High	Moderate	Plants Excel Spreadsheet
Tridens chapmanii	Chapman's Triodia	G5T3	S2		High	Moderate	Plants Excel Spreadsheet
Tridens strictus	Spike Triodia, Longspike Fluffgrass, Longspike Tridens	G5	S1S2		High		Plants Excel Spreadsheet
Trifolium reflexum	Buffalo Clover	G3G4	S1		High		Plants Excel Spreadsheet

Triglochin striata	Southern Arrowgrass	G5	S1		High		Plants Excel Spreadsheet
Trillium grandiflorum	Large-flowered Trillium, White Trillium, Great White Trillium	G5	S1		High		Plants Excel Spreadsheet
Trillium lancifolium	Lanceleaf Trillium, Narrowleaf Trillium	G3	S1		High	Moderate	Plants Excel Spreadsheet
Trillium oostingii	Wateree River Trillium	G1	S1		Highest	Very High	Plants Excel Spreadsheet
Trillium persistens	Persistent Trillium, Edna's Trillium	G1	S1	Federally Endangered	Highest	Very High	Plants Excel Spreadsheet
Trillium pusillum var. 3	Aiken Least Trillium	G4TNR	S1		High		Plants Excel Spreadsheet
Trillium pusillum var. pusillum	Carolina Least Trillium, Carolina Dwarf Trillium	G4T3	S1		Highest	High	Plants Excel Spreadsheet
Trillium reliquum	Relict Trillium	G3	S1	Federally Endangered	Highest	Moderate	Plants Excel Spreadsheet
Trillium rugelii	Southern Nodding Trillium	G4	S2		High		Plants Excel Spreadsheet
Trillium simile	Sweet White Trillium	G3	S1S2		High	Moderate	Plants Excel Spreadsheet
Trillium vaseyi	Sweet Trillium, Vasey's Trillium, Sweet Beth	G3	S3		Moderate		Plants Excel Spreadsheet
Triosteum aurantiacum var. aurantiacum	Orange-fruited Horse-gentian	G5T5	S1		High		Plants Excel Spreadsheet
Triosteum perfoliatum	Perfoliate Horse-gentian	G5	SH		High		Plants Excel Spreadsheet
Tsuga caroliniana	Carolina Hemlock, Crag Hemlock	G3	S2		Highest		Plants Excel Spreadsheet
Urtica chamaedryoides	Dwarf Stinging Nettle, Heartleaf Nettle, Ortiguilla	G4G5	S2		High		Plants Excel Spreadsheet
Usnea angulata	Angular Beard Lichen, Fisherman's Dream	G3G5	S1		High		Plants Excel Spreadsheet
Utricularia floridana	Florida Bladderwort	G3G5	S2		High		Plants Excel Spreadsheet
Utricularia foliosa	Flatstem Bladderwort	G5	S1		High		Plants Excel Spreadsheet
Utricularia macrorhiza	Greater Bladderwort	G5	S1		High		Plants Excel Spreadsheet
Utricularia olivacea	Dwarf Bladderwort, Minute Bladderwort	G4	S2		High		Plants Excel Spreadsheet
Utricularia resupinata	Northeastern Bladderwort, Resupinate Bladderwort	G4	S1		High		Plants Excel Spreadsheet
Uvularia floridana	Florida Bellwort	G3	S1		High		Plants Excel Spreadsheet
Uvularia grandiflora	Large-flowered Bellwort	G5	S1?		High		Plants Excel Spreadsheet
Vaccinium caesariense	New Jersey Highbush Blueberry	G4?Q	S1?		High		Plants Excel Spreadsheet
Vaccinium sempervirens	Rayner's Blueberry	G4G5T1	S1		Highest	Very High	Plants Excel Spreadsheet
Vallisneria americana	Vallisneria, Water-celery, Tapegrass, Eelgrass	G5	S1		High		Plants Excel Spreadsheet
Vandenboschia boschiana	Appalachian Filmy Fern	G4	S1		High	Moderate	Plants Excel Spreadsheet

Verbena simplex	Narrowleaf Vervain	G5	S1		High		Plants Excel Spreadsheet
Vernonia angustifolia var. scaberrima	Georgia Sandhill Ironweed, Georgia Slender Ironweed	G5T2T4	S3S4		Moderate		Plants Excel Spreadsheet
Vernonia pulchella	Pretty Ironweed	G3	S1		High		Plants Excel Spreadsheet
Veronicastrum virginicum	Culver's-root, Culver's-physic	G4	S1		High	Moderate	Plants Excel Spreadsheet
Vicia acutifolia	Fourleaf Vetch	G4G5	S1		High		Plants Excel Spreadsheet
Vigna luteola	Wild Cowpea	G5	S1		High		Plants Excel Spreadsheet
Viola brittoniana	Northern Coastal Violet, Coast Violet	G4G5	S1		High		Plants Excel Spreadsheet
Viola labradorica	American Dog-violet	G5	S1		High		Plants Excel Spreadsheet
Viola tenuipes	Southern Wedge-leaf Violet	GNR	S1		High		Plants Excel Spreadsheet
Vittaria appalachiana	Appalachian Shoestring Fern, "Appalachian Gametophyte"	G4	S1		High		Plants Excel Spreadsheet
Waldsteinia doniana	Southern Barren Strawberry	G3G5	S2		High		Plants Excel Spreadsheet
Waldsteinia lobata	Lobed Barren Strawberry	G3	S3		Moderate	Moderate	Plants Excel Spreadsheet
Warea cuneifolia	Carolina Warea, Carolina Pineland-cress	G3	S1		High	Moderate	Plants Excel Spreadsheet
Wolffia columbiana	Colombian Watermeal	G5	S1?		High		Plants Excel Spreadsheet
Xerophyllum asphodeloides	Turkeybeard, Beargrass, Mountain-asphodel	G4	S2		High		Plants Excel Spreadsheet
Xyris brevifolia	Shortleaf Yellow-eyed-grass	G4G5	S1		High		Plants Excel Spreadsheet
Xyris chapmanii	Chapman's Yellow-eyed-grass	G3	S1		High	Moderate	Plants Excel Spreadsheet
Xyris curtissii	Curtiss's Yellow-eyed-grass	G5T5	S1		High		Plants Excel Spreadsheet
Xyris elliottii	Elliott's Yellow-eyed-grass	G4	S2		High		Plants Excel Spreadsheet
Xyris flabelliformis	Fanleaf Yellow-eyed-grass	G4	S1		High		Plants Excel Spreadsheet
Xyris scabrifolia	Roughleaf Yellow-eyed-grass	G3	S1		High	Moderate	Plants Excel Spreadsheet
Xyris serotina	Gray-leaved Yellow-eyed-grass	G3G4	S1		High	Moderate	Plants Excel Spreadsheet
Xyris stricta	Strict Yellow-eyed-grass	G4	S1		High		Plants Excel Spreadsheet
Xyris torta	Twisted Yellow-eyed-grass, Mountain Yellow-eyed-grass, Slender Yellow-eyed-grass	G5	S1		High		Plants Excel Spreadsheet
Yeatesia viridiflora	Yellow Bractspike	G3G5	S1		High		Plants Excel Spreadsheet
Zanthoxylum americanum	Northern Toothache Tree, Northern Prickly-ash	G5	S1		High		Plants Excel Spreadsheet
Zephyranthes simpsonii	Florida Atamasco-lily, Red-margined Atamasco-lily	G2G3	S1S2		Highest	High	Plants Excel Spreadsheet

SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK	PROTECTION STATUS	SGCN PRIORITY	RSGCN PRIORITY	LOCATION / HABITAT(S)
INSECTS & ALLIES							
COCKROACHES							
Cryptocercus garciai	Grateful Dead Dinosaur Roach / Brown-hooded Cockroach	GNR	SNR		Data Deficient		
MOTHS							
Acronicta perblanda	Cypress Daggermoth	G3G4	SNR		Data Deficient		
Acronicta sinescripta	"a daggermoth"	G3G4	SNR		Data Deficient		
Agnorisma bollii	"a moth"	G4?	SNR		Data Deficient		
Baltodonta broui	"a prominent moth"	G3G4	SNR		Data Deficient		
Ceratomia undulosa	Waved Sphinx Moth	G5	SNR		Data Deficient		
Copivaleria grotei	Grote's Sallow	G5	SNR		Data Deficient		
Cosmopterix sinelinea	"a moth"	GNR	SNR		Data Deficient		
Cryptaspasma bipenicilla	"a Tortricid moth"	GNR	SNR		Data Deficient		
Cyclophora culicaria	Sand-Myrtle Geometer	GU	SNR		Data Deficient		
Dargida quadrannulata	"an armyworm moth"	GNR	SNR		Data Deficient		
Datana modesta	"a prominent moth"	GUQ	SNR		Data Deficient		
Derrima stellata	Pink Star Moth	G4	SNR		Data Deficient		
Eucoptocnemis dapsilis	"a cutworm moth"	G4	SNR		Data Deficient		
Eupithecia palpata	Small Pine Looper Moth	G5	SNR		Data Deficient		
Franclemontia interrogans	Franclemont's Cane Moth	G3G4	SNR		Data Deficient		
Homaledra heptathalama	Exclamation Moth	GNR	SNR		Data Deficient		
Hyparpax perophoroides	Red-lined Yellow Prominent	G3G4	SNR		Data Deficient		
Hypomecis buchholzaria	Blue Spiderwort Moth	G3G4	SNR		Data Deficient		
Hyposopygia nov. sp.	"a hayworm moth"	GNR	SNR		Data Deficient		

Idia majoralis	Greater Idia	GNR	SNR		Data Deficient		
Leucania extincta	"a cutworm moth"	G4	SNR		Data Deficient		
Manduca jasminearum	Ash Sphinx Moth	G3?	SNR		Data Deficient		
Marmara fraxinicola	Serpentine Miner	GNR	SNR		Data Deficient		
Meropleon ambifusca	Newman's Brocade	G4G5	SNR		Data Deficient		
Meropleon cinnamicolor	"a cutworm moth"	GU	SNR		Data Deficient		
Meropleon diversicolor	Multicolored Sedgeminer Moth	G5	SNR		Data Deficient		
Metarranthis lateritiaria	"an inchworm moth"	G3G4	SNR		Data Deficient		
Neoprocris floridana	Laurel Cherry Smoky Moth	GNR	SNR		Data Deficient		
Olceclostera angelica	Angel Moth	G5	SNR		Data Deficient		
Papaipema duovata	Seaside Goldenrod Borer	G2G3	SNR		Data Deficient		
Papaipema furcata	Ash Tip Borer Moth	G4	SNR		Data Deficient		
Phyllocnistis subpersea	"a leaf miner moth"	GNR	SNR		Data Deficient		
Phytometra ernestinana	Ernestine's Moth	G4	SNR		Data Deficient		
Plagodis kuetzingi	Purple Plagodis	G5	SNR		Data Deficient		
Pococera humerella	"a webworm moth"	GNR	SNR		Data Deficient		
Podosesia aureocincta	Banded Ash Clearwing Moth	GNR	SNR		Data Deficient		
Pyreferra ceromatica	Anointed Sallow Moth	GU	SNR		Data Deficient		
Ribua innoxia	"a pyralid moth"	GNR	SNR		Data Deficient		
Salebriaria fergusonella	"a snout moth"	GNR	SNR		Data Deficient		
Schizura matheri	"a prominent moth"	GU	SNR		Data Deficient		
Sphinx drupiferarum	Wild Cherry Sphinx	G3G5	SNR		Data Deficient		
Sphinx franckii	Franck's Sphinx Moth	G4G5	SNR		Data Deficient		
Spragueia margana	"a bird dropping moth"	GNR	SNR		Data Deficient		

Spragueia perstructana	"a bird dropping moth"	GNR	SNR		Data Deficient		
Tornos cinctarius	"a Geometrid moth"	GNR	SNR		Data Deficient		
Zale fictilis	Fictilis Zale Moth	G5	SNR		Data Deficient		
Zale perculta	Okefenokee Zale	G2?	SNR		Data Deficient		
BUTTERFLIES							
Amblyscirtes carolina	Carolina Skipper	G3G4	S2S4		Data Deficient		
Anaea andria	Goatweed Leafwing	G4G5	SNR		Data Deficient		
Atrytone arogos	Arogos Skipper	G2G3	SH		Data Deficient		
Atrytonopsis loammi	Loammi Skipper/Southern Dusted Skipper	G2	SH		Data Deficient		
Boloria bellona	Meadow Fritillary	G5	SNR		Data Deficient		
Callophrys hesseli	Hessel's Hairstreak	G3	S1		Data Deficient		
Callophrys irus	Frosted Elfin	G3	S2S3		Data Deficient		
Celastrina nigra	Dusky Azure	GU	SNR		Data Deficient		
Danaus plexippus	Monarch Butterfly	G4	S4		Data Deficient		
Euphydryas phaeton	Baltimore Checkerspot	G4	SNR		Data Deficient		
Euphyes berryi	Berry's Skipper	G2	SNR		Data Deficient		
Euphyes bimacula	Two-spotted Skipper	G4	S1?		Data Deficient		
Glaucopsyche lygdamus	Silvery Blue	G5	SNR		Data Deficient		
Hesperia leonardus	Leonard's Skipper	G4	SNR		Data Deficient		
Lycaena phlaeas	Small Copper	G5	SNR		Data Deficient		
Megathymus cofaqui	Cofaqui Giant Skipper	G3G4	S1		Data Deficient		
Nastra neamathla	Southern Swarthy Skipper	G4	SNR		Data Deficient		
Phyciodes (cocyta) incognitus	Mimic Crescent	GU	SNR		Data Deficient		
Pieris virginiensis	West Virginia White	G2G3	SNR		Data Deficient		

Poanes aaroni	Saffron Skipper	G4	SNR		Data Deficient		
Poanes hobomok	Homobok Skipper	G5	SNR		Data Deficient		
Polites peckius	Peck's Skipper	G5	SNR		Data Deficient		
Polygonia faunus	Green Comma	G5	SNR		Data Deficient		
Pterourus appalachiensis	Appalachian Swallowtail	G4	SNR		Data Deficient		
Pyrgus communis	Common Checkered Skipper	G5	S5		Data Deficient		
Satyrium edwardsii	Edwards' Hairstreak	G4	S2S4		Data Deficient		
Speyeria aphrodite	Aphrodite Fritillary	G5	SNR		Data Deficient		
OTHER BEES							
Xenoglossa kansensis	Kansas Squash Bee	G4?	SNR		Data Deficient		
Nomia maneei	Pearly-banded Bee	G3?	SNR		Data Deficient		
Megachile albitarsis	White-footed Leaf-cutter Bee	G4	SNR		Data Deficient		
Megachile georgica	"a bee"	G4	SNR		Data Deficient		
Megachile integra	"a bee"	G2G3	SNR		Data Deficient		
Megachile mucida	"a bee"	G4	SNR		Data Deficient		
Megachile pruina	Hoary Leaf-cutter Bee	G4?	SNR		Data Deficient		
Megachile pseudobrevis	"a bee"	G4	SNR		Data Deficient		
Megachile rubi	"a bee"	G3	SNR		Data Deficient		
Osmia albiventris	White-bellied Mason Bee	G4?	SNR		Data Deficient		
BUMBLEBEES							
Bombus affinis	Rusty-patched Bumblebee	G2	SH	Federally Endangered	Highest	Very High	
Bombus fervidus	Golden Northern Bumblebee	G3G4	SNR		High		
Bombus flavidus	Flavid Cuckoo Bumblebee	G5?	SNR		Data Deficient		
Bombus fraternus	Southern Plains Bumblebee	G2G4	SNR		High	Moderate	
Bombus pensylvanicus	American Bumblebee	G3G4	SNR		High	Moderate	

Bombus perplexus	Confusing Bumblebee	G5	SNR		Data Deficient		
Bombus sandersoni	Sanderson's Bumblebee	G5	SNR		Data Deficient		
Bombus terricola	Yellow-banded Bumblebee	G3G4	SNR		High	High	
Bombus vagans	Half-black Bumblebee	G4	SNR		Data Deficient		
Bombus variabilis	Variable Cuckoo Bumblebee	G1G2	SNR		Highest	Very High	
ANTS							
Colobopsis mississippiensis	Mississippi Gate-keeper Ant	GNR	SNR		Data Deficient		
Crematogaster vermiculata	Swamp Acrobat Ant	GNR	SNR		Data Deficient		
Pogonomyrmex badius	Florida Harvester Ant	G5	SNR		Data Deficient		
Polyergus longicornis	Long-horned Amazon Ant	GNR	SNR		Data Deficient		
SAWFLIES							
Eupareophora parca	Spiny Ash Sawfly	GNR	SNR		Data Deficient		
Tethida barda	Black-headed ash sawfly	GNR	SNR		Data Deficient		
SPIDERS							
Antrodiaetus unicolor	Folding Trapdoor Spider	GNR	S2		Data Deficient		
Araneus bicentenarius	Giant Orb-Weaver	GNR	S2/S3		Data Deficient		
Argiope florida	Sandhill Argiope	GNR	S2/S3		Data Deficient		
Cyclocosmia sp.	Hourglass Trapdoor	GNR	S1		Data Deficient		
Deinopis spinosa	Ogre-faced Spider	GNR	S1		Data Deficient		
Dolomedes vittatus	Whitewater Fishing Spider	GNR	S1		Data Deficient		
Hypochilus pococki	"a lampshade spider"	G4G5	S1		Data Deficient		
Maevia intermedia	Jumping Spider sp.	GNR	S1		Data Deficient		
Myrmekiaphila sp.	Ant-loving Trapdoor sp.	GNR	S1		Data Deficient		
Paramaevia hobbsae	Jumping Spider sp.	GNR	S1		Data Deficient		
Phidippus workmani	Workman's Jumping Spider	G2G3	S1		Data Deficient		

Sphodros coylei	Coyle's Purseweb Spider	G4?	S1		Data Deficient		
SCORPIONS							
Vaejovis carolinianus	Carolina/Southern Devil Scorpion	G5	S2/S3		Data Deficient		
STONEFLIES							
Alloperla furcula	Blackwater Sallfly	G2	SNR		Data Deficient		
Isoperla bellona	Smokies Stripetail	G3	SNR		Data Deficient		
Megaleuctra williamsae	Smokies Needlefly	G3	SNR		Data Deficient		
Oconoperla innubila	Hairy Springfly	G2	SNR		Data Deficient		
Taeniopteryx robinae	Savannah Willowfly	G1	SNR		Data Deficient		
DRAGONFLIES & DAMSELFLIES							
Arigomphus villosipes	Unicorn Clubtail	G5	SNR		Data Deficient		
Boyeria grafiana	Ocellated Darner	G5	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin-Santee & Savannah Drainages; Piedmont Ecobasin- Santee & Savannah Basins
Cordulegaster erronea	Tiger Spiketail	G4	SNR		Data Deficient		
Enallagma concisum	Cherry Bluet	G4	SNR		Moderate		
Enallagma davisi	Sandhill Bluet	G5	SNR		High		
Gomphurus septima	Septima's Clubtail	G3	SNR		High		
Gynacantha nervosa	Twilight Darner	G5	SNR		Data Deficient		
Helocordulia uhleri	Uhler's Sundragon	G5	SNR		Data Deficient		AQUATIC STAGE: Sandhills Ecobasin-Santee & Pee Dee Drainages
Hylogomphus abbreviatus	Spine-crowned Clubtail	G4	SNR		Data Deficient		AQUATIC STAGE: Coastal Plain Ecobasin-Pee Dee Drainage
Hylogomphus parvidens	Piedmont Clubtail	G4	SNR		Moderate		AQUATIC STAGE: Blue Ridge Ecobasin-Santee Drainage; Piedmont Ecobasin-Santee Drainage; Coastal Plain Ecobasin-Santee Drainage
Hylogomphus viridifrons	Green-faced Clubtail	G3G4	SNR		High		

Lestes eurinus	Amber-winged Spreadwing	G5	SNR		Data Deficient		
Lestes vidua	Carolina Spreadwing	G5	SNR		High		
Macromia alleghaniensis	Allegheny River Cruiser	G4	SNR		Data Deficient		
Macromia margarita	Mountain River Cruiser	G3	S1S2		Highest		
Neurocordulia virginiensis	Cinnamon Shadowdragon	G4	SNR		Moderate		
Ophiogomphus edmundo	Edmund's Snaketail	G2	SNR		Highest		
Ophiogomphus howei	Pygmy Snaketail	G3	SNR		High		
Ophiogomphus incurvatus	Appalachian Snaketail	G3	SNR		Moderate		AQUSTIC STAGE: Blue Ridge Ecobasin-Santee Drainage; Piedmont Ecobasin; Santee Drainage; Sandhills Ecobasin-Savannah Drainage; Coastal Plain Ecobasin-Savannah Drainage
Phanogomphus australis	Clearlake Clubtail	G4	SNR		High		
Phanogomphus diminutus	Diminutive Clubtail	G3G4	SNR		Highest		AQUATIC STAGE: Coastal Plain Ecobasin-Santee Drainage
Somatochlora provocans	Treetop Emerald	G4	SNR		Data Deficient		
Stenogomphurus rogersi	Sable Clubtail	G4	SNR		Highest		
Stylurus amnicola	Riverine Clubtail	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin-Savannah Drainage; Piedmont Ecobasin-Savannah Drainage; Sandhills Ecobasin-Santee & Savannah Drainages; Coastal Plain Ecobasin- Santee & Pee Dee Drainages
Stylurus ivae	Shining Clubtail	G4	SNR		High		AQUATIC STAGE: Sandhills Ecobasin-Savannah Drainage; Coastal Plain Ecobasin-ACE Drainage
Stylurus laurae	Laura's Clubtail	G4	SNR		Moderate		
Stylurus scudderi	Zebra Clubtail	G5	SNR		Data Deficient		
Stylurus spiniceps	Arrow Clubtail	G5	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin-Santee Drainage
Stylurus townesi	Townes' Clubtail	G3	S1S3		Highest		
Sympetrum rubicundulum	Ruby Meadowhawk	G5	SNR		Data Deficient		

Triacanthagyna trifida	Phantom Darner	G5	SNR		Data Deficient		
FRUITFLIES							
Peronyma quadrifasciata	"a fruitfly"	GNR	SNR		Data Deficient		
Trupanea dacetoptera	"a fruitfly"	GNR	SNR		Data Deficient		
Trupanea mevarna	"a fruitfly"	GNR	SNR		Data Deficient		
FLIES							
Basilia boardmani	"a fly"	G3	SNR		Data Deficient		
Dasineura pellex	Ash Bullet Gall Midge	GNR	SNR		Data Deficient		
Machimus polyphemi	Gopher Tortoise Robber Fly	G2	S1		Data Deficient		
Microdon craigheadii	"a fly"	G4G5	SNR		Data Deficient		
Microdon fuscipennis	Short-horned Ant Fly	GH (possibly extinct)	SNR		Data Deficient		
Milesia scutellata	Yellow-backed Giant	G3G4	SNR		Data Deficient		
Trichobius corynorhini	"a fly"	GNR	SNR		Data Deficient		
Trichobius major	"a fly"	GNR	SNR		Data Deficient		
Tropidia calcarata	Lily-loving Thickleg	G3G4	SNR		Data Deficient		
GROUND BEETLES							
Anillinus "mica" (n.sp.)	"a beetle"	GNR	SNR		Data Deficient		
Anillinus "South Carolina Waldrop Stone" (n.sp.)	"a beetle"	GNR	SNR		Data Deficient		
Bembidion rufotinctum	"a beetle"	GNR	SNR		Data Deficient		
Chlaenius augustus	"a beetle"	GNR	SNR		Data Deficient		
Cicindela abdominalis	Eastern Pine-barrens Tiger Beetle	G3G4	S3S4		Data Deficient		
Cicindela hirticollis hirticollis	Hairy-necked Tiger Beetle	G5T4	SNR		Data Deficient		
Cicindela nigrior	Autumn Tiger Beetle	G2G3	SNR		Data Deficient		
Cicindela patruela patruela	Northern Barrens Tiger Beetle	G3T3	SNR		Data Deficient		

Cicindela purpurea purpurea	Cow Path Tiger Beetle	G5T5	SNR		Data Deficient		
Cicindela splendida splendida	Splendid Tiger Beetle	G5	S3		Data Deficient		
Ellipsoptera gratiosa	Whitish Tiger Beetle	G3G4	S3S4		Data Deficient		
Eunota striga	Elusive Tiger Beetle	G3G4	SX		Data Deficient		
Eunota togata	White-cloaked Tiger Beetle	G5	S1		Data Deficient		
Evolenes exarata	"a beetle"	GNR	SNR		Data Deficient		
Habroscelimorpha dorsalis media	Eastern Beach Tiger Beetle	G3G4T3T4	S4	Nominate *dorsalis* is Federally Threatened	Data Deficient		
Pterostichus fallax	"a beetle"	GNR	SNR		Data Deficient		
Scaphinotus elevatus	Eastern Snail-eater	GNR	SNR		Data Deficient		
Sphaeroderus stenostomus	Poetic Snail-eating Beetle	G5	SNR		Data Deficient		
TRUE BUGS							
Allopodops mississippiensis	"a true bug"	G2G3	SNR		Data Deficient		
Trioza magnoliae	"a true bug"	GNR	SNR		Data Deficient		
Tropidosteptes cardinalis	Red Ash Plant Bug	GNR	SNR		Data Deficient		
FIREFLIES							
Phausis reticulata	Blue Ghost Firefly	G4	S2S4		Data Deficient		
Photinus acuminatus	Pointy-lobed Firefly	G1	S1S3		Highest		
Photinus consimilis	Cattail Flash-Train Firefly	GU	S3S4		Data Deficient		
Photuris fairchildi	Fairchild's Firefly	G5	S3S5		Data Deficient		
Photinus umbratus	"a firefly"	GU	SU		Data Deficient		
Photuris forresti	Loopy Five Firefly	G1	S1S2		Highest		
Photuris frontalis	Snappy Single-Sync Firefly	G4?	S2S4		Data Deficient		
Pyractomena lucifera	Marsh Imp	GU	S2S4		Data Deficient		
Pyractomena marginalis	Marginal Firefly	GU	SU		Data Deficient		
Pyractomena similis	"a firefly"	GU	SU		Data		

					Deficient		
LADYBUGS							
Adalia bipunctata	Two-spotted Lady Beetle	G5	SNR		Data Deficient		
Anatis labiculata	Fifteen-spotted Lady Beetle	G5	SNR		Data Deficient		
Coccinella novemnotata	Nine-spotted Lady Beetle	G5	SNR		Data Deficient		
FLAT BARK BEETLES							
Cucujus clavipes	Red Flat Bark Beetle	G5	SNR		Data Deficient		
TRUE WEEVILS							
Cercopeus paulus	Little Mischievous Weevil	GNR	SNR		Data Deficient		
Cercopeus tibialis	Notched Mischievous Weevil	GNR	SNR		Data Deficient		
Curculio caryatrypes	Greater Chestnut Weevil	GNR	SNR		Data Deficient		
Heilipus squamosus	Avocado Weevil	GNR	SNR		Data Deficient		
Hylesinus aculeatus	Eastern Ash Bark Beetle	G5	SNR		Data Deficient		
Lignyodes helvolus	Yellowish Ash Weevil	GNR	SNR		Data Deficient		
CLICK BEETLES							
Selonodon appalachiensis	Appalachian Crescent-moon Click Beetle	GNR	SNR		Data Deficient		
Selonodon bicolor	Rusty Crescent-moon Click Beetle	GNR	SNR		Data Deficient		
FALSE CLICK BEETLES							
Perothops mucidus		GNR	SNR		Data Deficient		
EARTH-BORING DUNG BEETLES							
Bolbocerosoma hamatum	Hooked Earth-boring Beetle	G3G4	SNR		Data Deficient		
Bolbocerosoma tumefactum	Single Spot Earth-boring Beetle	GNR	SNR		Data Deficient		
Bradycinetulus ferrugineus	Red Slow Earth-boring Beetle	GNR	SNR		Data Deficient		
Mycotrupes retusus	Sandhills Earth-boring Beetle	GNR	SNR		Data Deficient		
WHIRLIGIG BEETLES							

Spanglerogyrus albiventris	Red Hills Unique Whirligig Beetle	G1G3	SNR		Data Deficient		
CLOWN / HISTER BEETLES							
Baconia stephani		GNR	SNR		Data Deficient		
Haeterius brunneipennis		GNR	SNR		Data Deficient		
SCAVENGER SCARAB BEETLES							
Ceratocanthus aeneus	Bronze Knife-eyed Scarab	G2G3	SNR		Data Deficient		
STAG BEETLES							
Ceruchus piceus	"a stag beetle"	G5	SNR		Data Deficient		
Dorcus brevis	"a stag beetle"	GNR	SNR		Data Deficient		
Dorcus parallelus	The Antelope Beetle	GNR	SNR		Data Deficient		
Nicagus obscurus	"a stage beetle"	GNR	SNR		Data Deficient		
NET-WINGED BEETLES							
Caenia dimidiata	Divided Net-winged Beetle	G5	SNR		Data Deficient		
Calopteron discrepans	Banded Net-winged Beetle	GNR	SNR		Data Deficient		
Calopteron reticulatum	Reticulated Net-winged Beetle	GNR	SNR		Data Deficient		
FALSE DARKLING BEETLE							
Melandrya striata	"a false darkling beetle"	G5	SNR		Data Deficient		
BLISTER BEETLES							
Epicauta atrata	"a blister beetle"	GNR	SNR		Data Deficient		
Epicauta funebris	"a blister beetle"	GNR	SNR		Data Deficient		
Epicauta strigosa	"a blister beetle"	GNR	SNR		Data Deficient		
Meloe americanus	Buttercup Oil Beetle	GNR	SNR		Data Deficient		
Meloe campanicollis	"a blister beetle"	GNR	SNR		Data Deficient		
Meloe impressus	Impressive Oil Beetle	G5	SNR		Data Deficient		
FALSE BLISTER BEETLES							

Hypasclera dorsalis	"a false blister beetle"	GNR	SNR		Data Deficient		
Hypasclera ignota	"a false blister beetle"	GNR	SNR		Data Deficient		
Hypasclera pleuralis	"a false blister beetle"	GNR	SNR		Data Deficient		
TOE-WINGED BEETLES							
Anchytarsus bicolor	"a toe-winged beetle"	GNR	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee & Savannah Drainages; Piedmont Ecobasin-Santee, Savannah, & Pee Dee Drainages; Sandhills Ecobasin-Santee, Savannah, Pee Dee, & ACE Drainages; Coastal Plain Ecobasin-Santee, Pee Dee, & ACE Drainages
WEDGE-SHAPED BEETLES							
Macrosiagon limbata	"a wedge-shaped beetle"	GNR	SNR		Data Deficient		
Ripiphorus walshii	"a wedge-shaped beetle"	GNR	SNR		Data Deficient		
SCARABS							
Alloblackburneus troglodytes	Little Gopher Tortoise Scarab	G2G3	SNR		Data Deficient		
Cremastocheilus canaliculatus	"a scarab beetle"	G5	SNR		Data Deficient		
Cremastocheilus castaneae	"a scarab beetle"	GNR	SNR		Data Deficient		
Cremastocheilus harrisii	"a scarab beetle"	GNR	SNR		Data Deficient		
Cremastocheilus squamulosus	"a scarab beetle"	G2G3	SNR		Data Deficient		
Cremastocheilus variolosus	"a scarab beetle"	GNR	SNR		Data Deficient		
Dynastes tityus	Eastern Hercules Beetle	GNR	SNR		Data Deficient		
Euphoria (formerly Stephanucha) areata	"a scarab beetle"	GNR	SNR		Data Deficient		
Euphoria fulgida	The Emerald Euphoria	G5	SNR		Data Deficient		
Euphoria herbacea	The Olive Euphoria	GNR	SNR		Data Deficient		
Lichnanthe vulpina	Bumblebee Scarab	GNR	SNR		Data Deficient		
Onthophagus polyphemi	"a scarab beetle"	G2G3	SNR		Data Deficient		

Osmoderma eremicola	Hermit Flower Beetle	G5	SNR		Data Deficient		
Osmoderma scabra	"a scarab beetle"	G5	SNR		Data Deficient		
Trichiotinus affinis	"a scarab beetle"	G5	SNR		Data Deficient		
Trichiotinus bibens	Bronzed Flower Scarab	G4	SNR		Data Deficient		
Trichiotinus piger	Bee-Like Flower Scarab	G5	SNR		Data Deficient		
Xyloryctes jamaicensis	"a scarab beetle"	GNR	SNR		Data Deficient		
MARSH BEETLES							
Scirtes goodrichi	"a marsh beetle"	GNR	SNR		Data Deficient		
CARRION BEETLES							
Nicrophorus americanus	American Burying Beetle	G3	SH	Federally Endangered	Data Deficient		
SILVAN FLAT BARK BEETLES							
Telephanus atricapillus	Black-headed Toothed Bark Beetle	GNR	SNR		Data Deficient		
ROVE BEETLES							
Adranes coecus	"a rove beetle"	GNR	SNR		Data Deficient		
Dacnochilus laetus	"a rove beetle"	GNR	SNR		Data Deficient		
Dasycerus pacolet [n. sp.]	"a rove beetle"	GNR	SNR		Data Deficient		
Ecitoxenidia alabamae	"a rove beetle"	GNR	SNR		Data Deficient		
Mayetia "clemsonensis" (n.sp.)	"a rove beetle"	GNR	SNR		Data Deficient		
Microdonia occipitalis?	"a rove beetle"	GNR	SNR		Data Deficient		
Oxyporus femoralis	"a rove beetle"	GNR	SNR		Data Deficient		
Oxyporus lateralis	"a rove beetle"	GNR	SNR		Data Deficient		
Prespelea myersae	"a rove beetle"	GNR	SNR		Data Deficient		
LONGHORN BEETLES							
Crossidius grahami	"a longhorn beetle"	GNR	SNR		Data Deficient		
WOOD BORING BEETLES							

Phellopsis obcordata	Urwald Watcher Beetle	G5	SNR		Data Deficient		
CADDISFLIES							
Agapetus jocassee	Jocassee Saddle-case Caddisfly	G2G3	SNR		Data Deficient		
Agapetus spinosus	Spiney Sadle-case Caddisfly	G2	SNR		Data Deficient		
Agarodes libalis	Spring-loving Bush-tailed Caddisfly	G3	SNR		Data Deficient		
Agarodes tetron	Shameful Bush-tailed Caddisfly	G3G4	SNR		Data Deficient		
Agarodes wallacei	Wallace's Bush-tailed Caddisfly	G1G2	SNR		Data Deficient		
Brachycentrus etowahensis	Etowah Humpless Caddisfly	G3	SNR		Data Deficient		
Brachycentrus lunatus	Crescentic Humpless Caddisfly	G2G3	SNR		Data Deficient		
Ceraclea cama	Muzzled Long-horned Caddisfly	G1G2	SNR		Data Deficient		
Cheumatopsyche richardsoni	Richardson's Netspinning Caddisfly	G1G2	SNR		Data Deficient		
Chimarra augusta	August Finger-net Caddisfly	G3G4	SNR		Data Deficient		
Goera townesi	Townes' Weighted-case Caddisfly	G3G4	SNR		Data Deficient		
Goerita semata	Marked Weighted-case Caddisfly	G3	SNR		Data Deficient		
Helicopsyche paralimnella	Plain Snail-case Caddisfly	G2	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee & Savannah Drainages
Hydropsyche bidentata	Bidentate Netspinning Caddisfly	G1G2	SNR		Data Deficient		
Hydropsyche carolina	Carolina Netspinning Caddisfly	G3	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee Drainage
Hydropsyche catawba	Catawba Netspinning Caddisfly	G3	SNR		Data Deficient		
Hydropsyche macleodi	McLeod's Netspinning Caddisfly	G3G4	SNR		Data Deficient		
Hydroptila carolae	Carol's Varicolored Microcaddisfly	G1	SNR		Data Deficient		
Hydroptila englishi	English's Varicolored Microcaddisfly	G2	SNR		Data Deficient		
Hydroptila latosa	Broad Varicolored Microcaddisfly	G2G3	SNR		Data Deficient		
Hydroptila lloganae	Llogan's Varicolored Microcaddisfly	G3	SNR		Data Deficient		

Hydroptila tridentata	Three-tooth Varicolored Microcaddisfly	G1	SNR		Data Deficient		
Lepidostoma carolina	Carolina Bizarre Caddisfly	G1G2	SNR		Data Deficient		
Lepidostoma excavatum	Excavated Bizarre Caddisfly	G2G3	SNR		Data Deficient		
Lepidostoma flinti	Flint's Bizarre Caddisfly	G2	SNR		Data Deficient		
Lepidostoma lobatum	Lobed Bizarre Caddisfly	G2	SNR		Data Deficient		
Lepidostoma mitchelli	Mitchell's Bizarre Caddisfly	G3	SNR		Data Deficient		
Lepidostoma modestum	Gentle Bizarre Caddisfly	G3G4	SNR		Data Deficient		
Lepidostoma stylifer	Style-bearing Bizarre Caddisfly	G2G3	SNR		Data Deficient		
Lepidostoma wigginsi	Wiggins' Bizarre Caddisfly	G3G4	SNR		Data Deficient		
Micrasema rickeri	Ricker's Humpless Caddisfly	G3	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee & Savannah Drainages
Neophylax atlanta	Atlanta Little Caddisfly	G2G4	SNR		Data Deficient		
Neophylax mitchelli	Mitchell's Little Caddisfly	G3G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee & Savannah Drainages; Piedmont Ecobasin-Santee& Savannah Drainages
Neotrichia falca	Hooked Neotrichian Microcaddisfly	G3G4	SNR		Data Deficient		
Oecetis daytona	Daytona Long-horned Caddisfly	G3	SNR		Data Deficient		
Oecetis morsei	Morse's Long-horned Caddisfly	G3	SNR		Data Deficient		
Oecetis parva	Little Oecetis Longhorn Caddisfly	G2	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin-Santee Drainage
Oecetis porteri	Porter's Longhorned Caddisfly	G3G4	SNR		Data Deficient		
Oropsyche howellae	Howell's Netspinning Caddisfly	G1	SNR		Data Deficient		
Orthotrichia dentata	Dentate Orthotrichian Microcaddisfly	G2G3	SNR		Data Deficient		
Oxyethira dunbartonensis	Dunbarton Oxyethiran Microcaddisfly	G2G3	SNR		Data Deficient		
Oxyethira elerobi	Elerob's Oxyethiran Microcaddisfly	G3G4	SNR		Data Deficient		
Oxyethira roberti	Robert's Oxyethiran Microcaddisfly	G3G4	SNR		Data Deficient		

Oxyethira savanniensis	Savannah Oxyethiran Microcaddisfly	G3	SNR		Data Deficient		
Oxyethira sininsigne	Indistinct Oxyethiran Microcaddisfly	G3G4	SNR		Data Deficient		
Phylocentropus auriceps	Gold-headed Pitot-tube Caddisfly	G3G4	SNR		Data Deficient		
Polycentropus carlsoni	Carlson's Trumpet-net Caddisfly	G2G3	S1S3		Data Deficient		
Protoptila morettii	Moretti's Saddle-case Caddisfly	G1G2	SNR		Data Deficient		
Pseudogoera singularis	Singular Mortarjoin Caddisfly	G2G3	SNR		Data Deficient		
Psilotreta amera	Long-spined Mortarjoint Caddisfly	G3G4	SNR		Data Deficient		
Psilotreta rossi	Ross' Mortarjoint Caddisfly	G3	SNR		Data Deficient		
Pycnopsyche virginica	Virginia Northern Caddisfly	G3G4	SNR		Data Deficient		
Rhyacophila accola	Neighbor Free-living Caddisfly	G1G2	SNR		Data Deficient		
Rhyacophila amicis	Friendly Free-living Caddisfly	G3G4	SNR		Data Deficient		
Rhyacophila appalachia	Appalachian Free-living Caddisfly	G3	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Savannah Drainage
Rhyacophila montana	Mountain Free-living Caddisfly	G2G3	SNR		Data Deficient		
Rhyacophila mycta	Nosey Free-living Caddisfly	G3	SNR		Data Deficient		
Rhyacophila teddyi	Teddy's Free-living Caddisfly	G2	SNR		Data Deficient		
Setodes arenatus	Sand-loving Long-horned Caddisfly	G2G3	SNR		Data Deficient		
Theliopsyche corona	Crowned Bizarre Caddisfly	G2G3	SNR		Data Deficient		
Theliopsyche epilonis	Longer Bizarre Caddisfly	G2	SNR		Data Deficient		
Triaenodes bicornus	Bifurcate Long-horned Caddisfly	G2G3	SNR		Data Deficient		
Triaenodes dendyi	Dendy's Long-horned Caddisfly	G2G3	SNR		Data Deficient		
Triaenodes helo	Marsh Trianode Long-horned Caddisfly	G3	SNR		Data Deficient		
Triaenodes morsei	Morse's Long-horned Caddisfly	G1G2	SNR		Data Deficient		
Triaenodes smithi	Smith's Long-horned Caddisfly	G3G4	SNR		Data Deficient		

Triaenodes taenia	Ribboned Long-horned Caddisfly	G3G4	SNR		Data Deficient		
Wormaldia mohri	Mohr's Finger-net Caddisfly	G2G3	SNR		Data Deficient		
Wormaldia oconee	Oconee Finger-net Caddisfly	G1G2	SNR		Data Deficient		
Wormaldia thyria	Porthole Finger-net Caddisfly	G3	SNR		Data Deficient		
MAYFLIES							
Acanthametropus pecatonica	"a mayfly"	G2G4	SNR		Data Deficient		
Anafroptilum album	"a mayfly"	G5	SNR		Data Deficient		
Anthopotamus distinctus	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE- Piedmont Ecobasin-Pee Dee Drainage
Apobaetis etowah	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin-Santee & Savannah Drainages
Arthroplea bipunctata	"a mayfly"	G5	SNR		Data Deficient		
Baetisca becki	"a mayfly"	G2G3	SNR		Data Deficient		
Baetisca obesa	"a mayfly"	G5	SNR		Data Deficient		
Baetisca rogersi	"a mayfly"	G4	SNR		Data Deficient		
Baetopus trishae	"a mayfly"	G1	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Savannah Drainage
Barbaetis benfieldi	"a mayfly"	G2G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin-Santee Drainage; Piedmont Ecobasin-Santee Ddrainage
Brachycercus berneri	"a mayfly"	G4	SNR		Data Deficient		
Cercobrachys etowah	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecoregion-Savannah Drainage; Piedmont Ecobasin-Savannah Drainage; Coastal Plain Ecobasin-ACE Drainage
Cercobrachys pomeiok	"a mayfly"	G1G2	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin- Santee Drainage
Choroterpes basalis	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin-Savannah Drainage; Coastal Plain Ecobasin-Pee Dee Drainage
Dolania americana	American Sand Burrowing Mayfly	G4	SNR		Data		

					Deficient		
Ephemerella hispida	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee & Savannah Drainages
Ephemerella subvaria	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee Drainage
Eurylophella enoensis	"a mayfly"	G4	SNR		Data Deficient		
Eurylophella minimella	"a mayfly"	G4	SNR		Data Deficient		
Habrophlebiodes brunneipennis	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin- Santee Drainage; Sandhills Ecobasin-Santee Drainage
Heterocloeon berneri	"a mayfly"	G1G2	SNR		Data Deficient		
Heterocloeon petersi	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Savannah Drainage; Piedmont Ecobasin-Santee & Savannah Drainages; Sandhills Ecobasin-Santee Drainage
Homoeoneuria cahabensis	"a mayfly"	G3	SNR		Data Deficient		AQUATIC STAGE- Piedmont Ecobasin-Santee Drainage
Homoeoneuria dolani	"a mayfly"	G3G4	SNR		Data Deficient		AQUATIC STAGE- Piedmont Ecobasin-Santee Drainage
Isonychia sayi	"a mayfly"	G4	SNR		Data Deficient		
Maccaffertium lenati	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin-Santee Drainage; Piedmont Ecobasin-Santee & Savannah Drainages
Maccaffertium mediopunctatum	"a mayfly"	G5	SNR		Data Deficient		
Maccaffertium pulchellum	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Piedmont Ecobasin- Santee Drainage
Maccaffertium sinclairi	"a mayfly"	G2G3	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee Drainage
Maccaffertium vicarium	"a mayfly"	G5	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin- Santee Drainage
Neoleptophlebia assimilis	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecoregion-Santee & Savannah Drainages; Piedmont Ecobasin-Santee Drainage; Coastal Plain Ecobasin-ACE

							Drainage
Paraleptophlebia debilis	"a mayfly"	G5	SNR		Data Deficient		
Paraleptophlebia jeanae	"a mayfly"	G3G4	SNR		Data Deficient		
Paraleptophlebia moerens	"a mayfly"	G4	SNR		Data Deficient		
Procloeon bellum	"a mayfly"	G5	SNR		Data Deficient		
Procloeon quaesitum	"a mayfly"	G4	SNR		Data Deficient		
Procloeon rubropictum	"a mayfly"	G5	SNR		Data Deficient		
Siphlonurus decorus	"a mayfly"	G1G3	SNR		Data Deficient		
Siphlonurus marginatus	"a mayfly"	G4	SNR		Data Deficient		
Tricorythodes robacki	"a mayfly"	G4	SNR		Data Deficient		
Tsalia berneri	"a mayfly"	G4	SNR		Data Deficient		AQUATIC STAGE: Blue Ridge Ecobasin-Santee Drainage
GRASSHOPPERS							
Eotettix pusillus	Little Eastern Grasshopper	G2G3	SNR		Data Deficient		
Melanoplus attenuatus	Slender-bodied Spur-throat Grasshopper	G2G3	SNR		Data Deficient		
Melanoplus australis	Southern Spur-throat Grasshopper	G2G4	SNR		Data Deficient		
Melanoplus cherokee	Cherokee Melanoplus	G1G3	SNR		Data Deficient		
Melanoplus deceptus	Deceptive Melanoplus	G2G4	SNR		Data Deficient		
Melanoplus mirus	Weldon Short-wing Grasshopper	G1	SNR		Data Deficient		

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CHAPTER 7: CULTURALLY IMPORTANT SPECIES AND HABITATS

Introduction

This chapter will somewhat deviate from the typical western European style of writing to discuss culturally significant species to South Carolina's Indigenous Peoples using terminology consistent with their relationship with their fellow living beings. We acknowledge that before European contact, several sovereign tribal nations called this landscape home and still do today, although some may no longer reside within the State's geopolitical borders. Traditional lands held and still hold unique plant and animal communities with enduring importance to these Indigenous Peoples, and their cultural knowledge is a valuable part of any conservation plan. These plant and animal species will be discussed as "relatives" throughout this chapter in keeping with the associations Indigenous Peoples have with these entities. Relatives are considered providers, teachers, and elders, giving humans food, medicine, and the gifts of technology and ceremonial items. Animals and plants appear in art and language but also support aesthetics/spiritual values (non-consumptive). Ultimately, many relatives provide useful services to tribes directly or indirectly (i.e. via ecosystem services). Both plants and animals are harvested for human use but should still be treated with gratitude and respect and humans reciprocating by providing space for them to live and flourish. All species have their own intrinsic value, not just a value imposed by humans based on usefulness, and tribal entities are uniquely positioned to lead a global reconnection with the environment from a biodiversity standpoint.

Although all relatives and habitats are important to maintain trophic structure and thus stability of natural systems, the nature of the State Wildlife Action Plan (SWAP) is to identify those native relatives that are rare, facing precipitous declines, and are under threat. It is also a requirement of the State and Tribal Wildlife Grants Program to identify Species of Greatest Conservation Need (SGCN) in order to receive implementation funding. Therefore, a prioritization process had to be utilized, resulting in the current SWAP SGCN list identified in this document. It should be acknowledged that non-native relatives may be culturally important to some Tribes, but the SWAP only includes native relatives. In this cultural chapter, institutional scientific approaches are interwoven with indigenous knowledge when discussing conservation actions needed to support relatives and their habitats. Tribes recognize the need to safeguard their local ecosystems from which they receive basic needs like subsistence hunting, fishing, and native plants used in Food Sovereignty Programs. Ecosystem resilience is therefore important to their well-being (Reyes-Garcia et al. 2018). In the past, Indigenous Peoples spoke a variety of languages so that the same plant or animal has several different traditional names. In addition to the number of names, sadly, some of the names of these relatives have been lost or mispronounced so that use in the SWAP would be more confusing than helpful. Therefore, the English common name is used as well as binomial nomenclature (Linnaean system) for clarity and precision.

Additionally, the South Carolina Department of Natural Resources (SCDNR) engaged the Gullah-Geechee Nation, comprised of descendants of African slaves brought over to America from the 1600s to 1800s. The name is derived from the people and locations from which slaves were brought: the Gola people from Angola became "Gullah" plus the Gidzi people from Sierra Leone became "Geechee." However, many more ethnic/cultural groups from other parts of

Africa were a part of the slave trade and combined into this one name. The Gullah-Geechee Nation is recognized for its people's valuable contributions to the cultural diversity of coastal South Carolina and is given a section in this chapter as it relates to native species identified as culturally important.

All 25 entities contacted by SCDNR to request involvement in this cultural chapter included those in Box 7-1, although some were unable to participate at this time. Those with an asterisk (*) provided comment and are listed in the Acknowledgements section at the beginning of this SWAP by participant's name. The SWAP is meant to be implemented by all people at all levels of the community, and the contributions of these cultural groups is greatly appreciated toward a common conservation goal. The SWAP is a living document so that future participation by tribes that could not comment this time always have the opportunity to contribute mid-revision cycle.

BOX 7-1: Cultural Groups Contacted for SWAP Input

Federally Recognized Tribes

- Catawba Indian Nation*
- Absentee-Shawnee Tribe of Indians of Oklahoma
- Alabama-Quassarte Tribal Town
- Cherokee Nation
- Chickasaw Nation
- Eastern Band of Cherokee Indians of North Carolina*
- Eastern Shawnee Tribe of Oklahoma
- Kialegee Tribal Town
- Miccosukee Tribe of Indians of Florida
- Muscogee (Creek) Nation
- Seminole Nation of Oklahoma
- Seminole Tribe of Florida
- Shawnee Tribe
- Thlopthlocco Tribal Town
- Tuscarora Nation of New York
- United Keetoowah Band of Cherokee Indians in Oklahoma

State of South Carolina Recognized Tribes

- Beaver Creek Indians
- Edisto Natchez Kusso Tribe of South Carolina
- Pee Dee Indian Nation of Upper South Carolina
- Pee Dee Indian Tribe
- Piedmont American Indian Association, Lower Eastern Cherokee Nation of South Carolina
- The Santee Indian Organization
- Sumter Tribe of Cheraw Indians
- The Waccamaw Indian People*
- The Wassamasaw Tribe of Varnertown Indians

Other Cultural Groups in South Carolina

- Gullah-Geechee Nation [African-American]*

Indigenous Peoples' (Native American Tribes') Perspective

Indigenous Peoples (Tribes) that provided input this iteration of the SWAP included the Catawba Indian Nation, Eastern Band of Cherokee Indians of North Carolina, and Waccamaw Indian People. Indians. Ancestral lands of the Catawba stretched from the upstate (SC and NC) down to the coast of South Carolina, spanning multiple ecoregions and ecological communities. The Catawba people are known for their beautiful, burnished pottery with its unique mottled appearance that occurs as a result of the firing process. The clay used for this pottery is harvested from sacred clay holes along the riverbanks of the Catawba River. This practice is one of the oldest unbroken pottery traditions in the Americas having been passed down intergenerationally for at least 4,000 years. The Cherokee's ancestral lands once stretched over eight southeastern states from the peaks of the Appalachians to the flatlands. The Waccamaw Indian People's ancestral lands were more Coastal Plain from Cape Fear, NC down to the Waccamaw River, SC. However, many tribes had trading routes and ancestral lands that overlapped on the landscape so that most maps inaccurately describe their true presence within South Carolina's geopolitical boundaries. Indigenous Peoples identify themselves as stewards of the natural world to which they are intricately linked.

In planning this iteration of the SWAP, the SCDNR requested the following from participating tribes: (1) provide a list of relatives of cultural significance to their people for recognition in the SWAP and for cross-reference to SGCN, and (2) provide case studies of conservation projects in progress that demonstrate a shared approach to SWAP implementation. In the case of the Catawba Indian Nation, the Tribe is actively conducting surveys for relatives such as herpetofauna, deer, and bats to better inform management decisions on tribal lands. They are also in the process of recovering and restoring culturally, ecologically, and environmentally significant habitats that have been lost, severely declined, or suppressed since European arrival. The Nation is currently focused on three major reclamation/restoration efforts: Giant Rivercane, Rocky Shoals Spider Lily, and Piedmont prairies. The Waccamaw Indian People are actively compiling a list of plant relatives that have cultural significance to the Tribe as part of an investigation into lost indigenous knowledge. The Eastern Band of Cherokee Indians of North Carolina have a current Wildlife Action Plan for which the 2022 update was consulted as a reference for their conservation programs in progress.

Red Wolves in captivity at Cape Romain National Wildlife Refuge in 2021. Photo by Anna Smith, SCDNR.

When it comes to reconciling the Tribes' species lists with the State's SGCN list, it is important to remember that South Carolina's SGCN were defined using a methodology based on ecological metrics. Where these species overlap with culturally significant relatives specifically named by a tribe, the resulting list is Table 7-1:

Relatives of Conservation Concern (RCC). Sometimes relatives were listed only generally by tribes so that without further clarification, it is not known if the SGCN matched the RCC. For example, general terms included “ant”, “bat”, “bee/bumblebee”, “butterfly”, “catfish”, “crayfish”, “clam”, “cricket”, “damselfly”, “fly”, “glass lizard”, “green grasshopper”, “leech”, “mole”, “mudpuppy” (larval form of salamander), “mussels”, “perch”, “salamander”, “snail”, “spider”, “swan”, “toad”, “tree frog”, “wasp”, “water snake”, “freshwater fish assemblages”, and “*Hypericum* sp.” (Saint John’s Wort). Where logical assumptions could be made based on tribal ancestral lands and relatives’ known ranges, some RCC are further defined and included in Table 7-1. Some plants that are important to the tribes are non-native/exotic or agricultural products and are excluded from this SWAP which focuses on native species only. The SWAP does consider the full breadth of species that would benefit from whole ecosystem approaches to conservation and encourages “keeping common species common”. Unfortunately, nine additional relatives are no longer on the South Carolina landscape due to extirpation or extinction. In alphabetical order, these are: American Bison (extirpated), Carolina Parakeet (extinct), Eastern Cougar (extinct), Elk (extirpated), Gray Wolf (extirpated), Ivory-billed Woodpecker (extinct), Jaguar (extirpated), Passenger Pigeon (extinct), and Red Wolf (extirpated). Their absence is a powerful reminder of the critical role education, habitat protection, partnerships, and funding have on conservation outcomes.

TABLE 7-1: Relatives of Conservation Concern provided by tribal entities. Note that this is not a comprehensive list that may overlap with SGCN but are simply those specifically called out by name by the participating tribes. The Waccamaw Indian People also recognize a variety of fungi which are not covered in SC’s SWAP.

ANIMALS	Taxa Group	Catawba	EBCI	Waccamaw
American Alligator	Reptile	X		X
American Kestrel	Bird	X		
American Eel	Fish	X		
American Shad	Fish	X		
American Woodcock	Bird	X		
Atlantic Blue Crab	Marine Invertebrate			X
Bald Eagle	Bird	X	X	
Black Rail	Bird			X
Bog Turtle	Reptile		X	
Brown Shrimp	Marine Invertebrate			X
Carolina Heelsplitter	Mussel	X		
Carolina Pygmy Sunfish	Fish			X
"Carolina" Redhorse	Fish	X		
Carolina Sandhills Crayfish	Crayfish			X
Cedar Creek Crayfish (previously Waccamaw Crayfish)	Crayfish			X
Chuck-will's Widow	Bird	X		
Chimney Swift	Bird	X		
Common Nighthawk	Bird	X		
Eastern Box Turtle	Reptile	X	X	X
Eastern Brook Trout	Fish		X	

Eastern Diamondback Rattlesnake	Reptile	X		
Eastern Lampmussel	Mussel			X
Eastern Meadowlark	Bird	X		
Eastern Mud Turtle	Reptile	X		
Eastern Musk Turtle	Reptile	X		
Eastern Oyster	Marine Invertebrate			X
Eastern Painted Turtle	Reptile			X
Eastern Pondmussel	Mussel			X
Eastern River Cooter	Reptile			X
Eastern Whip-poor-will	Bird	X		X
Flat Bullhead	Fish	X		
Florida Gar	Fish	X		
Golden Eagle	Bird	X	X	X
Green Heron	Bird	X		
Hickory Shad	Fish	X		
Humpback Whale	Mammal			X
Knobbed Whelk	Marine Invertebrate			X
Lightning Whelk	Marine Invertebrate			X
Little Blue Heron	Bird	X		X
Monarch Butterfly	Insect			X
North Atlantic Right Whale	Mammal			X
Northern Bobwhite	Bird	X		X
Northern Long-eared Bat	Mammal		X	
Oak Toad	Amphibian	X		
Pee Dee Lotic Crayfish	Crayfish			X
Peregrine Falcon	Bird	X		
Red-headed Woodpecker	Bird	X		
Ruffed Grouse	Bird	X	X	
Southern Fox Squirrel	Mammal	X		X
Spotted Skunk	Mammal	X		
Snail Bullhead	Fish	X		
Snapping Turtle	Reptile	X		X
Striped Bass	Fish			X
Striped Mud Turtle	Reptile	X		
Swamp Rabbit	Mammal			X
Timber Rattlesnake	Reptile	X	X	
Waccamaw Spike (synonymized with Carolina Slabshell)	Mussel			X
White Catfish	Fish	X		
Wood Thrush	Bird	X		
Whooping Crane	Bird	X		

Yellow-billed Cuckoo	Bird	X		
PLANTS	**Taxa Group**	**Catawba**	**EBCI**	**Waccamaw**
American Pennyroyal (*Hedeoma pulegioides*)	Plant	X		
Giant Cane (*Arundinaria gigantea*) - canebreak habitat	Plant	X		
Little Heartleaf (*Hexastylis minor*)	Plant	X		
Longleaf Pine (*Pinus palustris*) - as a habitat component	Plant	X		
Mannagrass (*Glyceria obtusa*)	Plant	X		
Sarsaparilla Root (*Aralia nudicaulis*)	Plant	X		
Shoals Spiderlily/Cahaba Lily (*Hymenocallis coronaria*)	Plant	X		
Shortleaf Pine (*Pinus echinata*) - as a habitat component	Plant	X		
Venus Flytrap (*Dionaea muscipula*)	Plant			X
Yellow Wood (*Cladrastis kentuckea*)	Plant	X		

In the Supplemental Volume, a cultural icon is beside the names of species that are of cultural importance. The concept of icon representations is adapted from the Ojibwe's Ganawenindiwag Team (2023).

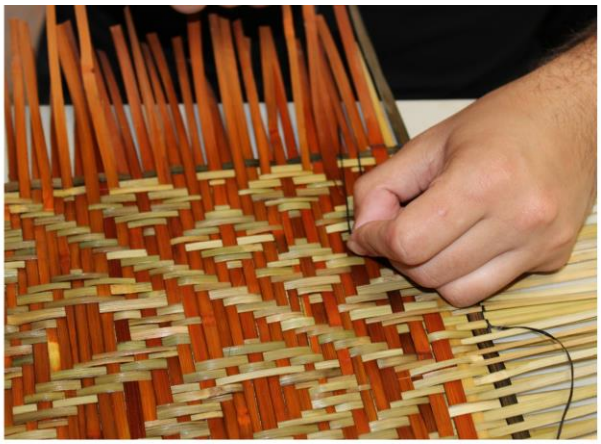
Case Study: Rivercane Restoration by the Catawba Indian Nation

Harvesting mature rivercane. Photo by Aaron Bumgardner, Catawba Indian Nation.

Rivercane, or technically Giant Cane (*Arundinaria gigantea*), is a valuable cultural relative for many Indigenous Peoples in the Southeast. This plant once formed large patches called canebrakes which can be considered their own ecosystems as they produce their own microclimate, stabilize floodplain soils, and provide habitat for a suite of species, some of which are now extinct. In addition, the plant itself was utilitarian for many indigenous cultures in the Southeast, including the Catawba. Once dried, it is more resistant to cracking or splitting, making it suitable for making mats, fishing poles, musical instruments, fishing weirs, and for weaving. The area between the joints on the stems are long

Tribe member Aaron Baumgardner weaving a rivercane basket. Photo provided by Aaron Bumgardner, Catawba Indian Nation.

and therefore can be fashioned into blowguns for hunting. Birds that are known to rely on rivercane for nesting habitat include Hooded Warbler and Swainson's Warbler and the now extinct Bachman's Warbler, Carolina Parakeet, and Passenger Pigeon. Black bears and other mammal and herpetofauna relatives found shelter in its thickets. Unfortunately, rivercane has experienced a 98% decline over its range from habitat degradation (e.g. wild hog rooting, cattle browsing new shoots) and habitat destruction (agriculture and urban development). Catawba rivercane restoration is showcased by the United South and Eastern Tribes' (USET) through two videos: USET Celebrates Earth Day and Honors the Work of the Catawba Indian Nation and Catawba Nation Rivercane Restoration.



Weaving a rivercane mat. Photo by Michelle Long, EBCI

Tribal citizen restoration of rivercane is a multifaceted effort, beginning with identifying and mapping existing areas of rivercane. This is followed by the development and implementation of a vigorous invasive species suppression and eradication strategy. Canopy openings are also created to allow sunlight to reach ground level through removal of understory and pruning of existing large trees in the overstory. The Tribe is also partnering with regional public and private landowners to identify remnant rivercane populations and create agreements to access populations for cultural harvests and ecological restoration transplants.

Through this rivercane restoration initiative, an opportunity is created for existing rivercane to grow and thrive. To expedite this process, the Catawba Indian Nation is currently experimenting and seeing success in three areas. First, there has been clearing and "freeing" of existing rivercane in areas where growth has been suppressed by significant invasives such as Chinese Privet (*Ligustrum sinense*).

Flagged rivercane restoration test plots on Reservation lands along the Greenway Trail (part of the Carolina Thread Trail) by the Catawba River. Photo by Anna Smith, SCDNR.

Secondly, harvesting and transplanting of rhizomes from other areas has taken place directly into other areas with existing rivercane to augment the population. Additionally, other populations have been rescued from areas slated for infrastructure development and grown out in the Tribe's greenhouse for future use in streambank restoration projects or for erosion control. Thirdly, large clumps of rivercane are being harvested from collaborative partners to create a continuous canebrake along a portion of the Catawba River on tribal lands.

Case Study: Rocky Shoals Spider Lily Restoration by the Catawba Indian Nation

The Catawba River is currently home to the largest Rocky Shoals Spider Lily (*Hymenocallis coronaria*) population in the world. The population is threatened by human activities such as hydroelectric dams that were constructed in the early 1900's, pollution, development, and climate change. This lily is charismatic and indicative of healthy water quality. Creation stories speak of the lily's leaves as the raiment of First Woman, but the plant is also a modern-day symbol of the river that shares the namesake of the Nation. Being good stewards of the land means recognizing the intrinsic value of relatives and caring for all of them regardless of their historic cultural value. This relative is also a SGCN of 'highest conservation priority' in the South Carolina SWAP.

Rocky Shoals Spider Lily in the Catawba River.
Photo by Robert Clark.

Restoration is underway, in cooperation with the non-profit Catawba Riverkeeper Foundation, to identify, map, and prioritize areas along the Catawba River for re-establishing this plant relative. Areas of quality flow, depth, and structure that will support seed growth have been identified and mapped, and seeds have been harvested from existing populations and meticulously planted by hand in these areas. These areas will continuously be monitored, and the program will be evaluated and adapted for future success.

Case Study: Piedmont Prairie Restoration by the Catawba Indian Nation

Historically, vast expanses of prairie and grassland savannahs once covered the South Carolina Piedmont region, and by some estimates, 19 million acres or 63% of ancestral Catawba lands were in this cover type (Rua Mordecai, SECAS, pers. comm.). These areas were characterized by grasses and wildflowers, with a scattering of trees and shrubs, and were grazed by native herbivores such as bison and elk. This ecosystem was shaped in large part by the dormant season burns set by Indigenous Peoples of the region to maintain these habitats for their survival. These grassland ecosystems were important to Indigenous Peoples as habitat to hunt and forage for plants to use for food, medicine, and industry (thatch, cordage, crafts, etc.). In addition, these

ecosystems were home to many now federally listed relatives including the federally endangered Schweinitz's Sunflower (*Helianthus schweinitzii*), a SGCN of 'highest conservation priority' in the South Carolina SWAP. Once locally abundant but only found in the Carolinas, this plant was valued by the Catawba as the tubers were a food source. It is now considered one of the rarest sunflowers in the United States. The goal of this restoration project is to restore the prairie ecosystems on tribal lands their historic compositions as closely as possible.

Schweinitz's Sunflowers (left) bloom during the fall. The Catawba Indian Nation are growing this plant relative on their tribal lands in pots (above) for eventual reintroduction into a Piedmont prairie system. Photos by Keith Bradley, SCDNR

Roadsides, existing lawns around buildings, view corridors, and other areas will be prepared and seeded with a native seed mix identified and vetted with tribal input. This seed mix will represent as closely as possible, the plants that would have populated these ecosystems. Soil testing will take place, and based on soil type, seed mixes will be developed and initial seeding take place. Management of prairie and savannah areas will consist of monitoring for non-native invasive plants and need for re-seeding if necessary, timely mowing in the months following seed drop, and chemical applications/mechanical removal to eliminate woody vegetation and invasive/exotic/undesirable plants. Special consideration will be taken to re-introduce threatened and endangered relatives such as Schweinitz's Sunflower and Georgia Aster (SGCN of 'moderate conservation priority' in the South Carolina SWAP) onto the prairie landscape. Seed collection and grow-out efforts will be utilized to produce plants without depleting any native populations. Grow-out plants will be transplanted into different locations throughout the restoration areas to establish self-sustaining populations.

Case Study: Plant Research and Educational Outreach by the Waccamaw Indian People

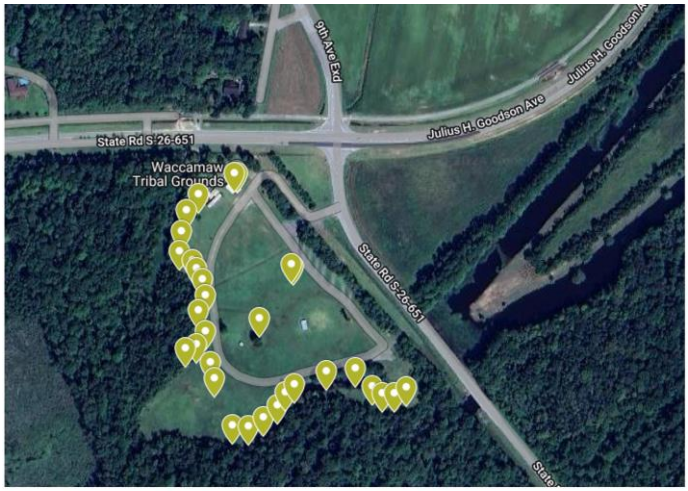
Every equinox and solstice, the Waccamaw Indian People hold a native plant inventory walk on tribal lands to log species observations during all four seasons. Lead by a botanist, this survey not only enhances the Tribe's knowledge of the species inhabiting ancestral lands but ties back to research currently being conducted into past ethnobotany accounts to identify botanical species of past (and continued) cultural significance for food, medicine, and utilitarian uses. Results are

shared on iNaturalist which SCDNR's Natural Heritage Program data-mines for SGCN records. The Waccamaw Indian People value all native plants and animals and consider them relatives, important for their intrinsic value and not necessarily their usefulness to humans. Even some non-native species have been adopted for cultural uses (e.g. Dandylion).

A map of the Waccamaw Ecological and Cultural Interpretive Trail and signage is available on the Tribe's website.

Marion Craddock, Jr. (Waccamaw Indian People, Firekeeper) assists researcher, Cecelia Bailey, emerge from a patch of non-native, invasive Taro during a June 2023 summer solstice botanical survey. Photo by Cheryl Cail (Waccamaw Indian People).

In an effort to expand appreciation for plant relatives, especially those underrepresented freshwater aquatic ones, the Tribe is planning to expand their Waccamaw Indian People Heritage Trail, complete with interpretive signage and a floating dock destination at Chinners Swamp. They plan to collaborate with the Horry County Museum in Conway, SC to create field trip opportunities that would bring visitors from the museum to tribal grounds in Aynor, SC. Historical signage would be located at relevant sites. Both tribal youth and local grade school children (1st – 5th grade) will be encouraged to participate in environmental education programs on site such as outdoor labs and nature walks in which a "find the plant" scavenger hunt is a component. The hope is to blend the cultural and the environmental importance of these relatives into a single program to emphasize the wholistic view of people as a part of the natural world and not separate from it.



The Waccamaw Ecological and Cultural Resources Interpretive Trail, a collaboration between the Waccamaw Indian People and Charleston Southern University. The yellowish-green pins represent sign locations.

Interpretive signs such as this one line the Waccamaw Cultural and Ecological Trail. Sign created/photo provided by Dr. Carolyn Dillon, Dr. Katie Stringer Clary, and students Saree Porter and Ashlynn Wydock (Charleston Southern University)

Case Study: Eastern Band of Cherokee Indian Wildlife Action Plan

The Eastern Band of Cherokee Indians (EBCI) / Anikituwagi have a Wildlife Action Plan created using a social-ecological framework. The Tribe has been involved with multiple projects such as the restoration of Eastern Brook Trout, Eastern Hellbender, Giant Rivercane, and spruce-fir forests as well as planting native pollinator habitats. Additionally, EBCI members fluent in the Cherokee language were consulted by academic researchers in the naming of three new salamander species on tribal lands. As part of their Plan, the Tribe has created a list of relatives of concern based on whether they meet the criteria of being culturally or ecologically significant or both. Under the ecological category, the EBCI also include non-native species that have been adopted for cultural purposes (e.g. Japanese Honeysuckle, *Lonicera japonica*, for basket making). However, those non-native species that cause net harm to EBCI natural, cultural, and economic resources are targeted for control (e.g. feral swine and coyotes). Several of these relatives are not found in South Carolina but others are, and these will benefit from a range-wide/ regional approach to conservation. Overall, the goal of the Tribe's Wildlife Action Plan is to maintain biodiversity which in turn maintains their cultural identity through the preservation of their aboriginal homelands. Research and survey on tribal lands informs management of those lands, and monitoring outcomes of those management regimes allows for adaptive management should efforts need to be adjusted due to external changes. [EBCI 2022]

Gullah/Geechee Peoples' Perspective

Along the Coastal Zone of South Carolina live the Gullah/Geechee people, the descendants of slaves of various ethnic backgrounds forcibly removed from their homelands of West and Central Africa, that worked and settled the area in the 1600s. Their unique language, culture, and artwork is a blend of elements taken from early colonial and African sources. Their Nation, formed in 2000 and internationally recognized, is now estimated to number one million people and stretches from Jacksonville, Florida to Jacksonville, North Carolina to 35 miles inland. The associated Gullah/Geechee Cultural Heritage Corridor is a National Heritage Area that was established by the United States Congress in 2006 to recognize and preserve the culture of the Nation. Queen Quet Marquetta L. Goodwine is the Chieftess and Head of State for the Gullah/Geechee Nation. She represents the Gullah/Geechee Nation at local, national, and international venues. Gullah/Geechee culture emerged from the soil of the Sea Islands. Gullah/Geechee people have become a central fixture on the landscape and adopted it and tended it as their own. Part of how their ancestors carved out a cultural landscape was via the rice impoundments they created that have now become critical habitat for a myriad of wildlife species. The slogan of the Gullah/Geechee Sea Island Coalition has been cited around the world: "Hunnuh mus tek cyear de root fa heal de tree." ("You must take care of the root in order to heal the tree"). This mirrors their symbiotic relationship with the environment that provides their traditional food and craft materials. The Gullah/Geechee are known for their sweetgrass basketry (often incorporating bullrush and long leaf pine needle components), storytelling, and their ties to the riverine, estuarine, and marine environments of the lower Coastal Plain and Coastal Zone. They frequently advocate for the restoration of the marsh, oyster reefs, and healthy populations of aquatic species important for subsistence fishing. The Gullah/Geechee are actively involved in surveying their own people to catalogue species of marine organisms that are culturally and socio-economically important to their nation as they are to Indigenous People (tribes). (Gullah/Geechee Nation 2023).

Sweetgrass baskets and photo by Cory Alston.

Case Study: Sweetgrass Plantings at Boone Hall Plantation

Sweetgrass (*Muhlenbergia sericea*) is known only from the southeastern states where it ranges on the Atlantic and Gulf coasts from North Carolina to eastern Texas. In South Carolina it is found in the wild mainly in the Coastal Zone in coastal grasslands and behind beach dunes where it provides shelter and travel corridors for small mammals, birds, and herpetofauna (Siegel and Kenworthy 2023). The plant is important for moisture retention and erosion control which are qualities important for maintaining coastal resilience from storm surges (Siegel and Kenworthy 2023). Threats to Sweetgrass include sea level rise from climate change, competition from other plants, and erosion and destruction associated with coastal development.

Apart from its wildlife habitat benefits, Sweetgrass is valued by the Gullah/Geechee community for use in basketry as they have for some 300 years (Dufault 2013). The baskets are sewn versus woven, a distinction made by the Gullah/Geechee when discussing the methodology used to create these functional works of art. In contrast to the closely-related Hairgrass (*Muhlenbergia capillaris*), and Savanna Hairgrass (*Muhlenbergia expansa*), the length and diameter of sweetgrass leaves and fibers as well as its flexibility make it amenable to basket making. Basket makers seek out "sweet spots" in the wild where they can harvest quality materials in suitable quantities (C. Alston, pers. comm.). Because the species is most frequently found in coastal areas where urbanization is increasing, not only is the plant disappearing from its native habitat but those stands that are left are often privatized so that basket weavers are no longer allowed to gather stems. South Carolina is losing more and more Sweetgrass every year and native stands are quickly becoming rare in the State.

In contrast to the decline of sweetgrass in the wild, the species has become extremely popular as a landscape plant. The reasons for its popularity are many, including very showy pink feathery flower heads, large size, clumping habit, and low maintenance needs. Many ornamental grasses are from other parts of the world and are spreading by seed and becoming invasive pests. This is not the case with sweetgrass which is well behaved where planted and does not spread by seed into artificial landscapes, likely due to seed gemination requirements available only in natural environments.

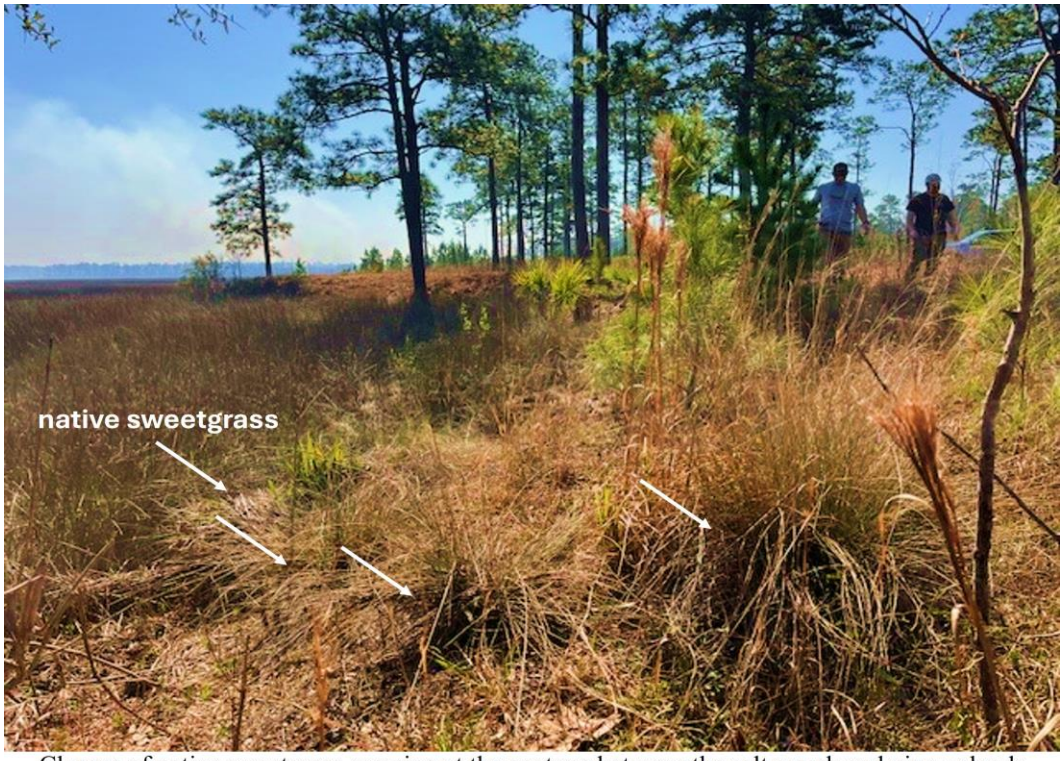
The abundance of sweetgrass in cultivation would at first glance seem to be a benefit to basket makers seeking raw materials. However, these cultivated plants, despite being the same species, do not possess the same quality as wild-harvested plants. This is summarized by Hurley et al. (2013): "The cultivars and management techniques used by landscapers often produce plants that are of marginal quality—difficult to harvest, and less than ideal to work with."

Sweetgrass project at Boone Hall Plantation in Charleston County, SC.
Photo by Anna Smith, SCDNR

This dichotomy between demand for raw materials and the ease with which the species is cultivated has been the subject of much writing and some

experimentation. The problems are discussed exhaustively by Dufault (2013). The author concludes that further experimentation is needed to determine how to cultivate sweetgrass to make it comparable in quality to wild grown sweetgrass. Problems to overcome include unknown reasons for early health declines in cultivated plants, ability to produce leaves with the same sewing qualities as wild plants, fire ant suppression, propagating materials with genetic diversity, and fertility practices.

In an effort to answer critical research questions, Sweetgrass is being grown at Boone Hall Plantation in Mount Pleasant, South Carolina in Charleston County through a collaboration with the basket makers of the local Gullah/Geechee community. *Muhlenbergia sericea* plants from a nursery were brought into the Charleston Place Hotel as part of a Juneteenth cultural exhibit and afterwards transferred to Boone Hall Plantation for this project. These plants have subsequently been divided and additional plots planted. Land managers and a representative from the Gullah/Geechee community have been learning how to get the soil requirements right for the plants to grow with proper flexibility which is critical for basketry use. The nature of this maintenance regime has been coined "benign neglect" by Dufault (2013) which also helps the plants re-adapt to their native soil conditions. The sweetgrass basket community's generational knowledge of the species and quality needs of basket materials is being coupled with available land and farming equipment. This past year, the grass was harvested for the first time and members of the basket artisans community gathered materials. This is an ideal scenario to counter loss of wild populations of a culturally important species that is part of the identity of the Gullah/Geechee people. Lessons learned can be used to reintroduce plants into more natural settings as needed in hummock island and dune systems.



Clumps of native sweetgrass growing at the ecotone between the salt marsh and pine uplands in Jasper County, SC. Photo by Anna H. Smith, SCDNR

Case Study: Living Shorelines and Oyster Reef Restoration Projects

In an interview by the Pew Charitable Trust (2021), Queen Quet explained how the Gullah/Geechee people see themselves as stewards of the salt marshes, maritime forests, oyster reefs, and the diversity of species that inhabit them. These ecologically important areas also provide food and sacred spaces for rejuvenation for the people. Subsistence fishing out of hand-made wooden bateau (flat-bottom boats) for blue crabs, fish, oysters, clams, and shrimp is an important activity as these species are particularly important staples in the Gullah/Geechee diet.

Coastal development, with its wetland destruction, hardscaping, litter, and pollution, is threatening not only wildlife and their sensitive habitats, but also the way-of-life and cultural identity of the Gullah/Geechee people. Sea level rise is eroding maritime forests and marshes that often have nowhere to retreat as they abut urbanization. Ocean acidification is affecting the calcium components of shellfish. Because of their ties to the land and sea, the Gullah/Geechee Nation created the Gullah-Geechee Nation Ocean Action Plan and have been involved in many planning initiatives that impact coastal ecosystems. Examples include the South Atlantic Salt Marsh Initiative and South Carolina Green Infrastructure Plan. The Gullah/Geechee speak for the ocean, to give it a voice, and advocate for Earth Law-based management models. The Earth Law Center defines this as "the idea that ecosystems have the right to exist, thrive, and evolve—and that Nature should be able to defend its rights, just like people can."

Since 2007, the Gullah/Geechee community has been engaged with the SCDNR Marine Resources Division and Clemson University to implement two community-based restoration programs: South Carolina Oyster Recycling and Enhancement Program (SCORE) and Living Shorelines initiative. The SCORE Program utilizes recycled oyster shells donated by citizens and restaurants to create substrates for new oyster reefs along shorelines. Living Shorelines projects include the planting of marsh grasses like Smooth Cordgrass (Spartina alterniflora) to stabilize banks—often behind new oyster reefs—and combat erosion. These projects have helped protect wildlife habitat and people against flooding and storm surge. Queen

Queen Quet places manufactured wired reefs (MWRs) on the shoreline. These MWRs were created by the Gullah/Geechee Fishing Association. Photo by Kwame Sha from Gullah/Geechee Alkebulan Archive.

Quet participated in a NERR Science Collaborative project as a Project Advisory Committee member and helped to allocate more than 9,250 linear feet of oyster resources over the three years of this project. These resources were allocated in target areas such as the ACE Basin and additional areas in Beaufort County and Colleton County. The Gullah/Geechee Nation community has also been involved in constructing oyster reefs at multiple restoration sites over the years and they continue this effort. The Gullah/Geechee Sea Island Coalition has expanded this effort through the "Gullah/Geechee Saving Environmental Action (SEA) & Marine Environment (ME) program." Gullah/Geechee SEA & ME encompasses a number of green infrastructure nature-based solutions to protect the southeastern coastline and thereby keep the Gullah/Geechee coast resilient.

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CHAPTER 8: CONSERVATION OPPORTUNITY AREAS, ACTIONS, AND MONITORING PROGRAMS

Conservation Opportunity Areas

South Carolina's landscape has a variety of habitats across its ecoregions, all of which are necessary to maintain diversity. However, some portions of the landscape score higher on the diversity scale and are therefore prioritized as Conservation Opportunity Areas (COAs). To create the South Carolina COAs map (Figure 8-1), the South Carolina Department of Natural Resources (SCDNR) instituted the first half of North Carolina Heritage Program's (2021) *Procedures for Rating Natural Areas* as a model. It details how each tracked element of occurrence is assigned a collective value 'score' based on its global (G) or subnational/state (S) rank combination (Tables 8-1a & b). For South Carolina, these element records are housed in SCDNR's Natural Heritage Database. Basically, for any unit of area on the ground, SCDNR can intersect data with it and summarize the relative importance that area has for imperiled/critically imperiled species, by summing the cumulative scores for each unique species found within the area. It is not just a sum of all element occurrence records, rather a sum of any unique species if an element for that species is found there to ensure there is no overrepresentation based on duplicate species records. In this case, SCDNR applied this scoring process using intact habitat cores generated by the Green Infrastructure Center. Any core over 100 acres was intersected with known tracked occurrence records and the score summed to assign that core a Collective Value Rank (C-Rank). Cores that ranked as C1, C2, C3, or C4 were determined to be a priority conservation area.

TABLE 8-1a: Scoring Criteria
The most positive scores are in cooler shades.

Collective Value Rating	Cumulative Element Score	Minimum Number of Elements
C1 (Exceptional)	91 and above	10
C2 (Very High)	61-90	7
C3 (High)	31-60	4
C4 (Moderate)	11-30	2
C5 (General)	2 -10	1

TABLE 8-1b: Scoring Criteria
More positive scores are in cooler shades.

G-Rank	S-Rank	Element Score
G1	S1	10
G2	S1	9
G2	S2	8
G3	S1	7
G3	S2	6
G3	S3	5
G4/G5	S1	4
G4/G5	S2	3
G4/G5	S3	2
G4/G5	S4/S5	1

To supplement this data, SCDNR also integrated hubs for regional connectivity identified within the 2023 Southeast Conservation Blueprint, a spatial plan developed by the Southeast Conservation Adaptation Strategy (SECAS) partnership. Using these hubs, which are large patches (~5,000+ acres) of highest priority Blueprint areas and/or protected lands, represent important areas where even though SCDNR may not have specific data for imperiled species, would nonetheless serve as important areas for population movement, gene flow, migration, etc. In addition, more than 2,000 people from over 600 different organizations within the Southeast region have actively participated in developing the Southeast Blueprint and including this information allows our methodology to take advantage of existing regional data that reflects widespread agreement among the conservation community. It also helps ensure that South Carolina's COAs align with its neighboring states that are also using the Blueprint to inform their COAs and contribute to a

wider regional strategy to connect lands and waters. It is important to note that white spaces on the following COA map do not denote areas where SGCN and their habitats are unimportant; rather, these areas are as yet undefined in significance and lower priority at this time.

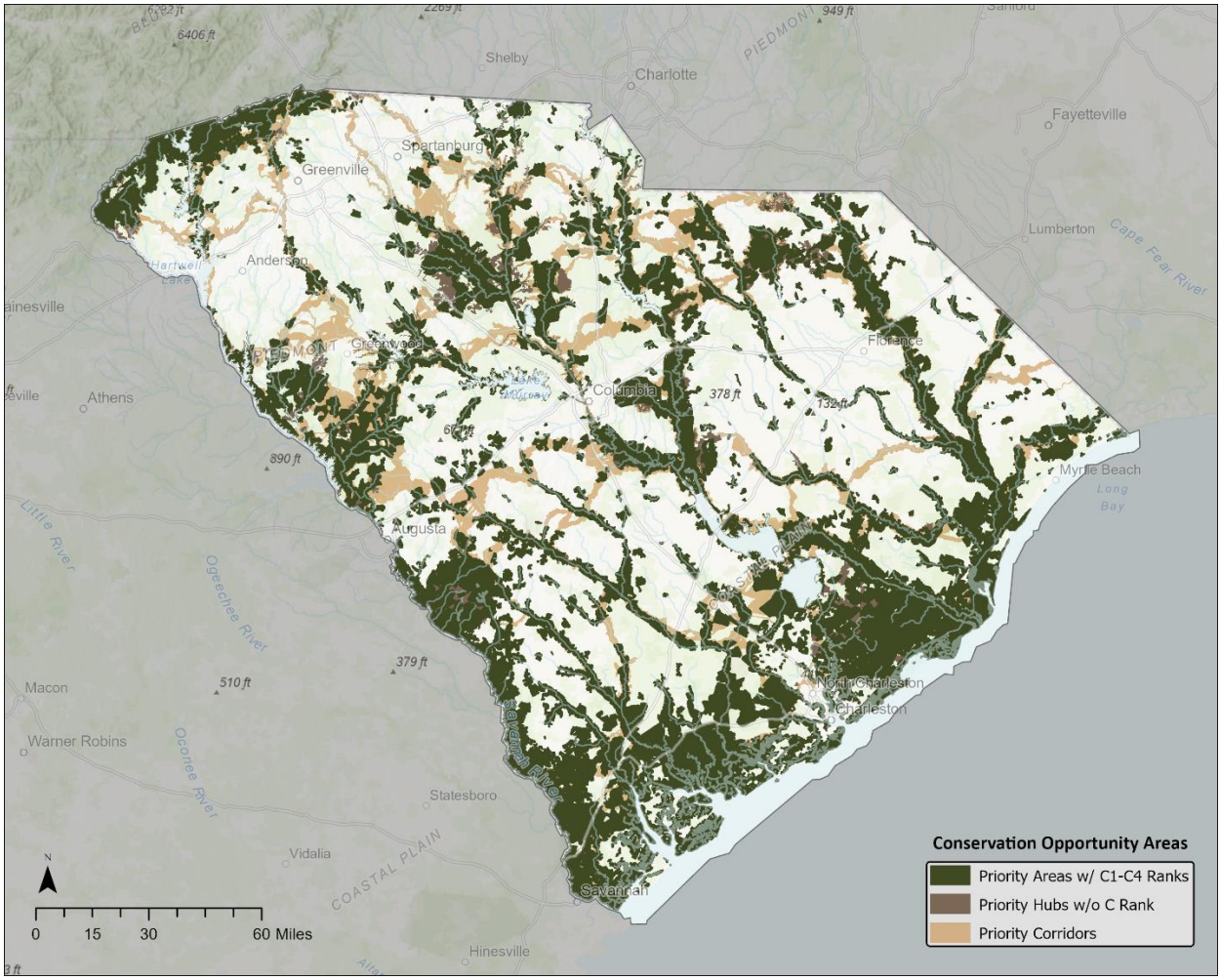


FIGURE 8-1: Conservation Opportunity Areas (COAs) in South Carolina address areas where conservation actions are prioritized to benefit Species of Greatest Conservation Need (SGCN) and their priority habitats. The total percent of the State that is considered any type of COA is slightly under 45%, although the 'core' areas (areas with C1-C4 ranks) are approximately 30% of the State.

Conservation Actions

The magnitude of the threats affecting hundreds of species and their habitats in South Carolina is staggering and constantly increasing. Because time, resources, and funding are limited, not all suggested actions can be initiated, thus making prioritization of conservation actions necessary. Six criteria, developed in 2005 by a steering committee, will still be utilized for this 2025 State Wildlife Action Plan (SWAP) iteration when considering what conservation actions to implement as they are still relevant. These criteria are presented in Box 8-1 in random order. Over the last 20 years, priority conservation actions identified in South Carolina's SWAPs have been attempted and measures of success documented. Ineffective actions have been removed

BOX 8-1: SIX CRITERIA USED FOR DETERMINATION OF 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 can 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.

while new technologies and adaptive management have resulted in new action items for 2025. In some cases, actions were combined with others or updated for relevance in 2025. For this current iteration of the SWAP, conservation partners were consulted about these newest objectives and goals that will be priorities to implement based on these same initial six criteria.

BOX 8-2: SEVEN CONSERVATION ACTION AREAS (CAAS)

1. Land Management
2. Invasive and Non-native Species Control
3. Habitat Protection and Restoration
4. Education and Outreach
5. Partnerships and Collaborations
6. Research and Survey
7. Regulatory Actions

In the first iteration of the SWAP in 2005, Conservation Action Committees created nine Conservation Action Areas (CAAs) with subsequent actions identified under each that followed the tenets of the six criteria for determining conservation actions. These original CAAs have been reworked into seven categories for this 2025 SWAP edition and are outlined in Box 8-2. Action items are addressed for each area of concern. Many of the action items overlap with other categories such as management, partnerships, and education. Unlike previous iterations of the South Carolina SWAP, the action items are not listed in order of importance or prioritized as highest, high, or moderate as all are equally necessary to achieve conservation objectives for Species of Greatest Conservation Need (SGCN) and their habitats. Other states' SWAP connectivity conservation actions were consulted (Hance et al. 2024) and incorporated as relevant to South Carolina.

Conservation Action Area 1: Land Management

As previously stated in Chapter 2, 90% of South Carolina's footprint is privately owned so that there is little authority over habitat conservation and wildlife management on those lands. Local, state and federal agencies that manage land in South Carolina, such as the SCDNR, South Carolina Forestry Commission (SCFC), South Carolina Parks and Tourism (SCPRT), United States Fish and Wildlife Service (USFWS), Department of Defense (DoD), and United States Forest Service (USFS), cannot possibly have a big enough impact with the remaining 10% of the land base under government ownership. Therefore, it is important that SCDNR enlists the

cooperation of private landowners to protect priority species and their habitats. Encouragingly, many citizens in South Carolina recognize the importance of natural resources and the value of these resources for our quality of life. Several programs are currently available to landowners through the SCDNR as well as other state and federal agencies and public and private entities. Despite the number of programs available in South Carolina, the changing urban landscape mandates that new programs are likely necessary. Further, many private landowners are not aware of the current programs available to them.

It will take a combined effort on private and public lands to positively impact South Carolina's land management regimes to benefits aquatic and terrestrial plants and animals. The SCDNR has an excellent working relationship with other public land managers throughout the State, but the conservation goals of these separate agencies may differ, resulting in different conservation strategies and efforts. The SCDNR partners with the Natural Resources Conservation Service (NRCS) to promote Farm Bill incentive programs to private landowners and provide technical assistance. The SCDNR also implements the Red-cockaded Woodpecker (RCW) Conservation Benefit Agreement Program (formerly the Safe Harbor Program) to formally enroll qualifying private lands in a management program to enhance Red-cockaded Woodpecker populations. The SCDNR also works with the USFWS to implement the Partners for Fish and Wildlife Program on various restoration projects on private lands. In order to provide the most efficient management of our priority species and their habitats, it is important to continue and strengthen partnerships between the SCDNR and other agencies.

Longleaf Pine restoration on suitable soils within its native range benefits a suite of species that require this habitat type. Photo provided by the SCFC.

Additionally, urban sprawl needs to be addressed as it is an impediment to land management as it fragments core habitats and blocks travel corridors for wildlife. Yale University (2021) defines urban sprawl as "a form of unplanned urban and suburban development that takes place over a

large area…" with negative impacts to the environment, economy of cities, and society. On average, the SCDNR processes 1,500 annual requests through its automated system for environmental reviews for development projects. This represents a five-fold increase since 2017 (Joe Lemeris, pers. comm.). These reviews are used for varying purposes, including due diligence to understand impacts to potential species on proposed development sites; assessing known species found on or near a property for conservation purposes; assessing potential impacts to species on managed/working forestlands; and as supplemental information provided to permitting/regulatory agencies such as the USFWS, United States Army Corp of Engineers, (USACE), and the South Carolina Department of Environmental Services (SCDES).

SCDNR's Office of Environmental Programs (OEP) is involved in reviewing proposed environmental impacts as published in the regulatory arena and providing science-based comments to help avoid and minimize impacts to the State's natural resources. Staff are involved with the review of 401 Water Quality Certifications and 404 Wetland Fill as part of the Clean Water Act, State and Federal Navigable Water Permits, Mining Permits, National Pollution Discharge Elimination System (NPDES) Permits, hydroelectric facilities and natural gas pipelines under the authority of the Federal Energy Regulatory Commission (FERC), Nuclear Regulatory Commission (NRC) projects, National Environmental Policy Act related projects, and Natural Resource Damage Assessments (NRDAs) related to oil spills and hazardous waste sites. OEP serves to provide official SCDNR comments on these various projects, reviewing and providing comments on an average of approximately 350 projects annually. [Lorianne Riggin, SCDNR, pers. comm.]

Partnerships between wildlife resource professionals and municipalities have resulted in more ecologically friendly comprehensive plans that direct development away from sensitive species and their habitats. Photo by Anna Smith, SCDNR

In 2005, an initial SWAP committee targeting urbanization concerns and consisting of municipal leaders, home builders' associations, academia, land trusts, and other non-profit organizations concluded that opportunities existed for land management and protection by strengthening comprehensive planning through research, enforcement, and public education. Additionally, coordinating the development process between the developer and the local-level stakeholders in a one-stop-shop manner would be helpful. Promoting stormwater management regulations and techniques for impervious surfaces was advised as was developing constructive wetlands education and incentives. They also suggested developing a

higher-level coordination and training program for all levels of government and professionals, including appointed and elected officials. These ideas still need implementing and are included in the action items for this section.

Action Items

1. Develop or expand partnerships with other entities to provide landowner assistance programs that focus on the conservation of priority species, including SGCN, and their habitats.
2. Continue to conduct outreach efforts to private landowners to:
    a. Explain to the public the ecological importance of protecting natural resources on private lands and the benefits of protecting those resources for all citizens of South Carolina.
        i. Explain the importance of protecting natural wetlands for wildlife habitat, storm water storage, etc.
        ii. Explain the importance of preserving areas for coastal marshes to migrate as sea levels rise.
    b. Train and encourage landowners to voluntarily participate in natural resource conservation activities on private properties from backyards to large tracts. Encourage multiple landowners to form cooperatives to better coordinate outreach and education efforts and management at larger scales.
    c. Encourage natural resource stewardship by promoting and encouraging forestry Best Management Practices (BMPs) on private lands but wider Streamside Management Zones (SMZ) such as 300 feet each side of a waterway.
    d. Explain the mission of the SCDNR and the programs conducted by the Department through increased marketing/outreach.
    e. Identify and promote cost share and landowner incentives as they are available.
3. Provide key information about management requirements for SGCN species and habitats in South Carolina to partners responsible for public land management.
4. 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 wetland buffers and corridors on wildlife and habitat
    c. A storm water demonstration project
    d. Nature-based solutions to coastal erosion, such as living shorelines and salt marsh restoration projects
    e. Supplemental/alternative revenue models for private lands, such as hunting and outdoor recreation, that are compatible with wildlife conservation
5. Educate municipalities on the proper way to do tree ordinances, taking into consideration species selection, spacing, and density.
6. Continue to work with partners to manage and protect priority species and their habitats in South Carolina through other agencies' funding programs.
7. Ensure that priority species and their habitats on SCDNR lands are managed in accordance with the conservation actions provided in the SWAP.

8. Engage local chambers of commerce and councils of government (COG) to help recover species through conservation efforts before species become state or federally listed, leading to less economic issues and landowner hindrances.
9. Rank available properties and build habitat corridors between isolated populations of plants and animals across private easements and public lands, also utilizing wildlife crossings where applicable.
10. Nature-based solutions such as "green" infrastructure should be encouraged instead of hardscaping ("gray" infrastructure) where appropriate within the estuarine environment. This includes the use of Living Shorelines, oyster reef restoration (SCORE Program), and others to stabilize banks, rebuild marsh, and act as wave abatement structures.
11. Maintain and enhance natural wetlands (green infrastructure) to serve as floodwater storage and wildlife habitat where appropriate.
12. Artificial reef creation and in-stream fish habitat structures should continue to be encouraged and utilized where appropriate.
13. Complete periodic updates of land use and land cover in the State to help translate threats from species to a habitat scale.
14. Continue statewide aquatic species and habitat monitoring to build out the existing database. Temporal trend analyses will become possible as well as supporting species distribution forecasting in the new Aquatic Planning Tool to support conservation decision-making.
15. Encourage responsible land use planning throughout South Carolina that ensures the protection of natural resources and habitat connectivity. To do this, an urban biologist is needed to collaborate with municipalities and communities to reduce the impacts of development. This can be accomplished by assisting local governments in drafting meaningful sections of comprehensive plans and related documents.
    a. Implementing Best Management Practices
    b. Discouraging development in sensitive habitats used by SGCN
    c. Planning development communities using low impact development, infill, and conservation community design principles by Arendt (2003; 2010) – see Box 8-3 and Literature Cited section
    d. Using passive recreation park design and trail systems, especially with minimal stream crossings
    e. Encouraging counties and municipalities to protect crucial areas through local ordinances, including a Wetlands Protection Ordinance
    f. Greenways and "green space" that also function as wildlife corridors
    g. Creation of a "green growth" manual for municipalities including natural

BOX 8-3: SUBDIVISION DESIGN PRINCIPLES

Conservation subdivision design is a principle whereby a considerable about of buildable uplands are conserved when designing a subdivision. With higher open space ratios comes benefits of protecting wildlife habitat and dispersal corridors, protecting cultural resources, and providing low-impact recreational space for subdivision inhabitants. The overall number of buildings is not necessarily decreased from more traditional designs, but the layout is the key, with designs centered around the most important cultural or ecologically significant resources. Next, a four-step process follows in which (1) primary and secondary conservation areas are mapped out; (2) house sites are selected; (3) streets and trails are drawn in; and (4) lot lines are defined. In conservation subdivision design, green space is the priority. [Arendt 2010]

resource-friendly ordinances and incentives for green growth
   h. Encouraging regular updates (every 5-10 years) of counties' and municipalities' Stormwater Management Plans, Comprehensive Plans, and other related documents
16. Encourage SCDNR staff and partner agencies to provide wildlife/habitat educational information to communities in an accessible and easy-to-understand format. 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 conservation easements.
   d. Collaborate with local governments to develop Best Management Practices (BMPs) for storm water run-off (education, incentives, and awards).
   e. Utilize the Aquatic Planning Tool (*in progress*) for estimating species probability of occurrence and the impacts of development within and among connected watersheds.
17. Research existing federal and state agency plans and partner initiatives to find ways to coordinate objectives and efforts.
18. Continue to participate in the environmental review process for development projects throughout South Carolina.
19. Continue to collaborate with the South Carolina Department of Transportation (SCDOT) to protect priority species and their habitats during the planning/development stage of new projects and infrastructure upgrades such as road construction, bridge and culvert replacement, etc. Direct wildlife mortality should be avoided as much as possible and wildlife movements and structure usage considered. Collaboration would continue as after-project monitoring.
20. Create decision support tools for modeling management of resources.
21. Identify, map, and conserve marsh migration corridors using predictive impact modeling.
22. Conduct scenario planning for landscape changes and subsequent adaptive management strategies in South Carolina starting with lands owned by the SCDNR. Incorporate probable future climate conditions and resulting range shifts into existing management plans for these properties, addressing tipping points (see Powell et al. 2017), the RAD (resist-accept-direct) framework, and desired future conditions.
23. Develop native plant seed banks and increase the demand for growers in South Carolina to prioritize native seed stocks.

Conservation Action Area 2: Invasive and Non-native Species Control

Various sources such as the National Wildlife Federation and the United States Fish and Wildlife Service claim that non-native invasive species are one of the main drivers of extinction along with habitat loss. It is estimated that 42% of threatened and endangered species have been impacted in some way with 18% of those having invasive species as the main cause of their decline (Kurth 2017, USFS 2024). Non-

Regulations enacted in 2021 prohibit the unregistered possession of non-native, invasive Argentine Black-and-White Tegu (or hybrid) and none may be bought, sold or transferred. Photo by Dustin Smith, North Carolina Zoo.

native invasive species negatively impact the environment, economy, and human health so that preventing their establishment and removal when found is critical for reducing threats to biodiversity. A recent study by González-Moreno et al. (2024) found that citizen science platforms like iNaturalist can sound the alarm faster than scientific literature about new incursions. Encouraging citizens to report new species to the SCDNR and USFWS will be helpful in the coming years as will data-mining by agencies and academia for new invasion records.

Action Items

1. Prevent the spread of existing invasive and non-native species, eliminating them where possible.
2. Determine the impacts of invasive and non-native species on South Carolina's SGCN and habitats used by those species.
3. Prevent the importation of additional invasive and non-native species to South Carolina through stricter legislation.
4. Develop and conduct an education and outreach campaign to raise awareness of the impacts of introducing non-native species into South Carolina and how to minimize spread.
5. Create decontamination protocol requirements for state agency equipment operators to reduce the risk of invasive plant species contamination and spread. Encourage Forest Stewardship Council™ (FSC) and Sustainable Forestry Initiative™ (SFI) standards to adopt this same protocol.
6. Create a Strike Team to combat invasive species on state-owned lands. This team can also assist dedicated prescribed burning teams during other seasons.
7. Continue to encourage conservation partners and the general public to report invasive species sightings (plants, animals, insects, diseases) on the SCDNR EDDMapS reporting page and other platforms.

An airboat is utilized to treat non-native, invasive Phragmites with herbicide in the Coastal Plain of South Carolina. Photo provided by Jamie Dozier, SCDNR.

8. Continue to data-mine sites such as iNaturalist for new invasion records.
9. Continue and develop new partnerships with other entities in South Carolina to address impacts associated with invasive and non-native species.
10. Continue to actively engage with the Gulf and South Atlantic Regional Panel on Aquatic Invasive Species (AIS), a regional panel covering North Carolina to Texas that reports to the Aquatic Nuisance Species Task Force and which facilitates communicates among states about emerging threats from AIS.
11. Encourage SCDOT to use appropriate native plant seed mixes post-construction where applicable.

Conservation Action Area 3: Habitat Protection and Restoration

Loss and fragmentation of habitat are major threats to many of the species included in South Carolina's SWAP. Habitat protection has been identified as one of the most important actions to assist in the protection of South Carolina's priority species, including SCGN, and their habitats by SCDNR biologists, species experts, and conservation partners. The importance that the SCDNR places on habitat protection for the benefit of South Carolina's wildlife is evident in the many programs currently in place at the SCDNR and in the partnerships SCDNR has forged with other state and federal agencies, organizations, academic institutions, and industries. It also remains the number one priority of the SCDNR Board per Resolution 101 (updated July 1, 2004). By focusing on whole habitats or ecosystems, SCDNR and its partners can protect species assemblages and in a more cost-effective manner.

The SCDNR is a member of the **SC Land Trust 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. Land trusts often act as intermediaries in land transactions which then are transferred to state agencies capable of managing the properties. Land trusts also hold easements on private lands which often provide critical linkages to state-owned conservation lands.

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 but conservation easements are also extremely beneficial for habitat protection. SCDNR continues to implement the national and state versions of the "30 by 30 Initiative" through its conservation land acquisition process and subsequent restoration on those lands. It is imperative that the SCDNR continue to partner with other agencies and organizations to acquire and manage lands that are available for conservation. A 2023 Statewide Sustainability Survey found that 81.3% of respondents supported land conservation with 75.6% supporting using state dollars to match federal and private sector funds to do conservation work (Sustain SC 2024).

Agency management obligations for large financial conservation acquisitions must be evaluated through a process developed and maintained by the Habitat Protection Committee (HPC). Potential properties must be considered suitable for protecting natural resources or meeting the mission and vision of the agency. The SCDNR has an evaluation process through the HPC that uses criteria to rank potential properties. These criteria include, in no rank order, the following:

1. Fish and Wildlife Habitat
2. Rare, Threatened or Endangered Species
3. Archaeological, Cultural and Historic Resources
4. Geologic Features
5. Riparian and Water Values
6. Public Recreation Potential
7. Imminent Threat of Conversion
8. Manageability
9. Forest Revenue Sustainability
10. Other Special Circumstances; Funding Stream Identification

Purchase of property by the SCDNR with public funds are subject to the Uniform

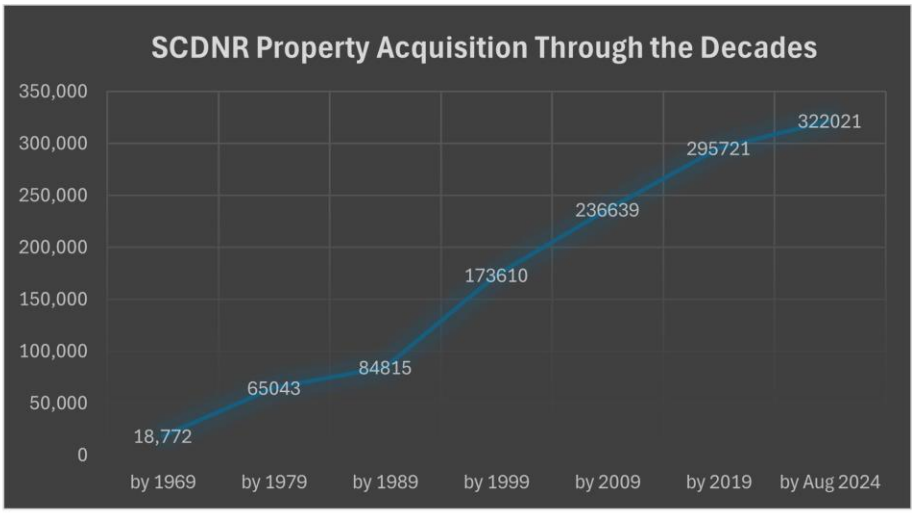


FIGURE: 8-2: Acres acquired by SCDNR from the beginning of active land acquisition to present.

SCDNR has restored wetlands embedded within longleaf pines while simultaneously improving those longleaf stands to benefit species requiring this buffer habitat for various phases in their life history. The left photo shows an isolated wetland in Hampton County, SC pre-restoration, and that same wetland is shown above post-restoration. Photos provided by Andrew Grosse, SCDNR.

Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. § 4601, et seq.) and the South Carolina Relocation Assistance Act (S.C. Code § 28-11-10, et seq. (1976, as amended)). Over the decades, the acreage of state-owned lands has increased dramatically (Figure 8-2), thanks in part to long-standing local, state, and federal grant programs and initiatives, some of which are outlined in Box 8-4. Many other funding sources include time-limited grant initiatives and mitigation assistance.

The 3R's of conservation biology should be considered when evaluating tracts for habitats and SGCN: resiliency, redundancy, and representation. Even if the SCDNR or its partners do not own lands, there are ways of protecting habitats. Coordination of wildlife goals and strategies during land planning processes and the ability of SCDNR to review development and environmental impact plans for relevance to priority species can also assist in protecting habitats. An ever-present theme throughout the SWAP, education and outreach is imperative in the protection of the State's habitats.

A barge carries oyster shells to a Living Shorelines restoration project in South Carolina. Photo by SCDNR-MRD/MRRI staff.

Oyster reef restoration in coastal South Carolina. Photo provided by Michael Hodges, SCDNR.

BOX 8-4: POPULAR FUNDING PROGRAMS UTILIZED FOR LAND PROTECTION & RESTORATION

- **SC Heritage Trust Program**: The purpose of this program is to inventory, evaluate, and protect the elements considered the most outstanding representatives of South Carolina's natural and cultural heritage. Funding for Heritage Trust staff, land purchases, and management activities comes from a small percentage of the State documentary deed stamp fee, the sale of Endangered Species License Tags, limited appropriated funds, plus monetary donations from the public. Land donations are also accepted.
- **US Forest Service Forest Legacy Program**: The purpose of this program is to identify and protect environmentally important forest land from conversion to non-forest uses through the use of conservation easements and fee-simple purchases.
- **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.
- **South Carolina Conservation Bank Act**: This act preserves the most significant natural and historic lands in our state by either purchasing the land outright or buying conservation easements from willing sellers. Dedicated funding is provided for the protection of wildlife habitat, parks, greenways, prime farmlands, historic sites, wildlife habitat, and other biologically sensitive areas in the State. Funds come from a percentage of South Carolina's deed-recording fees, which are collected when real estate is sold in the State. A volunteer board made up of conservationists, sportsmen, scientists, and business leaders from across the State oversee the disbursement of grants to protect land. The SCDNR acts as an advisor to this Board.
- **National Estuarine Research Reserve Grant Programs**: Administered by the National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA), Department of Commerce, the goals of the programs are to protect and restore ecologically significant habitats, including conserving lands that play a critical role in helping communities become more resilient to natural hazards. The focus is on coastal habitat restoration through planning, engineering, and design and land conservation projects that support the goals and intent of the Coastal Zone Management Act (CZMA), the Coastal and Estuarine Land Conservation Program (CELCP), and the Infrastructure Investment and Jobs Act, Public Law 117-58. Land acquisitions or easements must be within the reserve boundary, but some outside projects are allowed. However, projects outside the reserve boundary must benefit the reserve, its habitats, and its ecosystem.
- **National Coastal Wetlands Conservation Grant Program:** This US Fish and Wildlife Service program aids in acquiring interests in lands or waters that enhance, restore, or manage coastal wetlands ecosystems and associated uplands. The project has to lie within a coastal county (touches the ocean) or one county in from a coastal county as long as there is a hydrological connection. Highest ranked areas are maritime forests and sea islands. The Program is funded by revenues collected from excise taxes on sport fishing equipment, electric motors and sonar, import duties on fishing tackle, yachts and pleasure craft, a portion of the gasoline tax attributable to motorboats and small engines, and interest on the fund, under the authority of the Dingell-Johnson Sport Fish Restoration Act of 1950.
- **North American Wetlands Conservation Act (NAWCA):** Administered by the US Fish and Wildlife Service, this program supports conservation of wetlands and associated habitats for wetland migratory birds, like waterfowl, and other wildlife. Land can either be acquired (protected in perpetuity) or enhanced or restored (20-year life).
- **Pittman-Robertson Restoration Program:** This US Fish and Wildlife Service program supports restoration and management of bird and mammal populations and provides public use opportunities and hunter safety programs including shooting ranges. Eligible projects include those that select, restore, rehabilitate, and improve areas of land or water used as feeding, resting, or breeding habitat.
- **Recovery Land Acquisition Grant Program:** This US Fish and Wildlife Service program supports the acquisition of habitat for endangered and threatened species to secure long-term protection.
- **REPI Program:** This Department of Defense program has Challenge funds available for "land conservation, improvement, or management activities that limit incompatible development in the vicinity of DoD installations and ranges and enhance military installation resilience," among other options.

Action Items

1. Acquire property for the protection of priority species and to ensure habitat linkage through fee-simple acquisition and conservation easements covering all priority terrestrial, freshwater aquatic, estuarine, and marine habitats.
2. Continue to partner with private entities and other state and federal agencies and tribes to both promote habitat protection (including utilizing private easements) and provide technical support to private landowners.
3. Continue to partner with private entities and other state and federal agencies and tribes to acquire land for habitat protection. Develop additional partnerships for land acquisition.
4. 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 through dam removal, culvert modification, etc.
    d. Eliminate or reduce invasive and non-native species from habitats
    e. Replant native plants; encourage Piedmont Prairie and other native grassland projects
    f. Engage in wetland restoration and explore new techniques, such as the beneficial use of dredge material and thin layer placement.
    g. Restore ecotones (contiguous gradients) into adjacent habitats.
    h. Encouraging natural solutions to marine environments such as living shorelines versus man-made hardscaping.
5. Create more conservation incentives for private landowners, like cost share programs and Candidate Conservation Agreements with Assurances (CCAAs), to preserve or restore habitats important for SGCN.
6. Utilize federal and non-federal grant sources to purchase land fee-simple to add to South Carolina's portfolio of quality examples of both common and priority habitats to benefit SGCN and biodiversity in general.
7. Strongly encourage solar farming on brownfields, on building rooftops, near existing infrastructure (powerlines), non-prime farmlands, and in areas that are less environmentally sensitive.
8. Develop and implement protective Best Management Practices (BMPs) for habitats and land uses throughout South Carolina (e.g. pollinator habitat on solar farms) and wide SMZs (300 feet on either side of a waterway).
9. Continue to participate in the development and review of environmental plans (including FERC relicensing projects) to ensure appropriate habitat protection.
10. Educate owners and/or managers of ponds and lakes (e.g. private landowners, homeowner associations, municipalities, hydroelectric power companies, and watershed entities) about pond and lakeshore management utilizing native plants and shrubs and enhancing aquatic habitat through structure placement. Explain the ecosystem services and habitat provided by this natural infrastructure.
11. Educate landowners about proper stream crossings and fencing to keep livestock out of streams.

12. Encourage city, county and state planning entities to consider habitat protection in all comprehensive planning documents and when reviewing development projects and rezoning requests.
13. Where possible, collaborate with neighboring states to manage wildlife species and promote habitat protection on an ecoregions-wide and/or watershed-wide scale.
14. Continue SCDNR participation in Emergency Response training programs to ensure that the SCDNR has the most current information on planning logistics and technology for dealing with coastal oil and hazardous material releases, natural disasters, and emergency disease outbreaks as well as the most effective tools and training to deal with the aftermath.

Conservation Action Area 4: 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. As the State's population increases, it is important to remind the public that healthy ecosystems are those with intact biodiversity, and these healthy ecosystems provide environmental services humans need too (Hayes and Kunkel 2025). The concept of One Health (AFWA 2023) can help people envision the interconnectedness of wildlife, habitats, and themselves that also impacts the economy. 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.

The South Carolina SWAP is an integral part of many grade school presentations, teaching students about the conservation challenges facing many species in the State. Photo by Anna Smith, SCDNR. Wood Stork mount permitted through USFWS. Alligator skull permitted through SCDNR.

Although education and outreach may not directly contribute to the management of natural resources, these programs can assist in garnering support for environmental programs. Also, training workshops and online presentations can train lay persons to be valuable contributors to data collection efforts. Already, the SCDNR encourages the general public to report the tracked species using online Public Survey Forms (Survey123 app): Tracked Species Reporting, Spawning Horseshoe Crab Reporting, Baltimore Oriole Winter Survey, Diamondback Terrapin Reporting, Bald Eagle Nest Sighting, Manatee Sighting, Sea Turtle Observation, Ruffed Grouse

Observation, SCDNR Bat Watch!, Spotted Skunk Observation, Bobwhite Quail Observation, and Black Bear Sighting.

GatorWise

GatorWise is a project intended to promote realistic public perceptions about alligators and to provide guidance on responsible human behavior to minimize conflict between people and alligators. It is a collaborative project with members of 11 different state fish and wildlife agencies across the range of the American Alligator. See www.gatorwise.org.

In educating the general public, SCDNR's social media goals are to build trust in the agency and science, to educate and inform, to promote events and programs, and to instill stewardship and awe in the State's natural resources (Erin Weeks, SCDNR, pers. comm.). SCDNR currently has 50,000 subscribers to its award-winning *South Carolina Wildlife Magazine* which often highlights SWAP species and habitats. The associated 2026 calendar will cover SWAP species from all taxa groups. Recent examples include articles on Gopher Tortoise and Gopher Frog habitat restoration and augmentation. The Coastal Updates Newsletter has 100,000 subscribers while the Jocassee Journal has 3,311 (print and online). SCDNR's YouTube Channel has a variety of educational videos. A current partnership exists with South Carolina Educational Television (SC ETV), state network of the Public Broadcasting System (PBS) member stations, to create short video segments highlighting SGCN and their habitats as well as threats affecting them. For example, the Emmy Award winning series, "What's Wild" showcases native species in South Carolina, especially rare or declining species appearing in the SWAP. Sample episodes include: Four-toed Salamanders, Gopher Frogs , Gopher Tortoises, Carolina Heelsplitters, and Freshwater Fish Assemblages.

These programs, as well as social media posts (i.e. Facebook, You-Tube, and Instagram), are vital outreach components to citizens. SCDNR also has an active Community Engagement Program providing outreach to Hispanic and African American communities that can be expanded to include SWAP/SGCN education and appreciation.

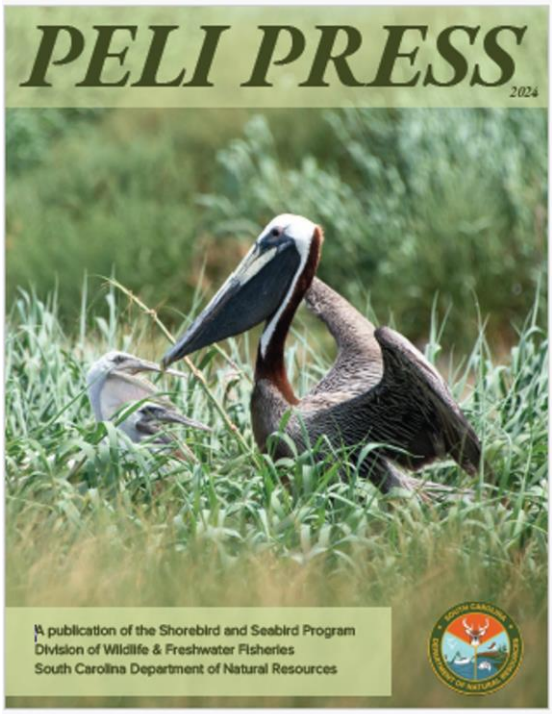
Outreach with interns showing them freshwater mussel propagation. Photo by Ericah Beason, SCDNR.

In educating developers, regulatory agencies, and environmental consultants, SCDNR created the South Carolina Department of Natural Resources State Listed Species Protection Guidance (2024). The purpose of this living document is to provide clarity for the avoidance of a take of a state listed species and what may be needed from permit applicants.

Private forest landowners benefit from workshops and demonstration areas. A recent example is the November 2024 "Managing Isolated Wetlands for Wildlife" workshop at Webb Wildlife Center in Hampton County, SC. Conservation partners including The Longleaf Alliance, SCDNR, USFWS, UGA Savannah River Ecology Lab, and the Amphibian and Reptile Conservancy provided a field tour to educate landowners on the benefits of isolated wetlands for wildlife, using prescribed fire to manage isolated wetlands in upland pine forests, how to do midstory control, and how to implement other restoration techniques.

Action Items

1. Develop and enhance education and outreach programs to the public and partners 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 the State. Highlight threats and opportunities. Programs could be in the form of seminar series, workshops, and training opportunities in the field.
2. Dispel misinformation and ensure that accurate information about priority species and their habitats is made available, both within the SCDNR and to any interested parties outside of the department. (Interested parties can include state and federal agencies, academic institutions, private landowners, local municipalities, organizations and industry.)



One of the publications SCDNR produces for education and outreach purposes, explaining what the agency does for SGCN.

3. Develop and enhance education and outreach programs that encourage land stewardship values, particularly to private landowners in priority habitats on private lands. Program components should include forestry and wildlife best management practices and the importance of using prescribed fire on pyric landscapes.
4. Introduce conservation partners to the SWAP and train them on the identification of SGCN and their habitat requirements. These partners can integrate this knowledge into their knowledge toolbox when working on their own lands and projects and when providing consultation services to private landowners and the general public.
5. In consultation with SCDNR biologists, identify "poster species" and habitats 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.
6. Provide seminar series, workshops, and other training opportunities for citizen scientists and volunteers to implement elements of the SWAP such as data collection

of presence/absence of species (including non-natives) and status and trends monitoring.

7. Create fact sheets ("mini-plans") and summaries to target user groups of the SWAP.
8. Support "Bat Week" and other taxa group highlights in South Carolina.
9. Provide lesson plans or updates to education curricula for K-12 students on SGCN life histories, threats, and ways to mitigate for those threats.
10. Continue to reach out to underserved communities with relevant messaging about natural resource conservation concepts; expand to include SWAP/SGCN education and appreciation.
11. Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
12. Educate the public and lawmakers on the illegal wildlife trade and its implications for conservation (AFWA 2025).
13. Continue to develop and enhance programs that educate fishermen about employing correct techniques for capture and release of marine mammals, fish, and invertebrates and programs that emphasize the importance of reporting ship strikes and entanglements to authorities.
14. Using education, outreach, and regulatory actions, mitigate habitat and species threats that are caused by human practices—albeit sometimes unintentional—such as entanglement in fishing gear, by-catch, boat strikes, dredging, chemical exposure, tower strikes, electrocutions, window strikes, nest disturbance, boat wakes, artificial light sources, and dewatering of streams.
15. Provide workshops and demonstrations of freshwater stream, lake, and pond stabilization and erosion control techniques.
16. Develop planned coordination and response protocols among agencies and organizations for emergency disease outbreak preparedness, response, and prevention.
17. Educate the public and lawmakers on the many benefits that salt marshes and other wetlands provide and best practices for enhancing existing marshes and future marsh migration areas.

Coordination with state museums for voucher freshwater mussel storage. From left to right: Jeff Smola (SCDNR), Dr. Art Bogan (North Carolina Museum of Natural Science), Briana Cairco (SCDNR), and Braxton Elms (SCDNR). Photo by Ericah Beason, SCDNR.

Conservation Action Area 5: Partnerships and Collaborations

As previously discussed, 90% of South Carolina is privately owned, making cooperation with private landowners critical to accomplish large conservation management objectives at a landscape scale. Also as important is collaborations with partners from other agencies, non-governmental organizations (NGOs), wildlife clubs, and other groups that can assist with surveys, procuring land acquisitions and conservation easements, and affecting political change to benefit SGCN and their habitats. SCDNR and its conservation partners benefit from knowledge sharing and leveraging resources to accomplish more than any single entity could alone. Sometimes NGOs can act as mediators between stakeholder groups, reconciling differences and facilitating changes on a larger scale and more quickly than SCDNR could as a state agency. New alliances should always be sought while continuing to strengthen existing relationships. A list of SCDNR's current conservation partners can be found in Appendix 2.

Action Items

1. Coordinate monitoring efforts across scales and jurisdictions through partnerships, considering incorporating international conservation in order to capture full life cycles.
2. Maintain participation in monitoring networks as established between states and other agencies.
3. Partner with SCDOT in the use of signage and caution lights to warn motorists to reduce speeds or use caution in areas where wildlife may be crossing, especially during specific times of the year.
4. Create a working group of agencies that identify priority areas for fish and wildlife crossing improvements based on crash data, roadkill counts, aquatic and terrestrial habitat connectivity priorities, barriers to marsh migration, etc. Include the SC Office of Resilience for priority areas where floodwaters may necessitate road/bridge/culvert improvements.
5. Partner with SCDOT to design and construct warning systems and wildlife and fish crossings/overpasses or underpasses/tunnels/culverts with fencing and native habitat components to guide fish wildlife and fish over and under roads to avoid mortality, to promote terrestrial and aquatic connectivity, and to maintain biodiversity across the landscape.
6. Partner with SCDOT and utility companies to implement no-mowing during critical growing and seeding phases for native plants along transportation corridors and roadsides.
7. Partner with the South Carolina Department of Environmental Services (SCDES) to update mining reclamation guidelines to better provide for wildlife habitat, especially grassland-dependent species.
8. Develop a network of partners and a corresponding confiscation response plan which identifies funding sources, protocols, and holding facilities for wildlife confiscations. Disease testing, genetic testing, and post-release monitoring should be part of this network. [AFWA 2025]
9. Maintain participation in monitoring networks as established between states and internationally for wide-ranging and migratory species.

10. Partner with climate science centers to identify ways to collect data that tracks local effects and impacts (downscaling of global climate models). Climate modeling and data-gathering methodologies should be standardized. Additionally, a centralized climate repository should be created with data and tools to support decision making by the SCDNR and its conservation partners.
11. Collaborate with neighboring states to address species and habitat range shifts due to climate change.
12. Continue to participate in national workshops and meetings that discuss adaptive management techniques as it relates to our changing world and network with colleagues and partners.
13. Foster partnerships within the State, region, and nationwide to address climate change in South Carolina.
14. Reinvigorate the South Carolina Plant Conservation Alliance.
15. Continue to engage in regional partnerships (e.g. the South Atlantic Salt Marsh Initiative) to share lessons learned and expand and increase the efficiency of habitat protection and restoration efforts.

Conservation Action Area 6: Research and Surveys

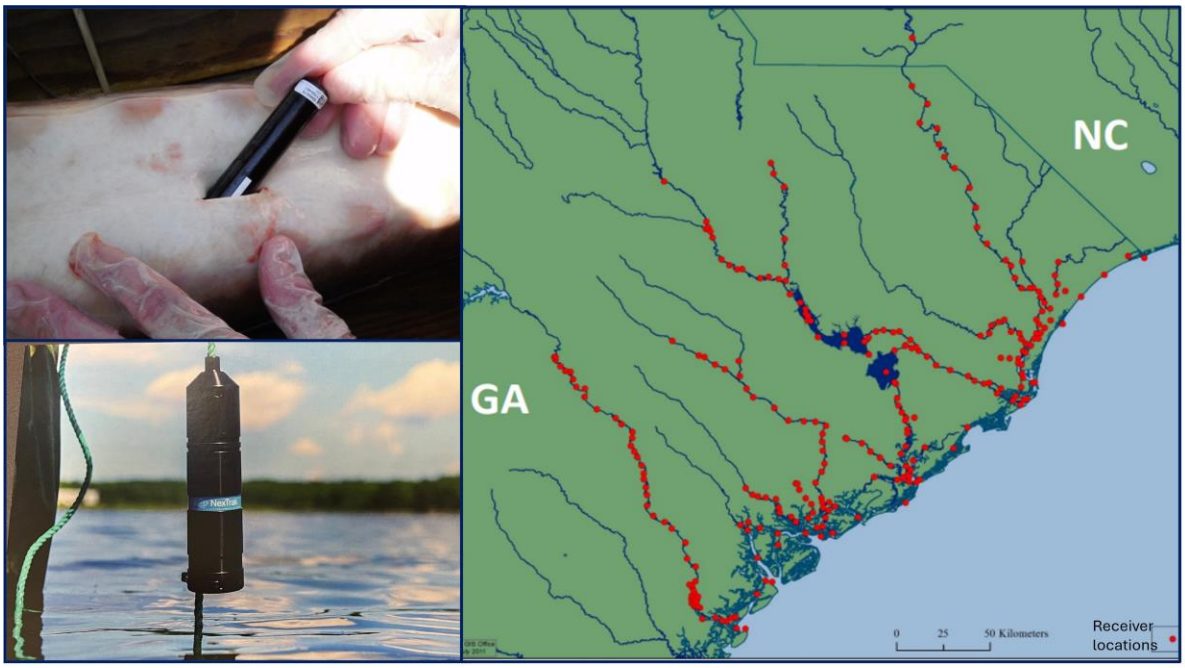
When preparation of South Carolina's first SWAP was initiated in 2004, it quickly became apparent that SCDNR and other entities were lacking data for many of the priority species and their habitats. It is still that way in 2025 with some species. Historically, research and survey activities have focused on managed species, federally or state listed species, and activities funded through grants and private dollars. In order to adequately manage for priority species in South Carolina, it is imperative that baseline research continue to be conducted for these species in partnership with academic institutions (e.g. Masters and PhD student projects), other state and federal agencies, non-profit organizations, and private consultants. Within this chapter of the SWAP, the monitoring section specifically addresses survey and research needs as they apply to SGCN. The conservation actions items below in bullet form, however, are presented to illustrate the type of information that needs to be gathered.

Collecting Gopher Frog (SGCN Highest) eggs for a cooperative head-start program with Riverbanks Zoo. Photo by Anna Smith, SCDNR

<u>Action Items</u>

1. Conduct field studies to inventory all plant and animal species on SCDNR-owned lands as well as collect abiotic information relevant to the species' aquatic and terrestrial ecosystems. Determine population presence and stability.

2. Partner with private landowners, Tribal entities, timber investment management organizations (TIMOs), and timber companies with substantial landholdings in South Carolina to survey for SGCN through biological inventories.
3. Work with academic and other partners to address emerging diseases through surveillance and research, including determining causes of death and/or population declines in SGCN.
4. Train partners to assist with element occurrence documentation for SGCN and other tracked species for entry into South Carolina's Natural Heritage Database.
5. Develop and implement DNA studies on new and previously identified species to clarify taxonomy of SGCN (species assignment and evolutionary lineage), distinct population segments, and gene flow.
6. Contribute to genetic databases and gene libraries for identifying SGCN' origination and to improve accuracy and reduce costs and time associated with repatriating confiscated animals and identifying poaching hotspots (AFWA 2025).
7. Museum records and online databases should be mined for relevant species data to incorporate into the South Carolina Natural Heritage Database.
8. Monitor the condition of SGCN populations and their choice habitat as discovered.
9. Determine the impacts of threats and stressors identified in Chapter 5 on South Carolina's SGCN.
10. Conduct research to identify the habitat requirements for South Carolina's priority species and determine whether existing habitats meet those requirements.



Atlantic and Shortnose Sturgeon (SGCN Highest) research using data-logging receivers in acoustic telemetry arrays in South Carolina rivers. Photos provided by Bill Post, SCDNR.

11. Add to the State's MOTUS tower array to track migratory birds and bats.
12. Determine the effects of plant and animal invasive and non-native species (including diseases) on South Carolina's priority species and their habitats.

13. Monitor the impacts of hunting/fishing on South Carolina's priority species to ensure that populations are being harvested sustainably and impact to non-hunted species are minimized.
14. Identify ways to collect data that tracts local effects and impacts from climate change (downscaling of global climate models).
15. Conduct climate-related monitoring of species and habitats as needed. Run species- or habitat-based vulnerability index assessments as needed for SGCN.
16. Mobilize citizen scientists to gather data by conducting surveys and reporting sightings.
17. Acquire better special data through remote sensing and ground-truthing to identify priority habitats/natural communities.
18. Continue to and increase mapping long distance migratory movements and habitat use by SGCN.

Conservation Action Area 7: Regulatory Actions

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

New laws, such as those addressing the regulation of harvest limits (e.g. Blue Crab), prohibition of take (e.g. Robust Redhorse), and native species ownership (e.g. see Turtle Registration), have all helped protect SGCN within South Carolina. However, more laws are needed to protect other vulnerable species. As SCDNR biologists and other experts prepared species accounts for this edition of the SWAP, they identified areas where existing laws and regulations may need to be changed in order to protect additional priority species and habitats (e.g. see current SC Code §16-11-590 on Sea Oat and Venus Flytrap protections). They also identified areas for which no laws or regulatory authority exists to protect these species.

On September 28, 2020, bill H.4831 was signed into law by SC Governor Henry McMaster establishing possession limits for native turtles in South Carolina and restricting transfers and sale. Photo by SCDNR media staff.

In addition, our Law Enforcement Division undergoes basic wildlife management training as it relates to their job. Course instruction covers upland game and fish rules and regulations as well

as non-game regulatory authority; wildlife diseases; snake, tree, and grain identification; depredation permitting; trapper education; marine regulations (i.e. TEDs for shrimp trawl nets); and why certain practices are illegal as well as the biological basis behind South Carolina's Title 50 laws.

Action Items

1. Enhance SCDNR Law Enforcement capability to address priority wildlife species law enforcement needs through:
    a. Increase support, capacity, and training (workshops) for new hires and current staff on SGCN and their habitat requirements and how to protect them.
    b. Provide law enforcement training on handling, identification, biosecurity, and other best practices to more effectively respond to illegal collection and trade cases of SGCN (AFWA 2025).
    c. Providing financial and capacity support to Law Enforcement for monitoring sensitive sites.
2. Pass legislation making it illegal to import, sell, stock, release, and transplant specific non-native animal and plant species throughout South Carolina without a permit issued by the SCDNR.
3. Pass legislation to encompass more SGCN protected from collection from the wild.
4. Pass legislation that allows for managing/monitoring captive wildlife in South Carolina.

Illegal collecting and poaching of wildlife and plants are threats to SGCN in South Carolina, often requiring intervention by law enforcement. Photo by SCW Staff.

5. Pass legislation at the state and local levels for the protection of wetlands which would limit such practices as "fill and build" in wetland habitats.
6. Increase restrictions for sensitive ecological sites (e.g. public closures, no pets allowed, etc. on shorebird nesting beaches).
7. Encourage the adoption by the State of South Carolina of a circular economy in state government where waste is reduced, reused, and recycled to decrease waste of resources to protect the environment and drive the economy (Sustain SC 2025).
8. Continue to develop State of the Resource Reports for marine species that are not currently targeted in commercial or recreational fisheries and for species that are targeted, but for which no plan currently exists. This will inform limits and other protection measures for priority species, including SGCN.
9. Investigate the need to amend existing SCDNR regulations and/or develop additional SCDNR regulations to address the conservation status of South Carolina's priority species.

10. Work with the SCDES on permitting regulations in favor of priority species and habitats.
11. Continue to assist the USFWS with data gathering to make informed, science-based decisions on listings, down-listings, and de-listings.
12. Educate members of the South Carolina Legislature and Congressional delegates on the plight of SGCN and their habitats and the importance of increased, dedicated, permanent funding for SWAP implementation through workshops, presentations, and field trips.

> "South Carolina's future prosperity requires us to enhance our efforts to respect and protect our land, our history, our culture and our environment."
> – SC Governor Henry McMaster

In summary, 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.

Native wildlife are not pets! Photo by Anna Smith, SCDNR.

Monitoring Programs

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

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

become the essential tools for detecting, measuring, interpreting, and responding to these changes over time.

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

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

The SCDNR and its partners use peer-reviewed protocols when conducting current monitoring programs. The following four types of monitoring programs are commonly implemented:

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.

Additionally, Box 8-5 defines the elements important to consider when designing new monitoring programs. More generally, the outcomes of research and survey projects affecting SGCN and their habitats, as well as the effectiveness of SWAP action items implemented, are also regularly monitored by the SCDNR. Management decisions and methods are thus informed by such research. Table 8-2 lists all current long-term monitoring programs in progress within the State of South Carolina for which SCDNR participates. There are other short-term monitoring programs in progress at SCDNR and with conservation partners, but these are not discussed here as they often end with the conclusion of a project. As an example of being adaptive, SCDNR conducted over 1,250 Furbearer Scent Station Routes statewide annually from 1984-2014 until research uncovered that these survey routes could be biased, especially since they were opportunistic along roadways. As rural landscapes became urbanized, routes became compromised and unusable. Other similar

BOX 8-5: BASIC ELEMENTS OF A MONITORING PROJECT AND PROGRAM

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

studies have been discontinued as methodologies and needs have become obsolete or have been incorporated into other monitoring regimes. A long-term study example includes the comprehensive hunter harvest surveys that have been conducted for all species in South Carolina periodically since 1963, 15 surveys span 55 years.

Measuring conservation outcomes is extremely important to make sure the species intended to prosper under restoration regimes are actually responding and thriving (Binley et al. 2025). Measuring such outcomes as changes in average physical fitness or population growth are much-needed follow-up metrics that should be gathered (Binley et al. 2025). However, sometimes it takes decades to see results so that researchers must have the funds and capacity to collect trend data over time. Examples of conservation practices that are typically used to elicit positive responses by threatened or endangered species include modified agricultural practices (leaving wild edges along crop edges) and alternative forestry and prescribed fire regimes. Often, less charismatic species are not followed as diligently (Binley et al. 2025), but this is where SWAP-related research and surveys are so important in following these lesser known or appreciated plants and animals.

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Table 8-2: Current Monitoring Programs that Include South Carolina Coverage. This table is arranged by topic and then alphabetically within those topics. Blank spaces mean N/A. [Abbreviations are as follows: SCDNR= South Carolina Department of Natural Resources, WFF= Wildlife and Freshwater Fisheries, MRD= Marine Resources Division SCFC= South Carolina Forestry Commission, SCPRT= South Carolina Parks Recreation and Tourism, USFS= United States Forest Service, USFWS=United States Fish and Wildlife Service, NOS= National Ocean Service, NOAA=National Oceanic and Atmospheric Administration, NMFS= National Marine Fisheries Services, DoD= Department of Defense, SCDHEC= South Carolina Department of Health and Environmental Control, SCDES= South Carolina Department of Environmental Services, SCEPA= South Carolina Environmental Protection Agency, ASMFC= Atlantic States Marine Fisheries Commission]

Name of Program	Coordinating Agency	Contact	Participating Partners	Extent of Coverage & Timing	Affected Species
HABITAT ASSESSMENTS (terrestrial and aquatic)					
Carolina Coastal Ocean Observing and Prediction System (CaroCOOPS)	University of South Carolina (USC), North Carolina State University	Madilyn Fletcher, USC	NOAA, USC, UNC-W	North Carolina to South Carolina from beach to shelf break	Oceanographic data from an instrumented array of coastal and offshore moorings used to monitor and model estuarine and coastal ocean conditions as well as develop predictive tools and ultimately forecasts (storm surge models, water quality and transport of pollutants, sediment transport and shoreline stability, and the state of the fisheries)
Habitat Assessments for Wintering Waterfowl	SCDNR	Molly Kneece, SCDNR-WFF		Bear Island, Beaver Dam Creek, Bonneau Ferry, Broad River, Clemson, Donnelley, Love Farm, Samworth, Sandy Beach, Santee Delta, and Wateree River HP/WMAs	priority habitats that provide food items for waterfowl species
Mast Survey	SCDNR	Tammy Wactor, SCDNR-WFF		Blue Ridge Ecoregion (mountains)	priority habitats that include mast-producing food items for Black Bear and other priority species in the region
HERPETOFAUNA STUDIES (including marine)					
American Alligator Eyeshine Survey	SCDNR	Morgan Hart, SCDNR-WFF	volunteers	Statewide; annually	American Alligator
American Alligator Mark-Recapture Survey	SCDNR	Morgan Hart, SCDNR-WFF	Clemson University, volunteers	Santee Coastal Reserve WMA	American Alligator
American Alligator Satellite Tracking Project	SCDNR	Morgan Hart, SCDNR-WFF	Clemson University, volunteers	Santee Coastal Reserve WMA, Bear Island WMA, Huntington Beach State Park	American Alligator
At-risk Reptile and Amphibian Monitoring	USFS	Jestin Clark, USFS	Amphibian and Reptile Conservancy (ARC), Andrew Grosse, SCDNR-WFF	Francis Marion National Forest	Frosted Flatwoods Salamander, Gopher Frog, Eastern Diamondback Rattlesnake, Pine Snake, Spotted Turtle, Chicken Turtle, Dwarf Siren, Ornate Chorus Frog

Diamondback Terrapin Citizen Science Reporting	SCDNR	Michael Arendt, SCDNR-MRD	general public	Coastal Zone of South Carolina	Diamondback Terrapin
Diamondback Terrapin Long-term Population Study	Sewannee College	Kristen Cecala, Sewannee College	Andrew Grosse, SCDNR-WFF; volunteers	Kiawah Island and surrounding marsh habitat	Diamondback Terrapin
Diamondback Terrapin Working Group (DTWG)	DTWG (301c3 organization)	Andrew Grosse, SCDNR-MRD	made up of individuals from academic, regulatory, and private institutions/organizations	Atlantic and Gulf Coast states; 2-day meetings annually; SCDNR last participated in 2015	supports research, management, conservation, and education efforts regarding Diamondback Terrapin
Eastern Diamondback Rattlesnake Survey	DoD	John Holloway, Marine Corp Recruit Depot-Parris Island	Jamie Waldron, Marshall University and Andrew Grosse, SCDNR-WFF	Parris Island and other locations within the species range in South Carolina	Eastern Diamondback Rattlesnake
Gopher Tortoise Population Surveys	SCDNR	Andrew Grosse, SCDNR-WFF	Private landowners	range-wide: every ~10 years	Gopher Tortoise
Gopher Frog Population Surveys	SCDNR	Andrew Grosse, SCDNR-WFF	USFS, USFWS, University of Georgia Savannah River Ecology Lab, Amphibian and Reptile Conservancy, Longleaf Alliance	range-wide; annually	Gopher Frog
Green Salamander Population Survey	SCDNR	Andrew Grosse, SCDNR-WFF	USFS, SCPRT, Clemson	range-wide; annually	Green Salamander
Managed Wetland Alligator Spotlight Surveys – Tom Yawkey Center	SCDNR	Mark McAlister, SCDNR-WFF		managed wetlands at the Tom Yawkey Wildlife Center	American Alligator
Pine Barrens Treefrog Population Survey	SCDNR	Andrew Grosse, SCDNR-WFF	USFWS, SCPRT	range-wide	Pine Barrens Treefrog
Sea Turtle Nesting Population Survey and Nest Protection	SCDNR	Michelle Pate, SCDNR-MRD	SCPRT, USFWS, volunteer network	entire South Carolina coast	all sea turtle species
Sea Turtle Stranding and Salvage Network	SCDNR	Michelle Pate, SCDNR-MRD	SCPRT, USFWS, volunteer network	South Carolina Coast and waterways and includes monthly aerial surveys from Port Royal Sound to Murrells Inlet conducted with SCDNR Law Enforcement Division	all sea turtle species
Spotted Turtle Population Survey	SCDNR	Andrew Grosse, SCDNR-WFF	Audubon Society, Orianne Society, Volunteers	range-wide	Spotted Turtle
Tramel Net Surveys *(see also Marine Fishes section)*	SCDNR	SCDNR-MRD	NOAA, ACE Basin volunteers including the public	South Carolina mid- to lower-estuary salt marsh edge and oyster reef habitats (Port Royal Sound, St. Helena Sount, Charleston Harbor, Bulls Bay & Cape Romain, Winyah Bay) – ongoing monthly since fall 1990	Diamondback Terrapin, Green Sea Turtle

Upland Snake Survey	SCDNR	Andrew Grosse, SCDNR-WFF	USFWS, SCFS, SCPRT, private landowners	Range-wide	Eastern Diamondback Rattlesnake, Pine Snake, Southern Hognose Snake, Timber Rattlesnake, Eastern Milk Snake (in total over 50 species of reptiles and amphibians)
Webster's Salamander	USFS	Jeff Magniez, USFS	Andrew Grosse, SCDNR-WFF	Sumter National Forest	Webster's Salamander
MAMMALIAN STUDIES (including marine)					
Bat Hibernacula Surveys	SCDNR	Jennifer Kindel SCDNR-WFF	SCPRT, USFS, SCDOT, private landowners, volunteers	Statewide; annually since 2016	Tricolored Bat, Little Brown Bat, Rafinesque's Big-eared Bat, Big-eared Bat, Southeastern Bat, Big Brown Bat, Evening Bat, Silver-haired Bat
Bat Mist-netting Surveys	SCDNR	Jennifer Kindel SCDNR-WFF	SCPRT, USFS, SCFC, SCARNG McCrady Training Center, volunteers	Statewide; annually since 2016	all bat species
Black Bear Bait Station Surveys	SCDNR	Tammy Wactor, SCDNR-WFF		Mountain region; every other year since 1993	Black Bear
Charleston Dolphin Abundance and Distribution (CDAD) Survey	NOS/NOA	Eric Zolman, NOS	NMFS/NOAA	Charleston Harbor, Cooper River, Wando River, Stono River; annually	Tamanend's Bottlenose Dolphin
Charleston Dolphin Shipside Feeding Survey	South Carolina Aquarium (SCA)	Patricia Fair, SCA; Meghan Galipeau, SCA	Jess Cusick, Utah Valley University; SCDNR-MRD	Charleston Harbor; annually since 2024	Tamanend's Bottlenose Dolphin
Coastal Carolina Dolphin Abundance and Distribution Survey	Coastal Carolina University (CCU)	Rob Young, CCU	NMFS/NOAA, NOS/NOAA	North Inlet and Winyah Bay, Georgetown County (estuaries); annually	Tamanend's Bottlenose Dolphin
Coastal Marine Mammal Assessments Program – UAS Surveys	NOS/NOAA	Wayne McFee, NOS/NOAA	CSS, Inc.; College of Charleston	Charleston estuaries	Tamanend's Bottlenose Dolphin
Estuarine Soundscape Observatory Network *(see also Marine Fishes section)*	USC-Beaufort	Eric Montie, USC-Beaufort	SCDNR-MRD, SECOORA, NOAA, BOEM, US Navy, College of Charleston	Winyah Bay, Charleston Harbor, Port Royal Sound and May River Estuaries; continuously from 2013	Tamanend's Bottlenose Dolphin, Alligator
Fox Squirrel Sighting Survey	SCDNR	Michael Hook, SCDNR-WFF	DNR, USFWS, SCFC, USFS, US DoD, and volunteers including public	statewide; begun in 1989 and conducted annually but then conducted even numbered years starting in 1994	Southern Fox Squirrel
Furbearer Harvest Data Collection	SCDNR	Jay Butfiloski, SCDNR-WFF	licensed trappers and hunters, night hunting registrants, predator management permit holders	statewide; annually	all furbearers
Gray Bat Bridge Surveys	SCDNR	Jennifer Kindel SCDNR-WFF	SCDOT, volunteers	Upstate; annually	Gray Bat

Lowcountry Marine Mammal Network (LMMN) Dolphin Photo Identification Survey	Lowcountry Marine Mammal Network	Lauren Rust, LMMN	NOS/NOAA	Kiawah River/Bohicket Creek/Captain Sam's Inlet	Tamanend's Bottlenose Dolphin
Lowcountry Dolphin Conservation Program	University of SC – Beaufort	Eric Montie, USC-B	College of Charleston	May River/Calibogue Sound, Hilton Head, SC	Tamanend's Bottlenose Dolphin
Manatee Citizen Science Sightings Reporting	SCDNR	Michelle Pate, SCDNR-MRD	general public	statewide	Florida Manatee
Marine Mammal Stranding Survey	NOS/NOAA	Wayne McFee, NOAA	NMFS/NOAA, SCDNR, Coastal Carolina University, Lowcountry Marine Mammal Network	Coastal Zone; annually	All marine mammals excluding Florida Manatee
Monitoring of the Charleston Dolphin Population	South Carolina Aquarium (SCA)	Patricia Fair, SCA	Meghan Galipeau, SCA; Jess Cusick, Utah Valley University; SCDNR-MRD	Charleston estuary	Tamanend's Bottlenose Dolphin
National Marine Mammal Foundation (NMMF) Photo Identification Survey	NMMF	Todd Speakman, NMMF	NOS/NOAA	Charleston estuary	Tamanend's Bottlenose Dolphin
NMFS, Beaufort Laboratory, Cetacean and Sea Turtle (CAST) Survey	NMFS/NOAA	Aleta Hohn, NMFS	SCDNR	Coastal Zone and Atlantic Ocean Shelf – Southeastern US; annually	Tamanend's Bottlenose Dolphin stock structure and genetics
North American Bat Monitoring Program – Acoustic Surveys (stationary and mobile)	SCDNR	Jennifer Kindel SCDNR-WFF	USFS, USFWS, private landowners, volunteers	statewide; annually since 2015	all bat species
Rabbit Hunter Survey	SCDNR	Michael Hook, SCDNR-WFF	volunteers	statewide; annually	Eastern Cottontail, Swamp Rabbit, Marsh Rabbit, American Woodcock, Northern Bobwhite quail
White-tailed Deer Chronic Wasting Disease Survey	SCDNR	Charles Ruth, SCDNR-WFF	taxidermists	statewide	White-tailed Deer
White-tailed Deer Spotlight Surveys	SCDNR	Charles Ruth, SCDNR-WFF	private consultants, tribes, Urban/Suburban Deer Management Program permit holders	statewide; year-round	White-tailed Deer
AVIAN STUDIES					
Bald Eagle Surveys	SCDNR	Amy Tegeler, SCDNR-WFF		Aerial survey over one third of South Carolina each year to determine status of known nests	Bald Eagle
Bald Eagle Mid-Winter Surveys	Avian Conservation Center	Jennifer McCarthey Tyrrell, ACC	USGS coordinates United States Surveys and SCDNR participates	Statewide; annually during winter	Bald Eagle

Black Rail Monitoring	SCDNR	Christine Hand, SCDNR-WFF	ACJV, Black Rail Working Group, USFWS	South Carolina Coastal Zone and Coastal Plain; annually	Black Rail
Bobwhite Quail Fall Covey Counts	SCDNR	Michael Hook, SCDNR-WFF	USFWS, SCFC, USFS, volunteers	Select WMAs	Northern Bobwhite
Bobwhite Quail Hunter Survey	SCDNR	Michael Hook, SCDNR-WFF	volunteers	Statewide	Northern Bobwhite, American Woodcock
Bobwhite Quail Summer Brood Survey	SCDNR	Michael Hook, SCDNR-WFF	USFWS, SCFC, USFS, US DoD, volunteers	Statewide	Northern Bobwhite
Bobwhite Quail Summer Whistling Cock Survey	SCDNR	Michael Hook, SCDNR-WFF	USFWS, SCFC, USFS, US DoD	Statewide during breeding season since 1979	Northern Bobwhite
Breeding Bird Survey	USGS	Bruce Peterjohn, Breeding Bird Lab	SCDNR, volunteers	surveys across the US and Canada during the breeding season; total number of routes is 4,461, 28 of which are in South Carolina	all bird species
Christmas Bird Count	Audubon	SCDNR-MRD	volunteers	United States and Canada; surveys conducted in December	all bird species
Ground Surveys for Wintering Waterfowl	SCDNR	Molly Kneese, SCDNR-WFF		Bear Island, Beaver Dam Creek, Bonneau Ferry, Broad River, Clemson, Donnelley, Love Farm, Samworth, Sandy Beach, Santee Delta, and Wateree River HP/WMAs	all waterfowl species
Harvest Information Program (HIP)	USFWS	Kathy Flemming, USFWS; Billy Dukes, SCDNR_WFF	those potentially hunting migratory birds in the State	statewide	species of duck, geese, American Woodcock, snipe, rail, gallinule
International Piping Plover Census	USGS	Melissa Bimbi, USFWS; Felicia Sanders, SCDNR-WFF	SCDNR	statewide along all beach habitat; every 10 years during the month of February	Piping Plover, Wilson's Plover, Red Knot
Midwinter Waterfowl Survey	USFWS	Heath Hagy, USFWS; Molly Kneece, SCDNR-WFF	Hunter Young & Mark McAlister, SCDNR-WFF	National Wildlife Refuges and select WMAs (Bear Island, Santee Coastal Reserve, Tom Yawkey Wildlife Center, Santee Delta, Samworth, Sandy Beach); annually since 1935 with some years missed and a change in methodology	all waterfowl species
Monitoring Avian Productivity and Survivorship (MAPS)	Institute for Bird Populations (IBP)	David DeSante, IBP	Amy Tegeler, SCDNR-WFF, volunteers	International (Canada, United States, Mexico); conducted during the breeding season at 2 SCDNR stations (Congaree National Park and McCrady) and 1 USFS station; see website for various points	all landbird species

Monthly Wading and Waterfowl Point Counts – Tom Yawkey Center	SCDNR	Mark McAlister, SCDNR-WFF		managed wetlands at the Tom Yawkey Wildlife Center	all wading birds and waterfowl
Mourning Dove Banding	USGS	Bird Banding Laboratory (USGS); Michael Hook, SCDNR-WFF	SCDNR and USFWS staff	statewide; annually	Mourning Dove
Mourning Dove Call Count Surveys	SCDNR	Michael Hook, SCDNR-WFF		statewide; annually since 1966	Mourning Dove
Mouring Dove Harvest Wing Collection	SCDNR	Michael Hook, SCDNR-WFF	volunteers	statewide; annually	Mourning Dove
National Bobwhite Technical Committee (previously Southeast Quail Study Group)	National Steering Committee (12 members)	National Steering Committee Chair (rotates every 2 years); Michael Hook, SCDNR-WFF	SCDNR and 6 other state wildlife agencies	25 states within the species' range	Northern Bobwhite
Region 8 Bird Point Counts	USFS (R8)	May Lee Hafer, USFS	USFS biologists	Francis-Marion Sumter National Forest; conducted during the breeding season	landbirds
Red-cockaded Woodpecker Monitoring	SCDNR	Matt Lerow, SCDNR-WFF	USFWS	extent of Red-cockaded Woodpecker range in South Carolina (Sandhills and Coastal Plain) in accordance with recovery plan guidelines. Conducted throughout the year	Red-cockaded Woodpecker
Red Knot Surveys	SCDNR	Janet Thibault, SCDNR-WFF	GADNR	coast-wide; annual spring aerial count	Red Knot
Seabird Nesting Colony Surveys	SCDNR	Janet Thibault & Felicia Sanders, SCDNR-WFF		complete statewide ground counts; annually	colonial nesting seabirds (Brown Pelican, Black Skimmer, gull species, tern species)
Spring Shorebird Surveys of Managed Wetlands – Tom Yawkey Center	SCDNR	Jamie Dozier, SCDNR-WFF		managed wetlands at the Tom Yawkey Wildlife Center	all shorebirds
United States Nightjar Survey Network	Center for Conservation Biology	Amy Tegeler, SCDNR-WFF	SCDNR, states and provinces in North America	nationwide	9 species of nightjar including Common Nighthawk, Chuck-will's-widow, and Whip-poor-will
Wading Bird Surveys	SCDNR	Christine Hand, SCDNR-WFF		South Carolina Coastal Zone and Coastal Plain; annual aerial surveys	colonial nesting wading birds (Wood Stork, heron species, egret species, ibis species, Anhinga)

Waterfowl Banding Program	USGS	USGS Bird Banding Laboratory; Molly Kneece, SCDNR-WFF	SCDNR and USFWS staff	statewide; annual	Black-bellied Whistling Duck, Mottled Duck, Wood Duck
Whimbrel Surveys	SCDNR	Felicia Sanders, SCDNR-WFF	USFWS, GADNR, Manomet	Spring nocturnal counts at important roost sites	Whimbrel
Wild Turkey Brood Surveys	SCDNR	Charles Ruth, SCDNR-WFF	volunteers including public	Statewide; annually since 1982	Eastern Wild Turkey
Wintering Baltimore Oriole Citizen Science Project	SCDNR	Amy Tegeler & Meredith Heather, SCDNR-WFF	general public	statewide; annually since 2022	Baltimore Oriole
Wood Stork Monitoring	SCDNR	Christine Hand, SCDNR-WFF	Wood Stork Working Group, USFWS	Statewide; annual nest counts and productivity estimates	Wood Stork
MARINE FISH AND INVERTEBRATE ASSESSMENTS					
Artificial Reef Monitoring Survey	SCDNR	Ryan Yaden, SCDNR-MRD	USFWS	Continental Shelf and estuarine; ongoing	habitat for a myriad of marine invertebrates and vertebrates
Bill-fishing Survey	SCDNR	Amy Dukes, SCDNR-MRD	Governor's Cup Bill-fishing Series participants	Offshore of South Carolina US territorial Atlantic Ocean; annually summer – fall	billfishes (marlin species, Swordfish, Sailfish), tuna sp., Dolphinfish, Wahoo
Blue Crab Pot-based Survey	SCDNR	Michael Kendrick, SCDNR-MRD		6 South Carolina estuaries sampled in October and November	monitoring relative abundance and population demographics of recreationally and commercially important Blue Crab
Coastal Longline Survey	SCDNR	Bryan Frazier, Ashley Galloway & Joseph Ballenger, SCDNR-MRD	NOAA, ACE Basin	South Carolina estuaries and coastal waters (Port Royal Sound, St. Helena Sound, Charleston Harbor, Winyah Bay); ongoing seasonally from Aug – Dec since 2007; an earlier version in Charleston Harbor operated seasonally since 1994	monitoring relative abundance and population demographics of adult Red Drum and coastal sharks (e.g. Atlantic Sharpnose, Finetooth, Blacknose, Blacktip, Sandbar, etc.) in nearshore coastal open waters
Coastal Trawl Survey (SEAMAP)	SCDNR	Tracey Smart, SCDNR-MRD	NMFS/NOAA, ASFMC	North Carolina, South Carolina, Georgia, and Florida coastal waters; ongoing since 1990	demersal finfish, invertebrates, Horseshoe Crab, and sea turtle sp.; water quality testing
Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN)	SCDNR	Bryan Frazier & Joey Ballenger, SCDNR-MRD	NOAA, ACE Basin volunteers including the public	South Carolina coastal waters and estuaries; ongoing seasonally from May – Aug since 1988	monitoring relative abundance and population demographics of various elasmobranch species

Crustacean Creek Trawl Survey	SCDNR	Michael Kendrick, SCDNR-MRD		7 tidal creeks in the Charleston Harbor Estuary sampled monthly	monitoring relative abundance and population demographics of recreationally and commercially important crustaceans (primarily penaeid shrimp and Blue Crab)
Electrofishing Survey	SCDNR	Joseph Ballenger & James Kilfoil, SCDNR-MRD	NOAA, ACE Basin volunteers including the public	South Carolina tidal freshwater and oligohaline areas (Combahee River, Edisto River, Ashley River, Cooper River, Waccamaw River/Winyah Bay) – ongoing monthly since 2001	monitoring relative abundance and population demographics of inshore recreational finfish species (e.g. Red Drum, Southern Flounder, Striped Bass, American Eel, Spot, Atlantic Croaker, etc.); Encounters ~130 species, ~40 of which annual relative abundance is tracked
Estuarine Soundscape Observatory Network *(see also Mammals section)*	USC-Beaufort	Eric Montie, USC-Beaufort	SCDNR-MRD, SECOORA, NOAA, BOEM, US Navy, College of Charleston	Winyah Bay, Charleston Harbor, Port Royal Sound and May River Estuaries; continuously from 2013	soniferous fish species behavior including Red Drum, Black Drum, Atlantic Croker, and others
Estuarine Trawl Survey	SCDNR	Michael Kendrick, Peter Kingsley-Smith, Joseph Ballenger, & James Kilfoil, SCDNR-MRD		South Carolina estuaries from Charleston Harbor to Calibogue Sound. Charleston Harbor is sampled monthly (6 stations), whereas other estuaries are sampled in March, April, August and December	monitoring relative abundance and population demographics of estuarine communities including recreationally- and commercially-important crustaceans (e.g. penaeid shrimp and Blue Crab), Horseshoe Crab, inshore recreational finfish (e.g. Weakfish, Spot, Atlantic Croaker, Southern Flounder), and forage fish (e.g. Atlantic Menhaden, Star Drum, Banded Drum, etc.)
Fishery-Dependent Freezer Fish Donation Program	SCDNR	Joseph Ballenger & Jonathan Tucker, SCDNR-MRD	NOAA	Coastal South Carolina; ongoing since 1990s	fishery-dependent sampling for population demographics (age, sex, size) of landed fish at annual tournaments for key recreational species (e.g. Red Drum, Spotted Seatrout, Southern Flounder, Sheepshead, etc.)
Fishery-Dependent Tournament Program	SCDNR	Joseph Ballenger, Brock Renkas, & Justin Yost – SCDNR-MRD	NOAA	Coastal South Carolina; ongoing since late 1980s with Mariculture Section in attendance since 2006	fishery-dependent sampling for population demographics (age, sex, size) of landed fish at annual tournaments for key recreational species (e.g. Red Drum, Spotted Seatrout, Southern Flounder, Sheepshead, etc.)
Fisheries Statistics Survey	SCDNR	Amy Dukes, SCDNR-MRD	NMFS/NOAA, Atlantic Coastal Cooperative Statistics Program (federal)	South Carolina Coastal Zone and US territorial Atlantic Ocean; annually	all commercial marine fishes and American Shad, Hickory Shad, Blueback Herring

Genetic Fin Clip Program	SCDNR	Justin Yost, SCDNR-MRD	volunteers	coastwide in South Carolina and can extend into neighboring states on occasion; samples run annually	Cobia, Red Drum, Seatrout, flounder sp., Tripletail, Tarpon
Horseshoe Crab Spawning Survey	SCDNR	Daniel Sasson, SCDNR-MRD		Conducted annually each sprint as funding allows	collecting data on Horseshoe Crab spawning activity and tagging Horseshoe Crabs for use in resighting analyses
Marine Game Fish Tagging Program	SCDNR	Matt Perkins, SCDNR-MRD	citizen scientists/taggers	South Carolina estuarine, territorial, and continental shelf waters	Red Drum, Southern Flounder, Sheepshead, Black Drum, Cobia, Dolphin, Tripletail, Tarpon, snapper sp., grouper sp., Greater Amberjack, etc.
Marine Fish Stock Enhancement Program	SCDNR	Aaron Watson, SCDNR-MRD	NOAA, SeaGrant	South Carolina estuaries where multiple species have been stocked; stocking occurs annually	monitoring the effectiveness of stocking approaches for Cobia, Red Drum, flounder sp., Spotted Seatrout
Marine Recreational Fisheries Statistical Survey, Marine Recreational Information Program	NMFS/NOAA	Brad Floyd, Eric Hiltz, & Amy Dukes – SCDNR-MRD		Coastwide in all estuaries and marine waters of the United States; annually	all recreational species including species taken from charter boats, head boats, piers, and from shore
Marine Resources Research Institute (MRRI) Tagging and Telemetry Studies	SCDNR-MRRI	Mike Arendt, SCDNR-MRD	multiple staff operating under various grants covering a multitude of species	coastal South Carolina; species tagged varies by year based on current grant	sharks, rays, finfish, sea turtles
Ocean Dredged Material Disposal Sites (ODMDS)	SCDNR	Andrew Tweel, SCDNR-MRD	USACE	Charleston ODMDS	assessment of impacts of sediment movements on hard bottom reef habitats and invertebrate populations within and surrounding ODMDS
Public Shellfish Ground Planting and Restoration	SCDNR	Andy Hollis, SCDNR-MRD		South Carolina Coastal Zone; annually	Eastern Oyster, Northern Quahog, Southern Quahog
Renourishment Studies	SCDNR	Andrew Tweel, SCDNR-MRD	USACE, local municipalities	entire South Carolina coast	monitoring the impact of dredging and beach nourishment on invertebrate populations on beaches and the nearshore zone
SECOOS Fish Watch	SCDNR	SCDNR-MRD	NOAA, UNC-W, University of Georgia	NC, SC, GA coastal waters; ongoing	underwater camera systems to document fish movements
Shellfish Culture Permit Monitoring	SCDNR	Stephen Czwartacki, SCDNR-MRD	shellfish culture/harvest permit holders	South Carolina Coastal Zone; annually	Eastern Oyster, Northern Quahog, Southern Quahog

Shellfish Mariculture Permit Management	SCDNR	Henry Davega, SCDNR-MRD	shellfish mariculture permit holders	South Carolina Coastal Zone; annually	Eastern Oyster, Northern Quahog, Southern Quahog
South Atlantic Deepwater Longline Survey (SADLS)	SCDNR/NOAA	Walter Bubley, SCDNR-MRD	NMFS/NOAA	Atlantic Ocean shelf and slope; ongoing since 2020	benthic or bottom-dwelling marine fishes, primarily tilefish sp. and grouper sp.; water quality testing
South Carolina Estuarine and Coastal Assessment Program (SCECAP)	SCDNR	Andrew Tweel, SCDNR-MRD	SCDES (formerly SCDHEC), USEPA, NOAA, USFWS	Coastal Zone estuaries; annually since 1999 through at least 2006	measurement of water and sediment quality and related presence and diversity of marine invertebrates and fishes; assessment of tidal creeks (nursery habitat for a variety of species)
South Carolina Oyster Demographic Assessment (SCODA) Program	SCDNR	Peter Kingsley-Smith, SCDNR-MRD		34 coastal index sites distributed statewide; conducted annually since 2015 in the fall/winter	data collected on size and abundance of live and dead oysters form standardized quadrat-based sampling to inform the understanding of natural mortality rates and spatial patterns of key oyster demographic parameters (survival, growth, recruitment, etc.)
Southeast Reef Fish Survey (SERFS, includes MARMAP & SEAMAP)	SCDNR	Tracey Smart, SCDNR-MRD	NMFS/NOAA	Atlantic Ocean shelf and slope; ongoing since 1990	Benthic or bottom-dwelling marine fishes, primarily snapper sp. and grouper sp.; water quality testing
NOAA Fisheries Marine Recreational Information Program (MRIP) Access Point Angler Intercept Survey (APAIS)& For Hire Telephone Survey (FHTS)	NOAA	Brad Floyd, SCDNR-MRD	SCDNR	South Carolina Coastal Zone; year-round	Red Drum, Spotted Seatrout, Sheepshead, flounder sp.
State Shellfish Ground Assessment	SCDNR	Stephen Czwartacki, SCDNR-MRD		South Carolina Coastal Zone; annually spring & summer	Eastern Oyster, Northern Quahog, Southern Quahog
Trammel Net Survey *(see also Herp section)*	SCDNR	Joseph Ballenger, SCDNR-MRD	NOAA, ACE Basin volunteers including the public	South Carolina mid- to lower-estuary salt marsh edge and oyster reef habitats (Port Royal Sound, St. Helena Sound, Charleston Harbor, Bulls Bay & Cape Romain, Winyah Bay) – ongoing monthly since fall 1990	monitoring relative abundance and population demographics of inshore recreational finfish (e.g. Red Drum, Spotted Seatrout, Southern Flounder, Sheepshead, Black Drum, etc.) and selected non-finfish species (e.g. Diamondback Terrapin, Blue Crab, Green Sea Turtle, Horseshoe Crab); Encounters ~130 species, ~35 of which annual relative abundance is tracked

Whelk Fishery Monitoring and Management	SCDNR	Stephen Czwartacki, SCDNR-MRD	whelk trawl fishery permit holders	South Carolina shallow Atlantic shelf ; annually winter – spring	Knobbed Whelk, Channeled Whelk
DIADROMOUS FISH ASSESSMENTS					
Adult American Shad Telemetry	SCDNR	Bill Post, SCDNR-WFF	Duke Energy, Dominion Energy (formally SCANA)	Lake Moultrie, Lake Marion, Wateree River, Congaree River, Broad River, Saluda River, Cooper River, Santee River	American Shad
Commercial Shad Fishery Monitoring	SCDNR	Bill Post, SCDNR-WFF	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	all State waters; annually	American Shad, Hickory Shad
Juvenile American Eel Survey	SCDNR	Ellen Waldrop, SCDNR-WFF	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	Upper Goose Creek below Goose Creek Reservoir (annually late winter – early spring); Rediversion Canal below St. Stephen Dam (year-round)	American Eel
Juvenile American Shad Surveys	SCDNR	Bill Post, SCDNR-WFF		Lake Marion, Lake Moultrie, Wateree River, Congaree River, Broad River, Upper Santee River, Cooper River	American Shad, Blueback Herring
Monitoring Fish Species at St. Stephen's Fish Lift	SCDNR	Bill Post, SCDNR-WFF		St. Stephen's Fish Lift	all diadromous and freshwater species
Monitoring Juvenile American Shad Stocks	SCDNR	Kyle Hoffman, SCDNR-WFF	USFWS	Edisto River, Great Pee De Rivere, and Savannah River	American Shad
Multi-State Sturgeon Telemetry	SCDNR	Bill Post, SCDNR-WFF	University of Georgia, University of North Carolina – Wilmington	NC, SC, GA coastal waters and rivers to the first impediment	Shortnose Sturgeon, Atlantic Sturgeon
Shad Tagging	SCDNR	Bill Post, SCDNR-WFF	ASMFC, Atlantic Coastal Fisheries Cooperative Management Act, NMFS/NOAA	Edisto, Santee and Waccamaw-Pee Dee Rivers; annually with three-year cycle per river	American Shad, Hickory Shad
Sturgeon Monitoring	SCDNR	Bill Post, SCDNR-MRD	Santee Cooper	Lake Marion, Lake Moultrie, Wateree River, Congaree River, Broad River, Saluda River, Upper Santee River, Cooper River	Shortnose Sturgeon, Atlantic Sturgeon
Sturgeon Surveys	SCDNR	Bill Post, SCDNR-WFF	NMFS/NOAA	Edisto Rivers; ongoing	Shortnose Sturgeon, Atlantic Sturgeon

FRESHWATER FISH AND INVERTEBRATE STUDIES					
"Bartram's" Bass Conservation	SCDNR	Mark Scott, SCDNR-WFF	Georgia DNR, University of Georgia, Clemson University	rangewide; Savannah and Santee Basins above the Fall Line; ongoing	"Bartram's" Bass
Carolina Heelsplitter Monitoring and Recovery Program	SCDNR	Ericah Beason, SCDNR-WFF; Joe Limpers, USFWS-ONFH	USFWS Orangeburg National Fish Hatchery (ONFH)	Slate Belt and Sandhills Ecoregions	Carolina Heelsplitter wild and propagated mussels
Eastern Brook Trout Joint Venture (EBTJV)	EBTJV	Dan Rankin, SCDNR-WFF	SCDNR, USFS, Trout Unlimited	entire United States range of the species; in South Carolina restoration to appropriate stream habitat; ongoing	Eastern Brook Trout
Freshwater Mussel Program	SCDNR	Ericah Beason, SCDNR-WFF	USFWS-ONFH, volunteers	Statewide; ongoing	all freshwater mussels and snails
Robust Redhorse Conservation Committee (RRCC)	SCDNR	Tanya Darden, SCDNR-MRD	MOU between state and federal resource agencies, universities, private industry, and the conservation community; 13 signatory and 2 cooperating members	Statewide; ongoing	Robust Redhorse
South Carolina Stream Assessment	SCDNR	Mark Scott, SCDNR-WFF	Clemson University, volunteers	statewide in freshwater streams; ongoing	sampling of all freshwater fish assemblages and habitats within freshwater stream systems

CHAPTER 9: SWAP IMPLEMENTATION AND ADAPTIVE MANAGEMENT

The primary focus of South Carolina's State Wildlife Action Plan (SWAP) is continued efficient and effective conservation and management of wildlife diversity. In the creation of the 2025 edition of this Plan, South Carolina Department of Natural Resources (SCDNR) staff and conservation partner organization engagement occurred to draft chapters. Agency staff created the list of Species of Greatest Conservation Need (SGCN) with external assistance from other wildlife professionals from across the Southeast and nationally. The public was encouraged to review the draft SWAP and relevant suggestions and edits incorporated into this final version. For a more detailed review of this process, see Chapter 1.

The South Carolina Department of Natural Resources (SCDNR) has been successfully implementing its various SWAPs since the first version in 2005. The 2025 Plan will meet also meet its mandate through the coordination of diverse conservation efforts and forging of effective partnerships. Coordination efforts will bring together expertise and funding sources from various partners and apply them to needs identified in the SWAP. The initial congressional intent for the SWAPs was to identify and focus on the species in greatest conservation need and yet "address the full array of wildlife and wildlife related issues." At this nexus, the SWAP provides focus and guidance for SCDNR priorities when allocating personnel and financial resources for research and management. It has been integrated into agency business practices such as the environmental review process and land acquisitions. The South Carolina SWAP has also grown in popularity and has been cited in multiple other agency and organization planning documents, reinforcing its tenets.

Andrew Grosse (SCDNR)- second from left, Kurt Buhlmann (UGA)- far right, and two wildlife rehabbers from Charlotte, NC, release "Carl", a waif Gopher Tortoise that was found in an electrical substation in Charlotte, NC, onto Aiken Gopher Tortoise Heritage Preserve. Photo by SCDNR.

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

A major part of the data management related to Species of Greatest Conservation Need (SGCN) listed in the SWAP is the SCDNR Heritage Trust Database for storing element occurrence records. This database is used by SCDNR biologists, permit reviewers, land use planners, conservation easement advocates, landowners, consultants, and other agencies and individuals who are interested in biological data and impacts on land use decisions. South Carolina's Natural Heritage Program (SCNHP) is part of the Heritage Trust and tracts rare species and natural communities across the State, many of which are SGCN or are being monitored for possible future inclusion in the SWAP if populations decline. Currently, SCNHP tracts 1,371 species, of which 230 are globally imperiled, 105 have a federal nexus, and 46 are state protected. Data can be analyzed and models created to best inform management decisions in-state and across the species' ranges.

Habitats preserved for SGCN follow the conservation biology principle of the 3R's—resiliency, redundancy, and representation. Resiliency is the ability of a population to rebound after events that impact the ecosystem in which they are found. Redundancy is making sure there are multiple populations across the landscape so that no single event could impact the species to the extent it cannot recover. Representation is making sure that genetic diversity and habitat diversity are maintained across the landscape and that connectivity is present among populations. All three of these conservation principles combined help buffer a species from catastrophic events and climate change, improving their adaptive capacity. [USFWS 2016]

Funding the Work

Every year, the State of South Carolina receives (through SCDNR) appropriated funds to implement the SWAP through the State Wildlife Grants (SWG) Program. These allotments are based on a formula using the total area of the state and population. Funds flow from the United States Fish and Wildlife Service (USFWS) to each state/territory/commonwealth's wildlife agency which oversees this grant program. Funds can be used for research, surveys, and habitat restoration if it will benefit a species specifically cited in that state's SWAP. There is a 35% match requirement for all implementation grants and a 25% match requirement for planning grants. South Carolina's appropriations over the last 22 years are graphically represented in Figure 9-1. Typically, the funding results in five to eight new projects a year. To date, South Carolina has completed 109 SWG with 18 more in progress.

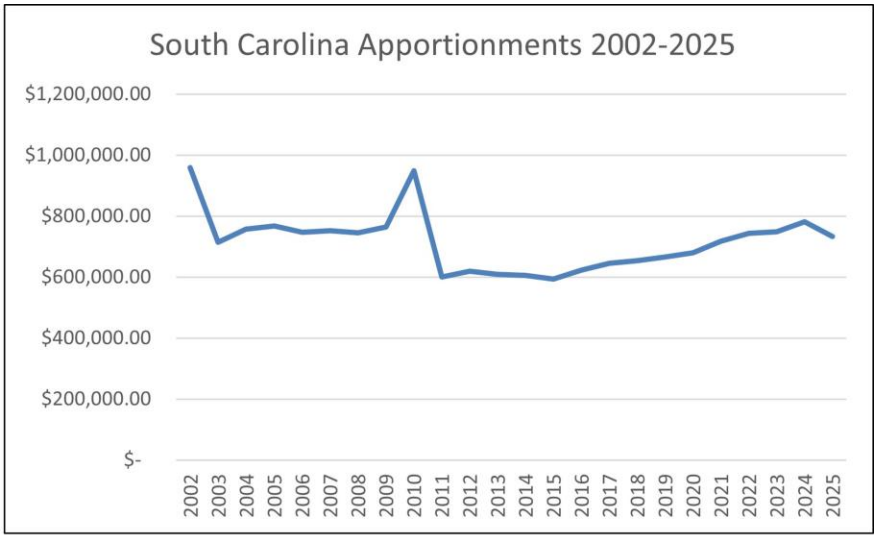


FIGURE 9-1: Federal apportionments directed to South Carolina since inception. Funding is based on a formula that considers the state's size and population.

The companion multi-state program created in 2008, Competitive State Wildlife Grants (C-SWG), has provided funding for 18 projects in which South Carolina has been a partner. Of these, South Carolina was or is currently the lead state for eight.

Depending on when the national budget is approved, states are typically provided their allotments in the spring of the year. The South Carolina SWAP Coordinator position is housed within the Wildlife and Freshwater Fisheries Division of the SCDNR and is funded through State Wildlife Grants matched with state funds. This same coordinator oversees grants related to land acquisition, restoration, research, and survey that serve the interests of SGCN and their habitats, along with providing a robust portfolio of conservation lands overseen by the SCDNR.

In South Carolina, the SWAP Coordinator solicits pre-proposals via an email network. All submitted proposals are reviewed and compiled by the Coordinator in preparation for formal review by the SWG Review Committee. The SWAP Coordinator is the Chair of this committee. Rigorous review and selection procedures ensure that sponsored projects are effective and efficient in meeting the goals and objectives of the SWAP. The SWG Review Committee evaluates all pre-proposals to determine if projects clearly focus on South Carolina priority species, habitats, and their associated mitigation actions recommended within the SWAP. The SWAP must be cited in the proposal. Division leadership is encouraged to meet with Principal Investigators (PIs) and prioritize their projects for consideration so that when the agency divisions and sections convene, it is clear what the most critical needs are for each. The selection process is meant to be fair to all divisions/sections and based on the need and merit of each proposed project. “Pet projects”, programs, and those that do not inform management decisions are not acceptable. The SCDNR seeks to fund innovative, interdisciplinary projects that attempt to address the needs of priority species listed in the SWAP and undertake practical application of SWAP goals. The urgent need to achieve environmental sustainability and protect South Carolina’s ecosystems challenges applicants to develop new ways to engage organizations in problem solving. Therefore, proposals selected should:

- 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.

Standing members of the South Carolina SWG Review Committee include the following or their designee:

- SWAP/SWG Coordinator
- Deputy Director of Wildlife and Freshwater Fisheries Division
- Assistant Deputy Director of Wildlife and Freshwater Fisheries Division
- Chief of Wildlife Management Section
- Assistant Chief of Wildlife Management Section
- Chief of Freshwater Fisheries Section
- Assistant Chief of Freshwater Fisheries Section
- Deputy Director of Marine Resources Division
- Director of the Marine Resources Research Institute (MRRI)

Project Investigators (PIs) whose pre-proposals were selected for funding are informed of the Committee's decision by the SWAP/SWG Coordinator, and a full proposal is requested using a template prepared by the Coordinator. The Coordinator also assists with all state and federally required forms, compliance statements, and uploads to the federal grant system (i.e. Grant Solutions and TRACS). Those not selected for funding receive constructive feedback from the Coordinator.

Since Competitive SWG do not involve allocated dollars and are nationally competitive, proposals are only vetted by the SWG Coordinator for thoroughness and merit, but PIs must have prior project and budget approval from their supervisors, business managers, and grants staff before coordinating with other state agencies, universities, museums, etc.

Adaptive Management, Maintenance, and Communication Plan

Implementation will continue to be a dynamic process through time, involving monitoring process management, performance assessment, adaptation as new information dictates, and refocusing to new tasks and projects as appropriate. As discussed in Chapter 8, a major component of the SWAP's coordination and review will be dependent on successful monitoring of conservation projects and actions: effectiveness monitoring. In the long-term, effective review and revision of the Plan will depend on the effectiveness monitoring protocols and procedures. Conservation actions will have to be evaluated based on their ability to further the goals and objectives of the SWAP. As an agency, SCDNR sets project objectives and identifies measures of success for management actions. Adaptive management comes in the form of updating species lists as well as monitoring and changing course based on trend data and targeted research. As SWAP projects are evaluated, similar indicators of success will be defined at the strategy level.

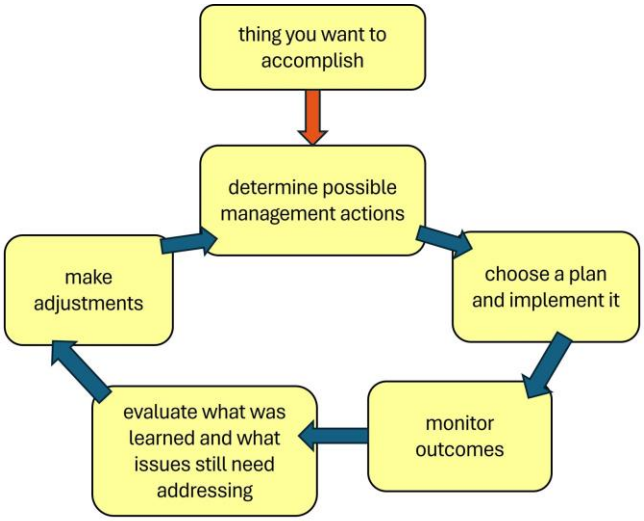


FIGURE 9-2: Adaptive management decision making cycle.

Adaptive management (Figure 9-2) is defined as a structured decision-making process that involves constant monitoring, re-evaluation as new information is learned, and adjusting to reach a desired outcome. It is a method that helps natural resource managers more effectively deal with uncertainties in dynamic ecological systems that are under threat from climate change, invasive species, habitat destruction, and other impacts. Utilizing this approach requires flexibility in management regimes. [Williams and Brown 2012]

Adaptive management requires constant communication between land managers and taxa experts. Likewise, the tool known as the Resist-Accept-Direct (RAD) Framework can guide resource managers in decision-making processes that are a part of adaptive management (CASC 2023). This framework helps land managers determine what desired future condition is needed on the landscape and to be wary of tipping points that may change it to a new steady state. Figure 9-3 defines each level of the framework. Land managers have the option of resisting change and instead returning the current ecosystem to its historic state through species reintroductions or augmentations (through breeding programs or translocations), accepting that changes are occurring and allowing the transformation to progress, or actively directing change to a new state using techniques like assisted migration of animals or planting tree species to establish them in areas that are already transitioning to support such species (Handler et al. 2018).

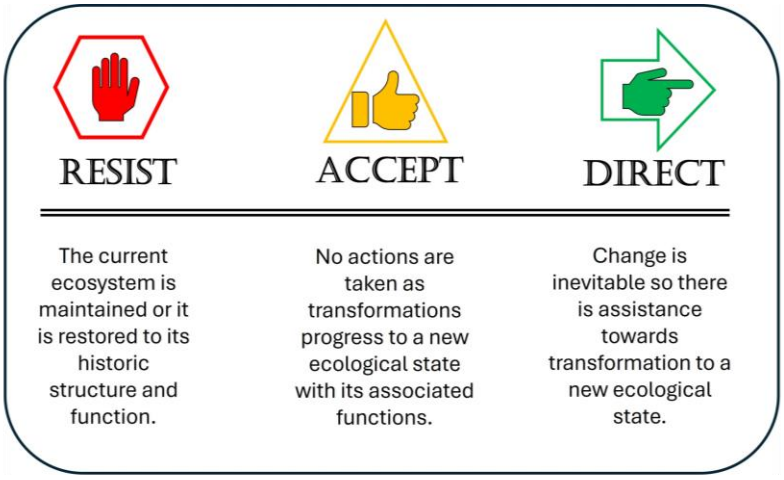


FIGURE 9-3: The Resist-Accept-Direct (RAD) Framework (graphic modeled after USGS).

Red-cockaded Woodpecker translocations can help re-establish colonies within the species' native range. Photos by SCDNR staff.

As a requirement of the USFWS, who oversees the SWG Program, project leaders are required to produce annual (interim) progress reports and final reports for review by the SWAP Coordinator, and these reports are evaluated for insight into adaptive management needs and reassessments of the SWAP. As in years past, final project reports will continue to be made available in an online repository linked to the SWAP website and summaries made available in this chapter of the SWAP. Interim and final reports are uploaded into the federal submission portals. Continued monitoring and evaluation of management actions will create an active implementation of the "living" SWAP document. Project leaders will also be involved in periodic communication efforts focused on increasing public awareness of SWAP implementation. Maintaining these communication links with the public and broader conservation community will be critical to the success of the SWAP.

Old editions of the SWAP will be archived by SCDNR and the newest version posted online and advertised through various social media platforms and through the *South Carolina Wildlife* magazine. Presentations by staff and partners at schools, workshops, conferences, public events, and other venues will introduce the SWAP and encourage citizen scientists and volunteers to contribute to its implementation. Even backyard habitat creation and Adopt-a-Highway programs are beneficial efforts to be encouraged as sustaining healthy ecosystems maintains diversity. Examples of public/partner engagement include:

- a June 2024 presentation at the Sustainable Forestry Initiative (SFI) Conservation Impact Workshop where SCDNR requested that SGCN be considered when determining Forests with Exceptional Conservation Value (FECVs) and harvest impacts;
- a year-long (December 2023 – December 2024) Natural Resources Conservation Service (NRCS) Learning Series where SCDNR experts presented on the major taxa groups in the SWAP so that NRCS staff could recognize them in the field and advise landowners of habitat management; and
- a presentation and nature walk with the Coastal Master Naturalists at Caw Caw Interpretive Center in April 2024 that focused on both native species and non-native invasive plant identification.

Review and Revision of the SWAP

As per Element 6 of the original legislation establishing the SWAP/SWG Program, all states made a commitment to review and revise the SWAP every ten years. The Program in South Carolina will continue to be reviewed on a 10-year cycle to ensure it and the SWAP remain relevant and current with evolving landscapes and developing conservation efforts. This cycle will include the previously described plans for monitoring, maintenance, adaptive management, review, and revision. Within the 10-year period, it is expected that certain matters may trigger a major revision of the SWAP or submission of

Presentations on the SWAP revision were made to conservation partners and input gathered. Photo by Sara Green, SCWF.

addendums or emerging issues letters (minor revisions) to the Plan. The identification of new information on species priorities gained through surveys, research, and monitoring or reprioritization of projects and actions following goal achievement will be recognized as adaptive management efforts requiring Plan reassessment. However, planning improvements such as (1) identification and elimination of flaws in the program or SWAP implementation process, (2) identification of more efficient or valid approaches to internal supporting processes such as species prioritization and threat assessment, and/or (3) expansion of those taxa groups treated only cursorily in this current SWAP document would contribute to the next iteration of the SWAP during a regular revision cycle. Technology is always advancing so that future issues may include new or improved range maps / species distribution models and habitat suitability models. The typical timeline of events for the revision of the SWAP are outlined in Figure 9-4.

TASKS	Two Year Timeline Divided by Quarters							
	Yr1 Q1	Y2 Q2	Y3 Q3	Y4 Q4	Y2 Q1	Y2 Q2	Y2 Q3	Y2 Q4
Letter of intent submitted to USFWS								
SWG planning grant written								
Taxa Teams formed								
Taxa Teams revise SGCN list								
Taxa Teams update species/guild accounts								
SWAP data gathering and chapter editing								
Indigenous Peoples / cultural groups engaged / review period								
Conservation Partners engaged and review period								
General public review								
Final compilation of comments, edits, and internal review								
Submit to USFWS								

FIGURE 9-4: Timeline of events required to complete a SWAP revision over two years.

State Wildlife Grant and Competitive State Wildlife Grant Project Summaries

Table 9-1 lists, in chronological order, SWG projects followed by summaries of each grant. Table 9-2 then follows as well as summaries of C-SWG projects. SWAP/SWG coordination and revision grants are not summarized as they are simply utilized to run the program in South Carolina and revise the SWAP. Pilot projects that evolved into other projects are summarized as noted. Due to personnel turnover, the author of the report may differ from the actual PI of the project for some of the earliest grants. This is noted in the title of each report. Also, there may be more PIs involved but only the lead(s) is/are listed. Grants currently still in progress are listed but not summarized. All final federal reports can be found online as part of SCDNR's SWAP page and go into more depth for each grant, including partners involved and if scientific publications or theses or dissertations resulted from them. It should be noted that many of these projects relied heavily on SCDNR staff but also involvement from partners in academia, conservation organizations, volunteers, and the general public, a testament to the breadth of SWAP implementation by both the professional and public sectors working cooperatively. The subjects of these projects range from research and survey of species or their habitats to habitat protection, enhancement, or restoration.

TABLE 9-1: State Wildlife Grants from 2005-present. T-1, T-3, T-12, T-18, T-22, and T-28 were unassigned numbers.

Federal Grant No.	Duration	Project / Grant Title
T-2-2 ***(see also T-26-R-1 & T-57-R-1)***	2004-2006	Herpetological Research and Survey in SC
T-4 ***(later became a part of T-13-R-2)***	2004-2005?	Swainson's Warbler and Swallow-tailed Kite Movements, Productivity, Survival, and Habitat Use
TT-5-1	2003-2011	Development of original CWCS
T-6 ***(continuation from WCRP R-3 grant)***	2004-2005	Census and Monitoring of Waterbird Nesting in the SC Coastal Plain
T-7-R-1	2006-2008	Conservation of Water and Seabirds in SC
T-8-R-1 ***(later became T-25)***	2005-2007	SC Stream Planning Project
T-9 F05AF00015	2004-2013	Robust Redhorse Restoration and Conservation
T-10-P ***(see also T-46)***	2005-2009	Landscape Planning for Priority Species on Agricultural Lands
T-11	2006-2008	Restoration of Longleaf Pine Forest on State Owned Land
T-13-R-2	2006-2009	Conservation of Migratory Landbirds in SC
T-14-T	2005-2009	Development of BMPs for Sustaining Wildlife in the Maritime Zone of SC
T-15-P	2005-2007	SC Reptile and Amphibian Conservation Planning
T-16-R	2005-2009	Upland Habitat Improvements on Lewis Ocean Bay Heritage Preserve
T-17-R	2006-2010	Protection and Management of Seabird Colonies (Monitoring/Breeding Parameters)
T-19-R	2006-2010	Habitat Enhancement on North and South Williman Islands, Beaufort County, SC
T-20	2006-2007	Status and Management Plan Development for Three Rare Burrowing Crayfish, *Distocambarus youngineri, D. hunteri,* and *Cambarus reflexus*
T-21-R	2007-2011	Coordination and Implementation of SC's CWCS (SWAP)
T-23-R-1 F06AF00025	2006-2011	Controlling Access to Known and Potential Bat Roosts
T-24	2006-2008	Fish Passage on the Broad River: An Assessment of Benefits of Freshwater Mussels
T-25-R-1 F06AF00028	2006-2013	SC Stream Conservation Implementation
T-26-R-1 F06AF00026 ***(see also T-2-2 & T-57-R-1)***	2006-2011	SC Reptile and Amphibian Conservation
T-27-R-1	2009-2012	Habitat Improvement for Grassland Birds
T-29	2007-2010	Coordination and Implementation of SC's CWCP (SWAP)
T-30-R	2007-2008	Taxonomy, life history, and distribution of the crayfish, *Procambarus echinatus*
T-31-R-1 F07AF00064	2007-2012	Assessing Introgressive Hybridization Within and Habitat Requirements of Native SC Redeye Bass
T-32-T-1	2007-2008	Restoring Seabird Nesting on Bird Key Stono Seabird Sanctuary
T-33-R-1 F07AF00062	2007-2012	Robust Redhorse Electrofishing and Radio Telemetry Tracking of the Great Pee Dee River, SC
T-34-HM-1 F07AF00063	2007-2014	Community Based Habitat Restoration and Large-Scale Resource Enhancement Through SCORE (multiple grant names)
T-35-R	2009-2010	Identification of Diamondback Terrapin Habitats in SC
T-36-HM	2008-2010	A GIS Model to Guide Landscape Scale Restoration at the Woodbury Tract and Hamilton Ridge Properties
T-37-T	2008-2010	Carolina Herp Atlas
T-38-R-1 F07AF00061	2007-2012	Mink Restoration and Monitoring Development Project
T-39-M-1 F08AF00087	2008-2013	Prescribed Burning Crew for SCDNR Lands
T-40-L	2008-2009	Conservation of Belfast Plantation, Phase I (acquisition)
T-41-R-1 F08AF00108	2008-2016	Conservation of Wading Birds, Shorebirds and Seabirds in South Carolina

T-42-R-1	2008-2009	Use of GIS to Assess the Demographic Isolation of RCW Groups in SC
T-43-R F08AF00110	2008-2017	Conservation of Migratory Landbirds in SC
T-44-R-1	2008-2010	Least Tern Reproductive Success on Rooftops
T-45-R-1	2008-2011	American Shad Culture and Stocking in the Edisto River
T-46-1-T F08AF00111 ***(see also T-10)***	2009-2012	Landscape Planning for Priority Wildlife Species on Agricultural Lands
T-47-R-1 F08AF00109	2008-2011	Conservation of Breeding Painted Buntings and Other Songbird Indicators in Early-successional Shrub-scrub Habitat Modified by CP-33 Buffers in SC
T-48-R	2008-2010	Effects of Predation on Seabird Nests in Cape Romain
T-49-R-1 F08AF00107	2008-2015	Sea Turtle Conservation on Botany Bay Plantation WMA
T-50-L	2009-2010	Conservation of Belfast Plantation, Phase II (acquisition)
T-51-R-1 F09AF00159	2009-2011	Ecology and Impacts of Coyotes on Loggerhead Sea Turtles, Least Terns, and Other Wildlife: Implications for Management
T-52-P-1 F10AF00421	2010-2017	Revision of South Carolina's Wildlife Conservation Strategy (SWAP)
T-53-R-1 F10AF00422	2010-2015	Striped Bass Stock Enhancement of Charleston Harbor Estuary/System (multiple grant names)
T-54-R-1 F10AF00443 Part 1	2010-2014	Monitoring Impacts of Yellow Pine Restoration on Avifauna in the SC Mountains
T-54-R-1 F10AF00443 Part 2	2015-2015	Relative abundance (CPUE) and distribution (habitat use) of Lionfish in the Southeast region based on Reef Fish Survey (video) observations
T-55-R-1 F10AF00444	2010-2012	Using Citizen Science in the Study and Conservation of Breeding Painted Buntings
T-56-R-1 F11AF00686	2010-2015	Continued monitoring of recently established crab trap-based oyster reefs to document their values as essential fish habitat for a diverse fauna in South Carolina (multiple grant names)
T-57-R-1 F11AF00666 ***(see also T-2-2 & T-26)***	2011-2016	SC Amphibian and Reptile Conservation
T-58-R-1 F12AF01378 ***(formerly T-45)***	2012-2015	Evaluation of American Shad Stocking in the Edisto River
T-59-R-1 F12AF01381	2012-2015	Composition of American Eels in Freshwater Habitats of SC and Their Infection Status by the Invasive Parasite Species, *Anguillicoloides crassus* (multiple grant names)
T-60-R-1 F12AF01382	2012-2015	Validation of Trammel Netting Monitoring Population Trends for Diamondback Terrapins in the Charleston Harbor Estuary (multiple grant names)
T-61-R-1	2012-2013	Decision Support Tools for Stream Conservation
SC-T-F13AF01180	2013-2015	Mapping and Classifying Tidal Freshwater Wetlands in the ACE Basin
SC-T-F13AF01182	2013-2014	Identification and Distribution of Crayfishes in South Carolina
SC-T-F13AF01183	2013-2016	Evaluation and Monitoring of the Santee River Basin Robust Redhorse Restoration Effort
SC-T-F13AF01185	2013-2015	Assessing the Status of MacGillivray's Seaside Sparrows (*Ammondramus maritimus macgillivraii*) in SC
SC-T-F13AF01207	2013-2015	Enhancement of Upstream Passage for American Eels at the St. Stephen Dam, SC
SC-T-F13AF01208	2013-2016	An Evaluation of Culturing Carolina Diamondback Terrapins for Responsible Stock Enhancement
SC-T-F14AF01233	2014-2020	South Carolina Small River Conservation Planning Project
SC-T-F15AF00727	2015-2018	Distribution, Population Ecology, Genetic Relatedness and Habitat Associations of Eastern Spotted Skunks in South Carolina
SC-T-F15AF00728	2015-2016	Using citizen-science to guide state-wide management of Diamondback Terrapins
SC-T-F15AF00730	2015-2017	Building partnerships on state, federal and private lands to promote conservation of seabirds and shorebirds
SC-T-F15AF00731	2015-2018	Potential Mechanism of Thermal Stress Impairment for Striped Bass Populations
SC-T-F15AF00729	2015-2017	Assessing the status of the Black Rail (*Laterallus jamaicensis)* in South Carolina
SC-T-F15AF00207	2015-2017	Continuation of the Carolina Herp Atlas
SC-T-F16AF00707	2016-2018	Conservation of seabirds, shorebirds, wading birds, and marsh birds in South Carolina (I)

SC-T-F16AF00708	2016-2020	Conservation of South Carolina Coastal Plain Reptiles and Amphibians (I)
SC-T-F16AF00598	2016-2017	Northern Yellow Bat Roost Selection and Fidelity in South Carolina
SC-T-F16AF00713	2016-2021	Optimal nesting microhabitat for Diamondback Terrapins in SC
SC-T-F16AF01121	2016-2019	Documentation of horseshoe crab nesting beaches and egg densities
SC-T-F16AF00714	2016-2017	Investigating the impacts of harvesting on ribbed mussel communities
SC-T-F16AF00720	2016-2018	Abundance and community composition of intertidal macrobenthic invertebrates
SC-T-F17AF00122	2016-2017	Participation by SC in the SEARS Program
SC-T-F17AF01196	2017-2020	Coordination of the SWG Program and Implementation of the SC SWAP
SC-T-F17AF01249	2017-2019	Atlantic Coast Joint Venture - Catalyzing Black Rail Conservation along the Atlantic Coast
SC-T-F17AF01208	2017-2020	Identifying Management Opportunities to Benefit Black Rails Nesting in Coastal South Carolina
SC-T-F17AF01207	2017-2019	Range, life history, and environmental tolerances of the Waccamaw crayfish (*Procambarus braswelli*) and the hummock crayfish (*Procambarus lunzi*) of near-coastal environments
SC-T-F17AF01195	2017-2020	SC Bat Monitoring and Research Project
SC-T-F18AF00026	2017-2019	Survey of Historic Flatwoods Salamander Localities
SC-T-F18AF00961	2018-2020	Conservation of seabirds, shorebirds, wading birds, and marsh birds in South Carolina (II)
SC-T-F18AF00962	2018-2022	Investigating dispersal of the invasive red swamp crayfish (Procambarus clarkii) and its effects on the distribution and status of native crayfish populations
SC-T-F18AF00964	2018-2021	Concentrations of organic contaminants in Carolina and Scalloped Hammerheads: Implications for success and survival in nursery habitats
SC-T-F18AF00965	2018-2020	Addressing crucial American Eel life history questions: Baseline data on the age and sex composition of American Eels in South Carolina, with a comparison of different aging methodologies
SC-T-F18AF00972	2018-2022	NABat monitoring in South Carolina
SC-T-F18AF00973	2018-2022	Green Salamander Population Assessment and Connectivity Across a Gradient of Forest Disturbance
SC-T-F19AF00717	2020-2022	Environmental DNA Determination of the Distribution of the Patch-Nosed Salamander (*Urspelerpes brucei*) in South Carolina
SC-T-F19AF00718	2019-2021	Response of Bachman's sparrow (*Peucaea aestivalis*) to habitat management in a wiregrass-free ecosystem
SC-T-F19AF00719	2020-2022	Effects of forest management on early-successional avian species in Carolina [GWWA, RUGR]
SC-T-F19AF00720	2019-2021	Identification of environmental and biological factors limiting occurrence of the Sandhills Chub (*Semotilus lumbee*) in South Carolina
SC-T-F19AF00722	2019-2020	Upstate Bridge Use by Highest Priority Bat Species
SC-T-F19AF00723	2019-2023	Utilizing trace elements and stable isotope analysis to reconstruct distribution of Scalloped and Carolina Hammerheads
SC-T-F19AF00749	2019-2022	Determining the relative importance of coastal habitat types to horseshoe crab reproduction and migratory shorebird foraging in South Carolina
SC-T-F19AF00750	2019-2020	Ecology of Estuarine Sensitive Infauna Along a Stress Gradient
SC-T-F19AF00779	2019-2022	Integrating crayfish into aquatic assessments from the uplands to the coast
SC-T-F19AF00780	2019-2022	Development, Testing, and Field Validation of an eDNA Tool for Robust Redhorse
F20AF11202-00	2020-2023	Microplastic Exposure for Key Ecological Species in Coastal South Carolina
F20AF11231-00	2020-2022	Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (III)
F20AF11283-00	2020-2023	Range and Roost Sites of Northern Long-eared Bats in South Carolina
F20AF11556-03	2020-2023	Coordination of the SWG and C-SWG Programs and Implementation of the SC SWAP
F21AF02397-00	2022-2023	Understanding Salt Marsh Loss Through Investigation of Periwinkle Fronts and Other Causes Across Multiple Spatial Scales
F21AF03242-01	2021-present	Conservation of South Carolina Coastal Plain Reptiles and Amphibians (II) Plus Blue Ridge Herps
F21AF03274-00	2021-2022	Determining the Importance of the South Carolina Coast to the Overwintering Survival and Reproductive Output of the Monarch Butterfly (*Danaus plexippus)*
F21AF03426-00	2021-2022	Developing Genetic Sequences for Benthic Prey Resources of Migratory Piping Plover and Red Knot
F21AF03593-03	2021-2024	Occupancy and Distribution of SWAP-listed Freshwater Mussel Species
F21AF03627-02	2021-present	Determining the Effects of Human Disturbance on the Ecology and Conservation Status of Populations of At-Risk Crayfish in the Genus *Distocambarus*
F21AF03715-00	2021-2023	Eastern Brook Trout Restoration in Pig Pen Branch and Lick Log Creek, Oconee County, South Carolina
F22AF03331-00	2022-present	Coastal Maternity Roost Sites of Five High Priority Bat Species

F22AF03386-00	2022-2024	Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (IV)
F22AF03387-02	2022-2024	Taxonomic Revision of Procambarus Crayfishes in South Carolina
F22AF03590-00	2022-present	High Resolution Acoustic Telemetry Array in the Edisto and Savannah Rivers
F22AF03676-01	2023-present	Edisto River Flow Effects on Summertime Water Temperatures: Are Thermal Tolerances of SWAP Fishes Exceeded at Low Flows?
F22AF03703-01	2023-present	Seasonal Patterns of Horseshoe Crab Spawning and the Relative Importance of Horseshoe Crab Eggs Within the Diets of South Carolina Shorebirds
F22AF03704-02	2023-present	Horizontal Movements of Carolina Hammerheads (*Sphyrna gilberti*) in the Western North Atlantic Ocean
F22AF03776-00	2023	Pilot Project to Document Presence of Sea Turtles in South Carolina Estuarine Waters in an Effort to Reduce Impacts of Watercraft on Endangered and Threatened Sea Turtles
F23AF02951-01	2023-2025	Genetic Characterization of Monarch Butterflies in South Carolina
F23AF03075-00	2023-present	Assessing Occurrence and Habitat Associations of Six Priority Small Mammal Species in High Elevation Appalachian Forests of South Carolina
F23AF03100-01	2023-2025	Planning for the 2025 SWAP Revision and Program Coordination
F23AF03154-01	2023-present	Exploration of Subtidal Oyster Presence in Areas Historically Identified as Supporting Subtidal Populations
F23AF03206-01	2023-present	Using Unmanned Aerial Systems (UAS) Technology to Understand the Relationship of Microhabitat to Estuarine Fish Species
F23AF03212-01	2023-present	Innovative Fish Aging Methods Using Near-infrared Spectroscopy Techniques to Understand Changes in Population Demography: Calibration Model Development for Bonnethead Shark
F24AF02859-01	2024-present	Distribution and Roost sites of Gray Bats in Northwestern South Carolina
F24AF02999-00	2024-present	Conservation of Seabirds, Shorebirds, and Wading Birds in South Carolina (V)
F25AF00610-00	2025-present	Exploration of a New Emerging Threat: Microplastics in Water, Sediment, and SWAP-listed Species in Charleston Harbor
F25AF00262-00	2025	Closing the Loop on the Horseshoe Crab Life Cycle from Eggs to Adults: Surveying Horseshoe Crabs Across Life Stages in Coastal South Carolina
F25AF00609-00	2025-present	South Carolina Horseshoe Crab Genetic Health Reassessment

Regular SWG Project Summaries

Herpetological Research in South Carolina (Federal Grant #: T-2-2 *See T-57-R-1 for summary*)

Swainson's Warbler and Swallow-tailed Kite Movements, Productivity, Survival, and Habitat Use (Federal Grant #: T-4 *See T-13-R-2 for summary*)

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

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

Grant T-7 funded the monitoring and management of waterbirds nesting on the South Carolina Coastal Plain from October 2006–September 2008. Bald Eagle surveys and ground visits were used to document chick production, estimate mortality rates, and assess population levels. Colonially nesting wading birds were surveyed. More extensive surveys were conducted at Wood Stork colonies to document nest numbers and to estimate productivity. A decline in numbers of colonially nesting wading birds that may be due to loss of habitat and drought

conditions was documented. Movements from natural wetlands to constructed wetlands and an increase in human-bird interactions was observed. Censuses were conducted for 6 species of seabirds, and signs were posted to protect sensitive nesting areas. Least Terns nesting on rooftops were surveyed. American Oystercatchers were surveyed and banded to yield data that will improve regional estimates of survival. Research projects conducted by 3 graduate students at Clemson University were supported and coordinated. Research topics include seabird/human disturbance, techniques to enhance Oystercatcher productivity, and identifying preferred winter foraging habitat for Oystercatchers.

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

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

The objective of this project was to establish self-sustaining populations of Robust Redhorse, (*Moxostoma robustum*), suckers in the Santee River Basin using Savannah River brood stock. The first step was to stock the Santee River Basin with cultured Savannah River strain Robust Redhorse (RRH). The Santee Basin was identified as a potential population establishment site because its size, location between two identified population, and evidence of historical RRH occurrence in the drainage. A primary consideration of this effort was to use progeny from 100 pairings to ensure that the new population would be genetically diverse. Brood stock collection was made from a numerically healthy and geographically nearby population of Savannah River RRH. Fish were collected during their natural spawning activities over a mid-channel gravel bar using stationary electro-fishing grids and a mobile electro-fishing boat. Eggs and milt were immediately collected from the actively spawning adults, and fertilization occurred individually between eggs from one female and milt from one male. Depending on the quantity, a female's eggs were divided between 1 and 3 males. Fertilized eggs were transported to the Bayless Hatchery for incubation and hatching. Grow-out was made in production ponds at the Dennis Wildlife Center. Spawning efforts occurred in every spring from 2004-2013.

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

We also surveyed and monitored the growth, survival, maturation, and spawning success as well as habitat use of stocked RRH in the Santee River Basin and monitored existing populations in

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

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

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

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

Landscape Planning for Priority Wildlife Species on Agricultural Lands (*Combined Summaries* for Federal Grants #: T-10-P and T-46-1-T, Duration: 2005-2009 / 2009-2021) PI: Judy Barnes (SCDNR, retired); Author: Billy Dukes (SCDNR)

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

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

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

The objective of T-11-1-R was to restore Longleaf Pine forests and associated herbaceous species on a minimum of 1,000 acres of state-owned lands. Accomplishments included herbicide treatment of 45 acres of established longleaf stands to reduce competing hardwood vegetation on three SCDNR-owned heritage preserves. Twenty-five acres of new longleaf plantings (8,000 seedlings) were established on Little Pee Dee River Heritage Preserve and 8500 containerized Longleaf Pine seedlings were interplanted within 42 acres of sparse existing stands of Longleaf Pine on Longleaf Pine Heritage Preserve. Re-establishment and/or improvement of 14 miles of firebreaks and prescribe burning of 1,213 acres of longleaf stands occurred on Woods Bay and Longleaf Pine Heritage Preserves. Aerial herbicide site preparation and planting of 14,000 Longleaf Pine seedlings was conducted to convert 25 acres to Longleaf Pine on Congaree Bluff Heritage Preserve. Site preparation and planting of 25 acres of Longleaf Pine was accomplished at Janet Harrison High Pond Heritage Preserve. Herbicide release of competing vegetation with 40 acres of longleaf was conducted at Longleaf Pine and Lynchburg Savannah Heritage Preserves. Understory brush control was utilized in 140 acres of longleaf stands at Webb Wildlife WMA. The construction of 18 miles of new firelanes at Lewis Ocean Bay Heritage Preserve was also accomplished as well as 162 acres of site prep and Longleaf Pine establishment at Woodbury WMA. McBee WMA underwent 8 acres of longleaf planting while 25 acres of longleaf plantings were done at Hamilton Ridge WMA. Site prep and planting of 831 acres of Longleaf Pine at Manchester State Forest was also accomplished. Mechanical understory control of competing vegetation in 32 acres of Longleaf Pine stands at Lewis Ocean Bay Heritage Preserve and herbicide timber stand improvement of 40 acres at McBee WMA was completed. The total longleaf habitat improvements made equaled 1,510 acres with new Longleaf Pine stands established on 1,135 acres.

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

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

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

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

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

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

SC Sea Grant office, SC Wildlife Federation, Coastal Conservation Association, and a number of private citizens. Additionally, the complete document was made available on the SCDNR website with 1,429 requests for the document being made in the first month after publication.

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

This multi-task project included 4 separate jobs for 4 separate priority species: Gopher Tortoise Eastern Diamondback Rattlesnake, Timber Rattlesnake, and seepage slope salamander species. Each job will be addressed in its own section.

Gopher Tortoise Management – The objective of this job was to develop a plan to recover and enhance the Gopher Tortoise population at Aiken Gopher Tortoise Heritage Preserve (AGTHP) in Aiken County to include the re-stocking of tortoises from the surrounding habitat and from other sites in South Carolina. Three 1 ha (2.5 ac.) pens were established on site at the Aiken Gopher Tortoise Heritage Preserve to provide an area to house relocated tortoises. These pens housed groups of tortoises for approximately one year and then were removed to allow the tortoises to become "established" in their new environment. Waif Gopher Tortoises were received from a variety of different places within the Southeastern US, and several federal and state agencies and placed into the pens. Pen 1 housed waif tortoises from the Southeast and a group of hatchling tortoises from Hilda, SC that were contained within the pen under a separate hatchling enclosure. Pen 2 contained tortoises that were trapped on the AGTHP and considered to be the "resident" group. Efforts were made to trap and relocate all known Gopher Tortoises occurring on the site. In addition, aprons of AGTHP tortoises were excavated during the summer of 2007 by Tracey Tuberville (UGA-SREL) and Kurt Buhlmann (SCDNR). One Gopher Tortoise nest containing two eggs was found. One of the eggs hatched, the other was infertile. That hatchling is small and is currently being maintained at SREL with the intention of adding it to the Pen 2 population in the spring of 2008. Pen 3 was used to house a group of Gopher Tortoises from a private property owner near the town of Grays, SC. In addition, two separate introductions of hatchling tortoises were made to Pen 3 during the Project period. Six hatchlings from laboratory-hatched eggs from the Tillman Sand Ridge Heritage Preserve were released into Pen 3 with starter burrows during summer 2007. An additional 6 hatchlings (also form Tillman Sand Ridge HP) were released into Pen 3 but covered under an 8 ft. x 8 ft. wire mesh cage in the autumn of 2007. The intention of the cage was to prevent predation by Coyotes, crows, or Raccoons. To date, the hatchlings seem to be surviving under the cages.

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

Diamondback Rattlesnake Management – The first objective of this job was to determine the feasibility of managing rattlesnake populations by translocating Eastern Diamondback Rattlesnakes to sites with appropriate habitat within the historic range of the species, and to develop a model for Eastern Diamondback Rattlesnake demography to include population size, survivorship, mortality, growth patterns, age classes, and sex ratio. The second objective was to conduct research and monitoring at the Webb Wildlife Center (continuation of ongoing

monitoring) and at least 3 other public properties in the SC Coastal Plain that support Longleaf Pine habitat. Another task was to determine the potential distribution of Longleaf Pine habitat on public properties in the SC Coastal Plain using a qualitative vector GIS model.

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

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

Timber Rattlesnake Surveys – The objectives of this job were to (1) determine the distribution of the montane phase and the Coastal Plain phase of this species in the region and to (2) develop a management strategy for the Timber Rattlesnake on public lands in South Carolina. (3) The population size and demography at selected sites had to be determined and included gathering information on population structure, sex ratios, mortality, reproductive success, survivorship, and mortality. (4) The home range size had to be determined as well as habitat use and seasonal activity patterns for both "forms" of this species in this region using radio telemetry.

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

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

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

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

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

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

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

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

better evaluate the health and condition of seabird populations in South Carolina in relation to the new regulations and for future comparisons. Research was conducted from 2006 to 2008.

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

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

This was a large, non-native invasive species eradication project that occurred on North Williman Island and South Williman Island which are located in north Beaufort County, South Carolina. Both islands exceed 1,000 acres in total size, and both are composed of a mosaic of tidal estuarine marshland and interspersed hammocks (small upland islands also called hummocks). These islands are State-owned and are under the management authority of SCDNR.

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

Habitat enhancement activities for this project were performed primarily on the largest hammocks within both North Williman Island and South Williman Island, hereafter referred to as "Goat Island" (436.4 acres) and "Big South Williman Island" (668.4 acres), respectively. Chinese Tallowtree was particularly abundant and problematic in association with isolated freshwater depression wetlands. Such freshwater wetlands are most abundant on the largest hammocks within both North Williman Island and South Williman Island, and particularly on "Goat Island" and "Big South Williman Island". Chinese Tallowtree out-competes many native

plants and, as observed in isolated wetlands on both North Williman Island and South Williman Island, may ultimately produce nearly mono-species stands. Fallen leaves of Chinese Tallowtree can alter water chemistry and water quality and may negatively impact populations of some amphibians. Additionally, dense populations of Chinese Tallowtree may limit surface water availability and alter hydrology in isolated wetlands due to high water demand and heightened evapotranspiration during late spring through early fall.

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

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

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

Primarily due to funding limitations, habitat enhancement on South Williman Island was limited to the placement of Wood Duck (*Aix sponsa*) nesting boxes (one box each) in 7 isolated wetlands

within "Big South Williman Island". Two Wood Duck nesting boxes were placed in an isolated freshwater wetland on "Goat Island". Wood Duck had been recorded in winter on both islands during initial SCDNR surveys, but no evidence of nesting was observed prior to these habitat enhancement efforts. All nesting boxes were erected in late winter 2008, and all boxes were inspected for signs of Wood Duck nesting activity during each spring, 2008-2010. One, 2 and 6 boxes were used by nesting wood duck in 2008, 2009, and 2010, respectively. The observed increase in nest box utilization over the 3 years of observations suggests a likely increase in the local Wood Duck population in the vicinity of the Williman Islands, potentially in response to the provision of nesting cavities.

In addition to the aforementioned habitat enhancement activities, complimentary habitat enhancement and restoration activities were achieved on "Goat Island" through a Cooperative Agreement between the United States Department of the Interior, Fish and Wildlife Service and SCDNR from 1 August 2008 through 30 June 2010. The Cooperative Agreement included: (1) the follow-up eradication of Chinese Tallowtree (mostly seedlings); (2) the removal of dead tree-stage Chinese Tallowtree snags (trees killed by herbicide injection in late 2007 and early 2008) from 3 isolated wetlands which previously had particularly dense stands of this invasive plant; and (3) the damming of old historic drainage ditches associated with 5 isolated wetlands. Positive responses of native plants, plant communities and wildlife observed on "Goat Island" through the completion of this project should be attributed to habitat enhancement activities achieved through both this project and the Cooperative Agreement.

"Goat Island" was more severely negatively impacted by the combined impacts of feral goats and Chinese Tallowtree than was any other hammock within either North Williman Island or South Williman Island. Both habitat restoration, as observed through positive responses of native plants and plant communities, and positive responses of wildlife were most obvious on this North Williman Island hammock. Habitat enhancement and restoration activities yielded a nearly immediate positive response in recovery of native plant communities, particularly in and near isolated wetlands and on the periphery or outer upland fringe of hammocks that had been drastically impacted by browsing goats. Wetland plant diversity increased dramatically, as demonstrated by a threefold increase in recorded plant species diversity in one isolated wetland as compared to the recorded diversity prior to habitat enhancement activities. Buttonbush (*Cephalanthus occidentalis*), which is a valuable wetland wildlife plant, responded dramatically to the removal of over-shading Chinese Tallowtrees and to the removal of feral goats. Prior to habitat enhancement activities, buttonbush was fairly widespread and abundant in wetlands on "Goat Island", but practically all specimens were in poor condition and few, if any, specimens produced blooms or seeds. Following habitat enhancement activities, buttonbush specimens throughout wetlands on "Goat Island" displayed dramatic growth of new stems and foliage and produced abundant flowers and seeds by 2009 and 2010. Plants typical of the upland-tidal marsh ecotone recovered from severe browsing with sprouting of new growth and by recolonization from seedlings. Sweetgrass plantings in peripheral upland areas of "Goat Island" were very successful and supplemented natural colonies of native grasses, including several naturally occurring sweetgrass colonies which slowly recovered and became established after goat removal. The recovery of this forest edge habitat should provide additional breeding and foraging habitat for Painted Bunting (*Passerina ciris*), a species of highest conservation priority in South Carolina and throughout the region. The recovery of forested plant communities and

habitats was more subtle since much of "Goat Island" and other North Williman Island hammocks are covered in closed canopy forest. Subcanopy shrubs, saplings, and herbs slowly responded with resprouting from previously heavily browsed trunks and stems and from rootstock. Also, substantial and diverse germination from the seedbank was observed. Prior to removal of feral goats, seedlings—including those of Chinese Tallowtree—were quickly consumed and were rarely observed. Several decades will likely be required for subcanopy plant communities to recover to a stage similar to such communities on nearby hammocks that have not been impacted by feral goats. With further recovery of shrub thickets and habitat complexity anticipated for "Goat Island" over the next several decades, additional recruitment of breeding birds will likely occur as gradually recovering habitats become suitable as nesting and brood-rearing habitat.

Amphibians and dragonflies were quickly recruited to depression wetlands that displayed enhanced surface water duration following removal of Chinese Tallowtree and damming of drainage ditches. Increased surface water retention in such isolated wetlands on "Goat Island" will likely sponsor an increased distribution of "Lunz's Crayfish"—or Hammock Crayfish—(*Procambarus lunzi*), a species of conservation priority in South Carolina, as well as other aquatic animals as well. Increased surface water retention may also attract American Alligator (*Alligator mississippiensis*) to additional wetlands on "Goat Island", which could result in the creation of dens and pools that may further enhance wetlands for potential colonization by additional aquatic species.

A rookery used by 4 species of wadingbirds was found in the largest wetland on "Goat Island" during SCDNR surveys in spring 2006. The removal of hundreds of large Chinese Tallowtrees from the perimeter of this wetland may have improved the quality of this wetland for wadingbird nesting and foraging habitat. Both White Ibis (*Eudocimus albus*) and the endangered Wood Stork *(Myctera americana*) were observed in higher numbers in association with this wetland after the removal of Chinese Tallowtrees, indicating that access to shallow water foraging sites was improved. Wading bird nests were not observed in Chinese Tallowtrees in spring 2006 or in spring 2007, and all wading bird nests were in either buttonbush or Coastal Plain willow (*Salix caroliniana*). Both of these native wetland plants responded very positively with enhanced growth following the eradication of competing Chinese Tallowtrees. By the spring of 2010, 5 species of wadingbirds, all of which are considered priority conservation species in South Carolina, were recorded within the rookery in this wetland. Also, 2 Great Blue Heron (*Ardea herodias*) nests were constructed in large pines bordering a small, open, isolated wetland on "Goat Island" in spring 2010. No wading bird nesting activity had been observed in association with this wetland prior to the eradication of many large Chinese Tallowtrees that had dominated the perimeter of this and other wetlands.

Habitat restoration and enhancement efforts on North Williman Island—particularly on "Goat Island"—and on "Big South Williman Island" yielded varied positive ecological impacts. The gradual recovery of habitats and plant communities should continue well into the future throughout North Williman Island hammocks on which habitat restoration and enhancement activities were conducted under this and the complementary Cooperative Agreement. Particularly for "Goat Island", where the most intensive habitat enhancement efforts were made and where feral goats had drastically impacted nearly all habitats by over-browsing, native plant

communities and associated wildlife should continue to show positive responses well into the future. However, since seeds of Chinese Tallowtree are very resilient within the seed-bank and can also be transported by birds and by water, future herbicide control of this aggressively invasive plant on hammocks of North Williman Island may be necessary to prevent recolonization by Chinese Tallowtree. Because of the positive results of efforts on hammocks of North Williman Island, serious consideration should be given to the expansion of Chinese Tallowtree eradication throughout the hammocks of South Williman Island, where many isolated freshwater wetlands remained heavily colonized by Chinese Tallowtree at the end of this project in 2010.

Status and Management Plan Development for Three Rare Burrowing Crayfish, *Distocambarus youngineri*, *D. hunteri*, and *Cambarus reflexus* (Federal Grant #: T-20, Duration: 2006-2007) PI: Jennifer Price (formerly SCDNR); Author: Jim Bulak (SCDNR, retired)

The purpose of this study was to create habitat models for 3 species of crayfish of conservation concern in South Carolina - *Distocambarus youngineri, D. hunteri, and Cambarus reflexus.* For the two species of *Distocambarus,* soils data were used to predict occurrence sites. The developed habitat model was a significant predictor of *D. youngineri* occurrence. This species was found in Piedmont prairie habitat. Future management efforts should focus on acquiring property with prairie or savanna-like vegetation structure in the Piedmont. Perhaps due to a severe drought during the collection period, *D. hunteri* was not collected during the study. Future efforts should use genetic techniques to verify collections of *D. hunteri;* its status of "critically imperiled" is appropriate.

Cambarus reflexus habitat was modeled at the Webb Wildlife Center, Palachucola Wildlife Management Area (WMA), and Hamilton Ridge WMA. Model selection indicated that the presence of wiregrass (*Aristida* sp.) was the most important habitat component, indicating *C. reflexus* was associated with high quality, fire-maintained, pine savanna habitats in the Coastal Plain. The species appears to be limited to the Coastal Plain and sensitive to soil surface disturbances. Management should focus on maintaining remnant pine savanna stands with prescribed burns to help maintain this species.

Controlling Access to Known and Potential Bat Roosts (Federal Grant #: T-23-R-1 F06AF00025, Duration: 2006-2011) PI and Author: Mary Bunch (SCDNR, retired)

Human disturbance is a very significant threat to bat colonies. Disturbance can be in the form of recreational caving, mining, or exclusions or disruptions to natural or man-made roosts. This project sought to protect some important bat roosts from human disturbance and to find new bat colonies. When awarded funding in 2006, White-nose Syndrome (WNS), a disease of hibernating bats, had not yet been discovered.

We assessed known roosts for suitability to bat-friendly gating or other measures to reduce disturbance. Sites with priority species from South Carolina's Comprehensive Wildlife Conservation Strategy (CWCS), the Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*), Southeastern Myotis (*Myotis austroriparius*), and Small-footed Myotis (*Myotis leibii*) were

given highest priority, but other bat species would also benefit from the work. We partnered with the US Forest Service and The Nature Conservancy to erect 6 bat-friendly gates at 5 locations and modified an existing barricade to allow bat passage at another site. We also sought to place a bat-friendly cupola on an open shaft to a tunnel but lacked sufficient funds for such a large project. We planned to erect a fence (site was not suited to gating) around the state's largest southeastern bat colony, but state parks declined the fence because they didn't want to maintain a fence. We mapped 338 potential mine sites and 17 old wells. All of the wells and 54 of the mine sites were evaluated. None of the wells were good bat habitat. Many of the old mine sites had no underground structure but we did locate 8 mine adits with Tri-colored Bats (*Perimyotis subflavus*). Of those, 5 would be suitable for gating.

Concrete bat roosts were built at 4 locations to serve as alternate roosts for Rafinesque's Big-eared Bats where known roosts were imperiled or limited. Other bats will also use the structures. Currently, all of those new roosts are in use by bats. After dramatic WNS related mortality was noted in other colonial hibernating bats typical to our mountains, we provided bat boxes to 3 state parks with known vulnerable colonies (threatened by exclusion), with great success at one of the parks.

Fish Passage on the Broad River: An Assessment of the Benefits to Freshwater Mussels (Federal Grant #: T-24, Duration: 2006-2008) PI: Jennifer Price (formerly SCDNR); Author: Jim Bulak (SCDNR, retired)

The objective of this work was to determine the effects of a newly constructed fish passage facility on the Broad River in Columbia, SC to freshwater mussel populations. Surveys were conducted on the Broad River, upstream of the dam, and on the Broad and Congaree Rivers, downstream of the dam. Nine species of mussels were downstream of the dam and 4 species were observed in upstream areas to Parr Reservoir. The Broad River upstream of Parr Reservoir contained sparse populations of mussels, possibly due to habitat degradation associated with sedimentation. Efforts were made to collect gravid females and determine the seasonality of reproduction of the various mussel species. Peak reproduction and release of glochidia generally occurred in April through June, though this general trend exhibited variability among the various species. Fish host evaluation was conducted for 6 species of mussels - *Ligumia nasuta, Elliptio roanokensis, Lampsilis cariosa, Lampsilis radiata,* and *Elliptio congarea.* Results suggest that the fish lift will benefit mussel populations upstream of the dam (to Parr Reservoir) as increased passage of glochidia-carrying fishes from the more species rich areas downstream of the dam should increase colonization potential. Continued monitoring is recommended.

South Carolina Stream Conservation Planning Project [SC Stream Assessment] (Federal Grant #: T-25-R-1 F06AF00027 *[formerly T-8]*, Duration: 2006-2013) PI and Author: Mark Scott (SCDNR); Map created by Kevin Kubach (SCDNR)

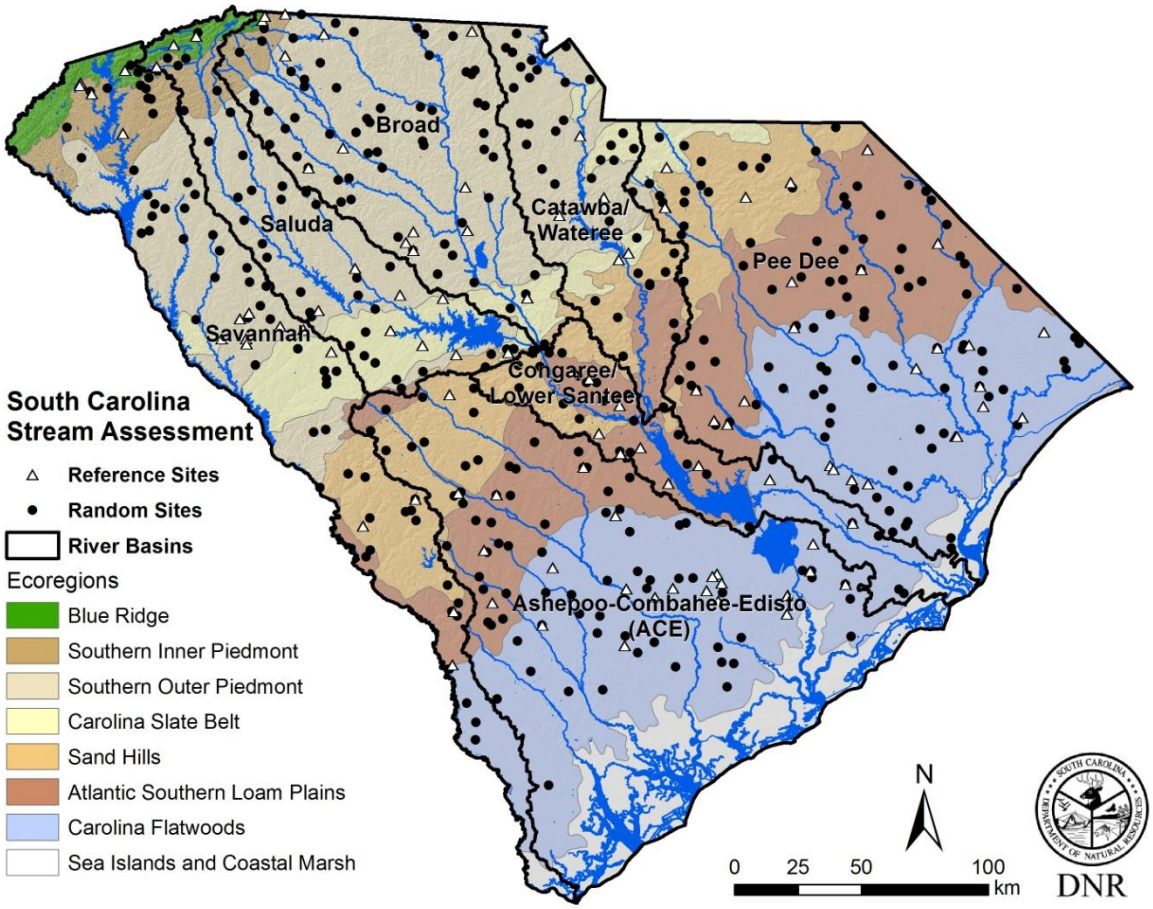
The objective of this project was to conduct an assessment of wadeable streams to gather appropriate data that will allow SCDNR to design effective and efficient management strategies to protect, conserve, and restore the aquatic resources of the State. Freshwater species worldwide face accelerated extinction rates relative to most other wildlife taxa. The Southeastern US, in particular, has been suffering long-term declines in native species of fish and aquatic

invertebrates. SC SWAP species of concern number well over 100 fish, reptiles, amphibians, mussels, crayfish, and snails that are directly dependent on aquatic systems for most or all of their life-stages. Common threats appear in their species accounts, generally associated with pollution from point- and non-point sources. Reversing the decline of native aquatic species requires an understanding of factors that are critical for maintenance of suitable habitat capable of supporting sensitive taxa. It follows that we must also understand the threats that degrade the quality of aquatic habitats to the point where they no longer support vulnerable species. The South Carolina Stream Assessment was designed to provide information to fill these gaps.

Watersheds of appropriate size (4 km^2 to 150 km^2) were sampling units stratified by unique combinations of ecoregion and major river basin in the state, called "ecobasins". Two methods of watershed selection were employed. The first method established long-term annual monitoring of least-impacted, or reference, watersheds, identified by biologists familiar with the region. This method is intended to provide expected resource condition as well as range due to temporal variability. The second method employed random selection of watersheds within ecobasin strata to allow statistically defensible estimates of statewide resource parameters from the sample data. Data collection was identical in both sampling designs, occurring at two spatial scales:

- *Watershed* – Point-sources as measured by NPDES permits; non-point sources as measured by appropriate land use/land cover classes in entire basin and within riparian buffer, hydrological disruption as measured by impounded area or occurrence of dams.
- *Stream Reach* – Selected measures of channel geomorphology and flow characteristics, water quality, and vertebrate and invertebrate community structure.

The Stream Assessment project ran from 2006 to 2013, with the data collection phase completed in 5 years and resulting in nearly 700 samples, each of which has over 200 associated variables that reside in an Oracle database titled StreamWeb. Estimates of stream resource condition have been calculated and mapped, and a number of publications and presentations have been produced to communicate various aspects of these data and results.



South Carolia Reptile and Amphibian Conservation (Federal Grant #: T-26-R-1 *See T-57-R-1 for summary*)

Habitat Improvement for Grassland Birds (Federal Grant #: T-27-R-1, Duration: 2006-2012) PI: Tim Ivey (SCDNR, deceased); Author: Brett M. Moule (SCDNR, retired)

The goal of this project was to improve grassland bird habitat on Oak Lea Wildlife Management Areas (WMA), Bland Tract WMA, and Tuomey Tract WMA by developing and implementing various management strategies (e.g. burning, mowing, disking; creating fallow buffers and fallow fields; establishing Longleaf Pine and native grasses) and monitoring bird population responses. Over the course of the grant period, 496 acres were winter disked to improve brood rearing and songbird habitat. In order to improve native grass habitat, 1,247 acres were burned while 2,095 acres were disked, fertilized, and planted to enhance forage for dove, quail, and migratory songbirds. Fallow buffer areas totaling 410 acres were maintained. Soft mast seedlings (6,200) and hardwood mast trees (400) were planted.

Fall quail covey counts were conducted on Oak Lea WMA, Bland Tract WMA, and Toumey Tract WMA in either October or November each year. Survey points were established on all 3 tracts, and summer quail and songbird surveys were conducted in July. These call counts were continued annually to monitor the impacts of management activities on quail and grassland birds.

Dove banding was conducted each year as part of the Eastern Management Unit project. Quail banding occurred the first year with walk-in trap sites to monitor impacts of hunting on the population.

Taxonomy, Life History, and Distribution of the Crayfish, *Procambarus echinatus* (Federal Grant #: T-30-R, Duration: 2007-2008) PI: William Poly (formerly SCDNR); Author: Jim Bulak (SCDNR, retired)

The goals of this project were to examine the distribution, abundance, life history, and taxonomic status of the Edisto Crayfish (*Procambarus echinatus*), a crayfish species of conservation concern. Surveys were made in the Salkehatchie, Edisto, Ashepoo, and Coosawhatchie River drainages. Detailed, quantitative sampling was conducted at 3 specific sites within these drainages. Collections indicated that *P.echinatus* was common in the study area, suggesting the perceived rarity of the species was associated with limited sampling for crayfish in these systems. The habitat for this species was undercut banks with root masses and accumulations of leafy debris in areas of good flow. Collections indicated that a new, distinct species, similar to *P. echinatus*, may be found in the South Edisto River and its tributaries as there was a substantial difference in the size of the structure of reproducing adults. This species was found in similar habitat to *P.echinatus.* Some concern exists that continued population expansion in Aiken County could impact the South Fork Edisto River crayfish. Additional monitoring of this perceived new species is recommended.

Assessing Introgressive Hybridization Within and Habitat Requirements of Native South Carolina Redeye Bass (Federal Grant #: T-31-R, Duration: 2007-2012) PI and Author: Jean Leitner (formerly SCDNR)

A survey was conducted to assess genetic impacts of Alabama Bass (*Micropterus henshalli*) introductions to Redeye Bass (*M. coosae*) in the Savannah Basin. Analysis was completed for N=669 Black Bass collected in 2004, and N=632 black bass collected in 2010 from reservoir sites on Lakes Russell, Hartwell, Keowee and Jocassee. Species composition was compared and showed a precipitous decline in Redeye Bass collected from 2004 to 2010. Our 2004 survey indicated redeye bass had been virtually eliminated from Lakes Keowee and Russell, where they comprised 0% and 2% of black bass collected, respectively. Collections in 2010 show little change in Redeye Bass proportions from these two lakes, but a decline is evident in Lakes Hartwell (from 26% to 8%) and Jocassee (from 39% to 14%). Hybrids between the two species were prevalent in collections and ranged across years/reservoirs from 26% to 54% of black bass collected. Proportions of hybrids increased from 2004–2010 on all but Lake Russell.

Genetic analysis of black bass collected from Savannah basin tributaries in 2009 and 2010 confirmed non-natives and/or hybrids from 5 of 9 collection sites, and from at least one tributary associated with each of 3 reservoirs. Three of these collections represent new documentation of Alabama Spotted Bass hybrids, as we collected only native black bass from those sites in 2004. The potential for the spread of Alabama Spotted Bass and their hybrids from the reservoirs to additional tributary populations is indicated. A new incidence of the non-native Smallmouth Bass (*M. dolomieu*) and their hybrids was documented in the Savannah River, as was the

presence of an extant Redeye Bass population throughout the Enoree River in the Santee drainage.

A GIS database was developed that includes all Savannah and Santee basin black bass collections associated with this study (2004–present), all Savannah and Santee Basin South Carolina Department of Natural Resources stream team collections made within the range of Redeye Bass (2008–present), and all historic South Carolina stream database collections that include record of Redeye Bass (1962–2002). The spatial distribution of tributary collections that included hybrids between Alabama Bass and Redeye Bass provides important information with respect to the spread of non-native black bass alleles in the Savannah Basin. Tributary populations where hybrids have been collected were those in closest geographic proximity to the reservoirs, within which non-native alleles are already widespread. Our results indicate that the spread of Alabama Bass alleles into the sampled tributary populations is the result of upstream movement from the reservoirs.

New genetic assays for the mtDNA locus ND2 were successfully developed. ND2 is one of 4 loci used to differentiate the species of black bass found or having genetic influence in South Carolina populations. Previously, sequencing of all loci was necessary to classify individual fish as a particular species or hybrid. Primers were designed for haplotypes specific for Largemouth Bass (*M. salmoides*), Florida Bass (*M. floridanus*), Alabama Bass, Redeye Bass, and Smallmouth Bass. These new assays provide a new tool, less expensive and time consuming than sequencing, for the evaluation of hybridization among black bass in South Carolina.

In an effort to assess the status of Redeye Bass in the Santee drainage as native or introduced, species of minnow were collected from sites within the Santee, Tennessee (French Broad), and Savannah River drainages. Genetic divergence among drainages, and diversity within drainages, was compared to that for Redeye Bass in the Savannah and Santee drainages. The Santee population of Redeye Bass is not genetically differentiated from populations collected throughout the upper Savannah River drainage. In contrast, Saffron and Warpaint Shiner populations collected in the Savannah and Santee drainages are significantly differentiated from each other. Pair-wise comparisons between individuals sampled from these 2 drainages, for 2 loci, were significantly differentiated. Results indicate that the Santee Basin Redeye Bass populations evaluated here are the result of a more recent, and likely human-mediated, introduction of fish originating from the Savannah Basin.

Restoring Seabird Nesting on Bird Key Stono Seabird Sanctuary (Federal Grant #: T-32-T-1, Duration: 2007-2008) PI and Author: Felicia Sanders (SCDNR)

Bird Key Stono Seabird Sanctuary is an estuarine sandbar that provides nesting, roosting, and foraging habitat for a variety of seabirds and shorebirds. From the late 1980s–1994, it was the largest Brown Pelican rookery in North America. Isolated sand islands, such as Bird Key, make ideal nesting habitat due to the lack of mammalian predators such as Raccoons. Bird Key was designated as a Seabird Sanctuary in March 2006 because of its importance as a seabird nesting island and because seabirds were declining probably due to human disturbance. The “sanctuary” status limited human disturbance on the island. This project used social attraction to decoy seabirds to Bird Key in efforts to increase the number of birds nesting on the island. Social

attraction is a combination of decoys and a sound system. The sound system is a solar-powered audio system which continuously plays the calls of nesting seabirds.

Unpainted 122 Royal Tern, 52 Black Skimmer, and 32 Least Tern decoys were purchased and shipped to Huntington State Park. Horry County school children painted the decoys as part of an educational program about seabirds. At the beginning of the nesting season, Least Tern decoys were spaced approximately 1 m apart on Bird Key. Black Skimmer decoys were placed approximately 2 m apart in 2 separate flocks of 26 decoys each. Royal Terns were placed approximately ½ m apart in one colony. The sound system was placed near the Royal Tern decoys. The sound system constantly played Black Skimmer, Least Tern, and Royal Tern calls. Five days after placing decoys on the island, approximately 40 Black Skimmers were roosting with and courting the decoys. Royal Terns and Least Terns were observed roosting with their decoys. The seabirds were mostly unsuccessful due to depredation by a Great Horned Owl although they nested on Bird Key in low numbers. These decoys were used in other projects to attract nesting seabirds and continued to be part of an educational program for school groups.

Robust Redhorse Electrofishing and Radio Telemetry Tracking of the Great Pee Dee River, SC (Federal Grant #: T-33-R-1 F07AF00062, Duration: 2007-2012) PIs: Ross Self (SCDNR) and Elizabeth Osier (formerly SCDNR); Author: Robert Stroud (SCDNR)

In late April and early May of 2008, SCDNR Freshwater Fisheries Region 2 personnel met with NCWRC, Progress Energy, Duke Energy, South Carolina Aquarium, and North Carolina Natural History Museum personnel to sample the Great Pee Dee River in NC by electrofishing for spawning Robust Redhorse. Twenty-three Robust Redhorse were collected between 22 April and 8 May 2008, of which 7 were recaptures from previous years, 2 were within year recaptures, and 14 were newly collected fish. All fish were PIT tagged and 10 had new radio tags surgically implanted. The fish ranged from 576 to 766 mm with a weight range of 2,630 to 8,450 grams. All fish were adult and many were ready to spawn.

In October 2008, boat electrofishing was conducted for two days on the Pee Dee River focusing below the South Carolina state line. One Robust Redhorse was collected. In late April and early May of 2009, the survey was conducted above the South Carolina state line using boat electrofishing. The areas targeted were known Robust Redhorse spawning grounds and locations where radio telemetered fish were detected. Twenty Robust Redhorse were collected between 20 April and 7 May 2009, of which 8 individuals were newly collected fish. All fish were PIT tagged and 10 had new radio tags surgically implanted. The fish ranged from 594 to 740 mm with a weight range of 2,986 to 6,660 grams. All fish were adult and many were ready to spawn.

Spring electrofishing for Robust Redhorse was not conducted in the Pee Dee River during or after October1, 2009. At the September 2009 annual meeting of the Yadkin-Pee Dee Technical Working Group of the Robust Redhorse Conservation Committee, it was decided that spring electrofishing would be suspended for 4 to 5 years until minimum flows are established at the Blewitt Falls Hydroelctric Facility.

SCDNR Freshwater Fisheries personnel participated in radio telemetry tracking of previously tagged Robust Redhorse in the Great Pee Dee River in October, November, and December 2007;

February 2008; March, April, July and August 2010; and March 2011. In 18 days of tracking during the grant period, 6 different fish were located a total of 22 times in the South Carolina portion of the Great Pee Dee River. Habitat ranged from open channel to along the riverbank, and always in association with submerged woody debris. Region 2's participation in tracking was not required from March 2008 through July 2009 due to a NC State graduate student having been funded by Progress Energy for the work. Radio telemetry tracking was not performed during 2012 due to the expected expiration of transmitter battery life.

Community Based Habitat Restoration and Large-Scale Resource Enhancement Through SCORE (Federal Grant #: T-34-HM-1 F07AF00063, Duration: 2007-2014) PIs: Nancy Hadley and David Whitaker (both SCDNR, retired); Author: Nancy Hadley (SCDNR, retired)

The goal of this project was to create intertidal oyster reefs and Spartina saltmarsh to provide essential fish habitat, protect shorelines from erosion, and provide forage for American Oystercatchers and other shorebirds, through a community-based restoration program. During the life of this project, more than 15,000 volunteers including more than 35 K-12 schools, have participated in active stewardship, contributing more than 38,000 hours of volunteer time. A total of 2.23 acres of oyster reefs have been constructed at 52 sites along 200 miles of SC coast, protecting more than 2 miles of shoreline. These reefs were constructed with more than 36,000 bushels of recycled oyster shells weighing approximately 1,000 tons. Approximately 5 acres of adjacent saltmarsh was created and/or protected during the life of the project. Public awareness has been increased through 87 visits to schools and participation in events focused on K-12 education, 29 presentations at community meetings and events, 9 teacher workshops, and local and national press coverage. SCORE was featured in Southern Living Magazine, Spirit Magazine (Southwest Airlines), SC Wildlife Magazine (twice), and Coastal Heritage. The SCORE program continues to engage the public, educate future generations, and create habitat through community involvement with funding from other sources.

Identification of Diamondback Terrapin Habitats in South Carolina (Federal Grant #: T-35, Duration: 2009-2010) PIs: Erin Levesque (SCDNR), David Whitaker (SCDNR, retired), and Elizabeth Broyles (former graduate student, College of Charleston); Author: Elizabeth Broyles (College of Charleston)

Very little is known about the current population number, sex ratio, and distribution of Diamondback Terrapin populations in Charleston, South Carolina estuaries. Terrapins were caught in the Ashley River, and population estimates were calculated using mark and recapture techniques and analyzed using the MARK program. Population size was estimated to be 3060 with a 95 % confidence interval of 1,964-4,156. This gives around 179-378 terrapins per km^2 of marsh habitat. The sex ratio was 1.7:1 male biased ($p < 0.001$). Investigations into changes in land usage were used to reveal reasons for change in terrapin abundance in the watersheds of the Ashley River, the Wando River, and the Charleston Harbor from 1995-2009. The number of terrapins caught at all Wando River sites combined significantly decreased during the study period ($r = 0.83$, $p < 0.001$). There has been approximately 12.9 km^2 (10% of 127.72 km^2) of land use change in the Wando River watershed from 1996-2006. Diamondback Terrapin abundance, estimated via catch per unit effort, has remained constant for most of the Ashley River and Charleston Harbor areas. Land use change has been minimal ($\leq$ 2%) in both of these

watersheds during the same time frame. The Wando River, on the other hand, had a significant decline in terrapin catch per unit of effort (CPUE) and also had a much greater amount (10%) of land use change. Land use can encroach on terrapin habitats and nesting sites as well as impact food and foraging areas. If the declining trend of the terrapin population in the Wando River continues, regulatory intervention may need to be considered. This information on population size, sex ratios, and distribution can be used as a baseline to track long-term changes in terrapin populations. This project produced a Master's thesis entitled, "Diamondback Terrapins (*Malaclemys terrapin*) of Charleston, South Carolina: Population Estimate, Sex Ratios, and Distribution."

A GIS Model to Guide Landscape-scale Restoration at the Woodbury Tract and Hamilton Ridge Properties (Federal Grant #: T-36-HM, Duration: 2008-2010) PI: Steve Bennett (SCDNR, retired); Author: Will Dillman (SCDNR)

The purpose of this investigation was to create a GIS-based model of pre-fire excluded landscape patch dynamics and hydrologic change for the Woodberry Tract and Hamilton Ridge properties. At the time of this project, these two properties were recent acquisitions by the SCDNR. Land use histories varied for both properties but included a variety of industrial forestry practices. In developing a Conservation Plan for these properties, the hopes were to (1) restore important ecological processes to the landscape (e.g. fire), and (2) provide habitat structures needed to maximize conservation benefits while using the species composition of the current industrial forest.

The use of GIS and a selection of historical aerial photography of the sites allowed identification of reference forest conditions, and the ability to identify likely locations where remnant fire-maintained landscapes most recently occurred. We were also able to create a GIS coverage identifying former isolated wetlands and a GIS coverage identifying changes in hydrology related to road construction and ditching at the Woodberry Tract and Hamilton Ridge properties. Indices were created to quantify mechanical degradation to the wetland area, provide measures of ecological integrity, and to measure the restoration potential of each wetland, based on time since degradation and current habitat structure, relative to other isolated wetlands in the study area.

Carolina Herp Atlas (Federal Grant #: T-37-T, Duration: 2008-2010) PI: Steve Bennett (SCDNR, retired) and Mike Dorcas (Davidson College); Author: Will Dillman (SCDNR)

The objective of this project was to develop the Carolina Herp Atlas (CHA) and to provide detailed locality data on the reptiles and amphibians of the Carolinas, in particular those species whose distribution and status are poorly known. The CHA was officially launched in March 2007. Prior to the launch, the Davidson College Herpetology Lab imported approximately 3,900 records, primarily from Mecklenburg, Iredell, and Cabarrus counties in the western Piedmont of North Carolina. From March 2007 through 16 November 2010, the CHA totaled 839 registered users, 91 of which identified South Carolina as their home residence. The CHA received 4,930 reptile and amphibian records from South Carolina. Of the 5,008 records, 912 were accompanied by a voucher photograph and/or given a status of 10. A total of 122 South Carolina reptile and amphibian species have at least one record in the CHA. Thus far, the CHA has collected species-

level distribution data on 151 species of amphibians and reptiles, including the occurrence of 32 anurans, 29 salamanders, 37 snakes, 11 lizards, 14 turtles, and the American alligator.

The CHA has thus far been a highly successful, citizen science-based project to document the distribution of reptiles and amphibians in South Carolina. The collection of 4,930 reptile and amphibian records in South Carolina (and 16,958 total records submitted from both South and North Carolina) during the first 3.5 years suggests that the CHA has the potential to surpass many other citizen science-based herpetological atlas projects. For example, the Georgia Herp Atlas collected a total of 7,452 records during the 5 years of operation. Thus far, the CHA represents a significant step towards the development of a better understanding of the distributions of reptiles and amphibians in the Carolinas. An overriding goal of the CHA is to promote conservation and understanding of reptiles and amphibians in South Carolina. The interactive nature of the CHA appears to appeal to a wide variety of people, including school teachers, professional herpetologists, and those generally interested in wildlife.

Mink Restoration and Monitoring Development Project (Federal Grant #: T-38-R, Duration 2007-2012) PI and Author Jay Butfiloski (SCDNR)

The goal of this project was to develop a monitoring program that would minimize staff time and effort by establishing alternative methods of American Mink survey techniques to be used to monitor the success of mink restoration along the coast of South Carolina. Track boards appeared to have the most promise as the boards could be set out and checked at a later date using one person. However, many of the same issues that previously plagued track board work such as tidal fluctuations, wave action, and other environmental factors hampered track board implementation. Once again, track boards were dismissed as a feasible tool in this instance. Previous mink survey work depended on spotlight surveys that required significant high tides occurring a few times per year. The exact heights of these tides were undetermined as to which would be sufficiently high enough for survey work, often leading to poor surveys and wasted manpower. Thus, emphasis was placed on perfecting spotlight surveys in an effort to evaluate which environmental factors were most significant in surveying mink. The project determined that tide heights 6.05 ft. above Mean Lower Low Water (MLLW) level as measured at the Charleston station and adjusted for local areas was the best predictor for when to use spotlight surveys.

During the course of this study, two family groups of mink (5 total) were relocated into the Hog Inlet portion in the northernmost coastal march in the State. This area was the last remaining significant portion of coastal marsh where mink had not been reintroduced. Moving captured mink to this marsh would be the last location along the coast where mink needed to be reintroduced to complete mink reintroduction that was begun in the late 1990s. However, during the course of this project, mink depredation in the original mink restoration site of Cape Romain National Wildlife Refuge (CRNWR) became a concern for refuge staff. As the reintroduced mink into CRNWR began to thrive, concerns from staff at the refuge centered on the impacts mink may be having on nesting shorebirds. Therefore, much of the emphasis of this project became the assessment of reintroduced mink impacts in the original reintroduction site.

A total of 9 mink were implanted with transmitters to assess impacts their activity may be having with other species. Radioed mink did not venture far from initial capture sites and most of their activity appeared to be tide dependent. In addition, diet analysis from mink taken from the CRNWR in an effort to increase shorebird nesting success found that out of 45 mink stomachs collected, 7.4 % contained avian material of unknown species. A bioenergetics model developed from this estimated that an individual mink would consume 8.5 avian prey items per month based on the sampled diet. It is still undetermined to what extent mink predation is affecting shorebird success at CRNWR, as other predators and mortality factors still plague nesting efforts on the refuge.

Prescribed Burning Crew for SC Department of Natural Resources Lands (Federal Grant #: T-39-M-1 F08AF0008, Duration: 2008-2013) PI and Author: Tim Ivey (SCDNR, deceased)

The objective of this grant was to facilitate and increase prescribed burning on Wildlife Management Areas and Heritage Preserves for wildlife habitat enhancement. SCDNR contracted with the South Carolina Forestry Commission to perform the fire management activities of the grant. During 2009, growing season prescribe burning was conducted on 8 SCDNR properties. A total of 3,830 acres were prescribe burned and 49.25 miles of firelanes were disced. During 2010, dormant and growing season prescribe burning was conducted on 18 SCDNR properties. A total of 10,312 acres were prescribe burned and 81.15 miles of firelanes were disced. During 2011, dormant and growing season prescribe burning was conducted on 23 SCDNR properties. A total of 7,906 acres were prescribe burned and 120.9 miles of firelanes were disced. During 2012, dormant and growing season prescribe burning was conducted on 19 SCDNR properties. A total of 6,322 acres were prescribe burned and 44.65 miles of firelanes were disced.

Conservation of Belfast Plantation, Phase I (Federal Grant #: T-40-L, Duration: 2008-2009) Author: Emily Cope (SCDNR) [*T-50-L is Phase II and is covered by this synopsis.*]

SCDNR utilized $1,188,654 from the USFWS (of which $1,063,654 was Wildlife Restoration funding and $125,000 was State Wildlife Grant funds) to acquire the southern half of the Belfast Tract totaling 2,436 acres (also known as Belfast Phase II). The total land acquisition cost for Phase II was $7,710,440. This completes the Belfast acquisition project by protecting a total of 4,664 acres. The Belfast Tract has long been managed to support a diverse range of wildlife species. The hardwood drains, creeks, and beaver ponds support waterfowl management objectives. In addition, the age-class diversity of the pine stands provides valuable wildlife habitat. The property supports excellent populations of deer and turkey, and the uplands provide excellent habitat for Bobwhite Quail. Improved timber thinning and a more aggressive prescribed burning regime will increase the already existing quail population. This will expand the ongoing efforts on the nearby Sumter National Forest to increase the Piedmont quail population. Mudlick Creek, the beaver ponds, and the man-made pond provide many fishing opportunities for sunfish and bass.

The property provides habitat for many priority bird species such as Acadian Flycatcher, American Woodcock, Great Blue Heron, Kentucky Warbler, Little Blue Heron, Louisiana Waterthrush, Rusty Blackbird, Wood Duck, Wood Thrush, and Yellow-crowned Night Heron. The wetlands associated with the river corridor and its tributaries provide habitat for many

reptiles and amphibians including but not limited to the black swamp snake, common snapping turtle, and yellow-belly turtle. Little River, which traverses the Belfast Tract and is the Southern boundary for Phase I, is comprised of Carolina Slatebelt geology. This specific geology is known to be associated with the federally-endangered mussel, the Carolina heelsplitter. While initial survey work has not detected the heelsplitter on the Belfast Tract, it has been located in the nearby area. Further survey work could find the heelsplitter on the tract or the tract may also serve as a restoration/reintroduction area for the species. In addition, several rare species of burrowing crayfish have been found in nearby areas.

Conservation of Water, Shore and Seabirds in South Carolina (Federal Grant #: T-41-R F08AF00108 Duration: 2008–2016) PI and Author: Felicia Sanders (SCDNR)

Many of the seabird, shorebird, wading bird, and marsh bird species that utilize South Carolina's coastal habitats are of conservation concern due to small and threatened populations. This grant funded efforts to reduce human disturbance at key seabird colonies and to conduct nest counts and population surveys of many waterbird species. These count data were incorporated into national databases to allow the agency to make informed management decisions as well as contribute to regional and global knowledge of the species. Survey, research and management activities were shared on webpages, in press releases, in publications, and at outreach events so that the results were made available to partners.

SCNDR staff coordinated with private, federal, state, and county-owned beach managers to close part of the beach for nesting seabirds and shorebirds at 30 sites during summer months and at 2 during the winter. Educational signs were placed at boat ramps and at beach entrances. Annual seabird nest counts were conducted for Black Skimmer, Brown Pelican, Common Tern, Forster's Tern, Gull-billed Tern, Least Tern, Sandwich Tern, and Royal Tern. Counts consisted of walking transects through the colonies and/or using aerial photographic surveys (starting in 2013) which were primarily conducted from SCDNR Law Enforcement planes. Least Tern nests were monitored at natural beach sites and on artificial sites mostly consisting of pebbled roofs in industrial areas. Peak statewide nest estimates for this project period were: Black Skimmer (2014) 1,110 nests; Brown Pelican (2013) 5,396; Gull-billed Tern (2012) 438; Royal Tern (2009) 13,078; and Sandwich Tern (2015) 3,414. From 2008 to 2016, the mean number of Least Tern nests in South Carolina was 1,139/year; 52% were on flat gravel-covered roofs, and 48% were on ground sites.

All known active Wood Stork colonies were surveyed in 2008 and from 2011 to 2016. We counted 1,839 (2008); 2,031 (2011); 1,827 (2012); 2,050 (2013); 2,501 (2014); 2,496 (2015); and 2,512 (2016) Wood Stork nests. The three- and five-year averages of the number of stork nests counted in South Carolina were 2,503 and 2,277, respectively. This grant period was the first time that either of these averages exceeded 2,000 nests per year since storks were first documented nesting in South Carolina in 1981. A sub-set of the stork nests were monitored in index colonies to determine how successful the storks are at raising young in South Carolina. During 2016, a total of 1,117 stork nests were monitored in 7 colonies, and an average of 1.7 chicks fledged per nest site. An average of 2.3 chicks fledged per successful nest site.

Aerial surveys and ground counts of nests in known wading bird colonies and in aerial transect survey plots were used to monitor the distribution and relative size of wading bird colonies during 2011- 2016. All species of wading birds were included in the surveys. The number of Roseate Spoonbills in South Carolina during the post-breeding season appears to be increasing; however, nesting has not yet been confirmed in the State. No Reddish Egret nests were found during the 2011-2016 surveys. Yellow-crowned Night Herons and Green Herons often nest in small, inconspicuous colonies and were rarely located during surveys.

During the winters of 2014 and 2015, we organized the first statewide winter shorebird surveys conducted in South Carolina. In 2014, although the weather was not ideal, 38,235 shorebirds and 28 species were counted from January 31 – February 7. In 2015 the weather was much improved from the previous year's conditions so that 47,287 shorebirds and 28 species were counted January 22 – January 31, 2015; Dunlin (27,087) were over half the total shorebirds. In both years, the high count was on the Intracoastal Waterway shell rakes in The Cape Romain Region (Cape Romain National Wildlife Refuge to Dewees Island) where in 2015 8,895 or 19% of the total shorebirds were counted.

Use of GIS to Assess the Demographic Isolation of Red-Cockaded Woodpecker Groups in SC (Federal Grant # T-42-R-1, Duration: 2008-2009) PI: Jason Brett Craig (former graduate student, Clemson University) and J. Drew Lanham (Clemson University); Author: Derrell Shipes (SCDNR, retired)

This project was sub-contracted to Clemson University. Jason B. Craig (graduate student) and Dr. J. Drew Lanham were the Principal Investigators and Ralph Costa and Dr. Robert Baldwin were collaborators. Eight km (5 mi.) and 25 km (15.5 mi.) radius circles were drawn around known active and inactive Red-Cockaded Woodpecker (RCW) cluster locations in SC in an effort to determine the occurrence of Demographically Isolated Groups (DIGs). These analyses concluded that there are 20 isolated clusters using 8 km (6 active, 14 inactive) and 3 isolated clusters using 25 km (1 active, 2 inactive). Habitat evaluation associated with isolated and non-isolated clusters was conducted. The concept of "isolation" and the location of isolated clusters are essential to the future management of this endangered species. It may be necessary to relocate isolated birds to larger populations in order for the relocated birds to reproduce and contribute genetically. There is a tendency for isolated clusters with small numbers of birds to "blink out".

Conservation of Migratory Land Birds in South Carolina (Federal Grant ID#: T-43 F08AF0010; Duration: 2008-2017), PI and Author: Amy Tegeler (SCDNR)

Many land bird populations are in decline. Some of the threats land birds face include climate change, unsustainable agriculture and forestry, poorly planned urban growth, and a general widespread decline in habitat quantity and quality. Over 240 land bird species occur in South Carolina, of which more than 60 are considered species of conservation concern in the 2015 State Wildlife Action Plan. South Carolina is important to year-round resident land birds as well as Neotropical migrants. As such, conservation of land bird species requires creating and implementing land bird conservation objectives both within the State and at regional scales. The objective of this grant was to coordinate and collaborate with internal and external partners to

implement land bird objectives outlined in the State Wildlife Action Plan at State and regional scales and to provide avian input into the State Wildlife Action Plan update. To meet this objective, collaborations were developed within the agency and with partners to develop, implement, and fund management, monitoring, and research projects to achieve land bird objectives. Collaborations included participating in regional working groups, citizen science projects, projects with non-profit organizations, initiatives with state and federal agencies, and co-advising graduate students. Collaborations were also developed with SCDNR biologists to implement projects on State and private lands to achieve land bird objectives. Examples of projects included songbird use of CP-33 habitat buffers, participation in the South Carolina Quail Technical Committee, breeding season songbird banding and winter Baltimore Oriole monitoring. The SCDNR was also represented at local, state, regional and national meetings to relay information and facilitate implementation and monitoring of South Carolina's State Wildlife Action Plan land bird objectives. In addition, information on land birds in South Carolina was organized and disseminated by writing papers, giving presentations, conducting workshops and field days, developing press releases, and through other means.

Least Tern Reproductive Success on Roof-tops (Federal Grant # T-44-R-1, Duration: 2008-2010) PI: Felicia Sanders (SCDNR); Author: Mary Catherine Martin (SCDNR)

Nesting of Least Terns (*Sternula antillarum*) on flat, gravel-covered roofs was followed at colony sites in Georgetown and Horry Counties in coastal South Carolina. Colony success and failure were documented. Incubation duration was determined at 5 roof colony sites by encasing temperature data loggers in clay eggs. Successful colonies were characterized by incubation temperatures at a constant range except for periods of heavy rainfall, while unsuccessful colonies had incubation temperatures with cooling ranges of 14-20°C (57-68°F) that occurred at night with repeated nest abandonment attributed to possible predators. Movements of fledged Least Terns were tracked by attaching radio transmitters to the legs of the young. Injuries resulted from the transmitter attachments complicating methods of this part of the study. A very limited number of fledged Least Terns were tracked and results were inconclusive. An assessment of fish samples found at colony sites indicated that the more inland the site, the more freshwater fish species present. In addition, observations indicated that adults and fledged young foraged at sites within a 5-10 km (3-6 mi.) radius from the colony site. Inland storm water retention ponds have become a valuable foraging site for Least Terns. Finally, eggs from colony sites were tested for heavy metal contaminants usually found in storm water retention ponds. No contaminants were present in amounts detrimental to hatching or the development of young.

American Shad Culture and Stocking in the Edisto River (Federal Grant #: T-45-R-1, Duration: 2008-2011) PI and Authors: Bill Post (SCDNR) and Chad Holbrook (formerly SCDNR now Santee Cooper)

Historically, the Edisto River in SC had one of the State's larger American Shad fisheries. Overfishing between the 1940s to1980s lead to a dramatic decline in shad landings and decreased abundance over time. These declines lead to added restrictions to the shad fishery beginning in 1998. More recently, in an effort to augment wild production, SCDNR and the USFWS formed a partnership to create a hatchery program. Over a 4-year period (2008-2011), the feasibility of on-river broodfish collections, hatchery production, young-of-year relative

abundance, annual hatchery contribution, movements of adult American Shad, genetic analysis of stock enhancement, and genetic uniqueness were evaluated for the Edisto River population. Collecting broodfish using electro-fishing gear proved to be successful with 347 adult American Shad caught over 3 years of sampling. Of the 347 collected fish, 235 have been used as broodfish; 92 had fin clip samples taken, were implanted with acoustic tags, and returned to the river; and the remaining 20 had fin clip samples taken and were returned to the river.

Collection efficiency of adult American Shad improved each year allowing us to increase the number of broodfish used each year as well as balancing the male/female ratio (2009 N=63; M 51, F 12; 2010 N=75; M 48, F 27; and 2011 N=97; M 57, F 36). Annual egg production has been variable and variability was independent of the number of females collected (2009 – 205,238; 2010 – 600,987; and 2011 – 184,677). From 2009-2011 a total of 39,688 fry were released, ranging from a high in 2010 of 22,209 to a low in 2011 of 4,836. Out-migrating young-of-the-year American Shad were successfully sampled with electrofishing gear in 2010 (601) and 2011 (1,291).

All collected fish were kept to determine hatchery contribution via OTC detection and genetic detection using microsatellite markers. Detection rates for hatchery fish varied between the two methods with OTC indicating a hatchery contribution of 6.8% in 2010 and 0.3% in 2011, while genetic testing indicated a hatchery contribution of 3.6% in 2010 and 0.0% in 2011.

Additionally, this project provided the opportunity to generate baseline genetic data which had not previously been determined for this stock, finding that genetic diversity for the Edisto River American Shad population is high. An initial evaluation of our stocking program detected no difference in genetic composition between the broodstock and field collections in any of our production years ($p>0.692$), indicating the appropriateness of our broodstock collection process in minimizing potential negative impacts of stocking on the wild population. However, significant spatial genetic differentiation was detected between the Santee River and Edisto River ($X^2=\infty$, $p=0.000$). Therefore, broodstock for stock enhancement purposes in the Edisto River should originate only from the Edisto River itself.

Our study was a comprehensive look at the potential of using responsible stock enhancement as an effective management tool. Broodfish collections and hatchery production was a success; however we hope to improve fry/egg ratio with more experience. Telemetry results were somewhat inconclusive; however, it did appear mature shad were congregating in areas near Givhans Ferry State Park around river mile 60. Young-of-the-year collections improved throughout the study and were efficient in 2010 and 2011. Although contribution was relatively low, we were able to detect hatchery individuals in the Edisto River population prior to out-migration. The results of this project, along with future work, will provide valuable information which can be incorporated into management plans to aid in the recovery of this important species in the Edisto River in South Carolina.

Landscape Planning for Priority Wildlife Species on Agricultural Lands (Federal Grant #: T-46-1-T F08AF00111 *See T-10-P summary*)

Conservation of Breeding Painted Buntings and Other Songbird Indicators in Early-Successional Shrub-Scrub Habitat (Federal Grant #: T-47-R-1 F08AF00109, Duration: 2008-2011) PI: Derrell Shipes (SCDNR, retired); Author: Mary Catherine Martin (SCDNR)

Objectives of this study were to determine: (1) abundance of breeding Painted Buntings (*Passerina ciris*) and other indicator songbird species in paired CP-33 and non-CP-33 fields; (2) nest location and success of Painted Buntings in paired CP-33 and non-CP-33 fields; and (3) a landscape/GAP analysis model which tracks seasonal crop rotation and predicts a pattern of habitat occupancy and breeding distribution of Painted Buntings and other early-successional shrub-scrub songbird species. CP-33 is a conservation program established by the Department of Agriculture to provide habitat for upland birds through landowner incentives to plant native grass buffers along row crop field margins.

Eight fields of 4 CP-33 and 4 non-CP-33 were study sites. In each field, habitat types were classified as agriculture, forest, CP-33 border, and cut (recently cut forest area). To determine the abundance of Painted Buntings, 3 survey types were utilized: spot maps, transect counts, and telemetry. The results of each type of survey indicated more Painted Buntings and other species were found in mature (≥ 10 years of growth) forest edges than in any other habitat, and there was no difference in species abundance between CP-33 and non-CP-33 fields. In addition, vegetation data gathered per protocols developed by the Breeding Biology Research and Monitoring Database (BBIRD) in the forested edges of agricultural fields, in the CP-33 strips, and in the crop fields indicated that wheat is preferred forage by Painted Buntings. Second, 3 types of fields (paired CP-33, non-CP-33, and a field managed for doves) were searched for Painted Bunting nests. Twenty-two nest sites were found in forest edge habitat, and none were found in the CP-33 and dove field habitats.

Finally, a landscape/GAP analysis map was created from the data obtained in the spot map, transect count, and radiotelemetry surveys. Results of the landscape/GAP analysis map indicated high priority habitats as: 25 m or less from the edge of mature forest; CP-33 strips, wheat fields, and early growth forests (≤ 10 years of growth) for foraging; and use of CP-33 strips, all agricultural fields, and early growth forests by Painted Buntings was limited to the edges of these habitats. Based on the completion of the study objectives, recommendations for Painted Bunting conservation in central rural South Carolina are: (1) mature forest edge habitat is essential; (2) painted buntings prefer to occupy and nest in the outermost edges of forests and/or thin forest strips (25 m or less from the edge); and (3) a source of food in the form of a wheat field or other grass seed as well as a source of insects when rearing young is necessary.

Effects of Predation on Seabird Nests in Cape Romain (Federal Grant # T-48-R, Duration: 2009-2010) PI and Author: Felicia Sanders (SCDNR)

The goal of this project was to monitor seabird nesting in Cape Romain National Wildlife Refuge to guide management that can benefit seabird species nesting at natural sites. Nesting chronology, reproductive success, and causes of colony abandonment and nest loss were documented for Least Terns and Black Skimmers in 2009-2010. Although species of conservation concern, little is known about the reproductive success of Least Terns and Black Skimmers throughout the Southeastern US.

Nest monitoring occurred at Raccoon Key, Lighthouse Island, Middle White Banks, and Cape Island. Each island was checked every 2-7 days depending upon weather and logistical constraints. Least Tern and Black Skimmer nests were randomly selected across all 4 study sites. Nests were marked by wooden stakes 0.5 m from the nest scrape. Eggs were floated to estimate initiation date. At each visit, researchers recorded the number and condition of eggs or young and when possible, and determined the cause of failure by visual observation. Chick survival was determined at select sites by banding 1-2 day-old chicks with a unique, 2-color leg band combination. Researchers conducted re-sighting surveys every 2-4 days for Least Terns until no fledglings were observed. To determine the minimal survival of Black Skimmer chicks, an island-wide fledgling count was conducted at the end of the season.

Peak nesting for Least Terns occurred from mid-May to mid-June and for Black Skimmers in mid-June. Predation and over-wash were the primary cause of nest failure based on visual cues at or near the nest. Collectively, these ecological stressors attributed to 65% of nest loss for Least Terns and Black Skimmers. Video cameras installed at colonies documented disturbance to colonies by Black Vulture, American mink, and Great Horned Owl. Of the 60 Least Tern chicks monitored, 13 (22%) were re-sighted at ≥ 17 days post hatch. Of the 52 Black Skimmer chicks monitored, 22 (42%) were re-sighted at ≥ 28 days post hatch. Nest success of Least Terns and Black Skimmers within CRNWR was variable among colonies and between years, suggesting that factors at the local level influenced reproductive success. Management techniques within the study area directed toward predator control to decrease nest loss of near-shore seabirds and shorebirds needs to focus on both the avian and mammalian predators identified in this study in order to be effective.

Sea Turtle Conservation on Botany Bay Plantation WMA (Federal Grant #: T-49-R-1 F08AF00107, Duration: 2008-2015) PIs: DuBose Griffin (formerly SCDNR) and Michelle Pate (SCDNR); Author: Michelle Pate, SCDNR

Sea turtles are listed as Threatened or Endangered under the Endangered Species Act. Four marine turtle species utilize South Carolina waters and nest on our beaches. The Loggerhead Sea Turtle (*Caretta caretta*) is the predominant species nesting along the coast, although nests from three other species (Kemp's Ridley, Green, and Leatherback) are observed periodically. Grant funds were used to employ a seasonal field technician to conduct sea turtle management activities on Botany Bay Island and Botany Bay Plantation Wildlife Management Area. This contiguous beach is the highest density nesting beach in South Carolina outside of the federally managed Cape Romain National Wildlife Refuge. The installation of a seasonal technician housed on-site allowed for sea turtle management continuity on the Botany Bay beach. The turtle project is now a standardized, season-long survey conducted seven days a week. The technician was trained and supervised by the SCDNR Marine Turtle Conservation Program and operated under state management guidelines, thus ensuring that scientifically approved methods were used to collect reliable estimates of nest incubation and hatching success. Activities conducted by the technician included nest identification/relocation, nest protection during incubation, genetic sample collection, post-emergence nest inventories to determine nest success, and visitor education. Predator control methods were conducted on an annual basis protecting sea turtle nests from mammalian depredation. This protection during incubation increased nest and

hatchling productivity, essential in threatened and endangered species population recovery efforts. The technician collected standardized data on sea turtles that stranded dead or alive on Botany Bay beach. The technician maintained continuity and quality of data collected from these stranded sea turtles as part of a larger nationwide Sea Turtle Stranding and Salvage Network (STSSN).

Conservation of Belfast Plantation, Phase II (Federal Grant #: T-50-L, Duration: 2009-2010) *See T-40-L summary.*

Ecology and Impacts of Coyotes on Loggerhead Sea Turtles, Least Terns, and Other Wildlife: Implications for Management (Federal Grant #: T-51-R-1 F09AF00159, Duration: 2009-2011) PI and Author: Jamie Dozier (SCDNR)

Control of abundant mammalian predators is a common element of management programs aimed at increasing reproductive and recruitment success of many threatened ground-nesting turtle and bird species. Recent colonization of Coyotes (*Canis latrans*) in South Carolina, however, is changing traditional community dynamics governing and impacting wildlife populations in coastal and barrier island systems. Coyotes have become a major nest predator on Federally Threatened Loggerhead Sea Turtles (*Caretta caretta*) having devastating impacts on nest survival. For example, in 2009 on the Tom Yawkey Wildlife Center Heritage Preserve (TYWCHP) in Georgetown, South Carolina, extensive Coyote depredation on turtle nests was documented with over 50% (21 of 40 nests; 1,208 eggs) of Loggerhead Sea Turtle nests either completely or partially destroyed. The purpose of this project was to attempt to understand Coyote ecology and impacts at the TYWCHP as it relates to Loggerhead Sea Turtle and Least Tern nesting success. A major portion of the study attempted to examine Coyote home range, habitat use, and diet composition on the island complex.

A total of 8 Coyotes were trapped and fitted with radio-transmitters during the study period. Unfortunately, a combination of equipment failure and extreme difficulty in locating collared Coyotes provided a low sample size of locations and data unreliable to support any reasonable estimations of Coyote home range, movements, or habitat use on TYWCHP. Over 400 Coyote scat samples were collected during the study periods on TYWCHP; 370 samples were usable for analysis. A total of 234 scats were collected on Cat Island and 136 on South Island. *Sigmodon* spp. were the most common food item found in Cat Island scats, followed by birds, vegetation, and *Peromyscus* spp. Birds were the most common item found in South Island samples, followed by *Sigmodon* spp., vegetation, and *Neotoma* spp. Cat Island samples comprised a larger percent of scats containing wild hog, lagomorphs, *Diospyros* spp., and soricomporphs, while South Island samples contained more birds, crabs, *Mephitis mephitis* (striped skunk), and mustelids. There was a significant difference between Coyote diet on the two islands ($A = 0.0090$, $p < 0.0001$). Test results yielded significant indicator values for three animal groups and one plant genus (birds, lagomorphs, wild hogs and *Ilex* spp.). Although birds were a component of Coyote diets, samples did not provide enough evidence to determine which species of birds or age class. Observation of Least Tern nesting colonies did not reveal Coyote presence during the study period.

An additional component added to the project was the question of Coyote impacts on mesopredators, in particularly Raccoons, in suppressing depredation/predation on prey items. Three experiments were conducted to examine Coyote-Raccoon interactions: 1) space use of radio-collared Raccoons (10-18) to test avoidance of Coyote urine, 2) avoidance of captured Raccoons (8) in enclosures to Coyote scat, and 3) avoidance of free-ranging Raccoons to monitored feeding sites containing Coyote scat. Summary results of all 3 experiments revealed that Raccoons did not avoid areas where Coyote presence was artificially induced; therefore, this suggested that the threat of Coyotes was not a deterrent in Raccoon use of areas in space and time. From a management perspective, the most significant finding was from a companion study conducted on TYWCHP during the same time period as this study revealing that selective trapping of Coyotes and beach night patrols significantly reduced Coyote depredation of sea turtle nests from 52% in 2009 to 15% in 2010.

Striped Bass Stock Enhancement of Charleston Harbor Estuary System (Federal Grant #: T-53-R-1 F10AF00422, Duration: 2010-2015) PI and Author: Mike Densen (formerly SCDNR now Hollings Marine Laboratory)

This project supported Striped Bass stock enhancement in Charleston Harbor from 2010 to 2014. Project funds were used to evaluate the potential for using stock enhancement as a means to re-establish historic levels of biodiversity and restore a key indicator species to coastal rivers in the Southeast with the ultimate goal of developing a conceptual restoration model for Striped Bass in coastal rivers.

Over the course of the project, Striped Bass (n=164,895) were stocked in the Ashley, Cooper, and Wando rivers of the Charleston Harbor system. Striped Bass from each stocked year class and each river were recaptured during this project. While there were multiple immigrants from the Santee-Cooper lakes captured in the Ashley (n=6), only one Striped Bass released in the Ashley River was recovered from outside of the Ashley River (Cooper). The persistence of multiple year classes within the Ashley River and the limited number of recaptures outside of the system indicate limited emigration of stocked fish out of the Ashley River.

The capture of wild young-of-the-year Striped Bass in 2009 and 2010 may indicate spawning activity is occurring in the Ashley River. It seems unlikely that fish collected at age 0 were spawned in a different system and migrated to the Ashley River at such a young age and small size. Histological examination of ovaries from female Striped Bass collected in the Ashley River revealed that almost 43% of all female Striped Bass captured above the age of 3 had GSI values higher than 5 and all seven females were categorized as either developing or recent spawners. All females aged two years or younger captured in the Ashley River were found to be immature. Of the 5 male Striped Bass examined between the ages of 1-3, all were either developing or sexually mature. The lack of substantial contribution of wild fish to the most recent 2012 and 2013 year classes could be an indication that the system is at capacity or environmental conditions were not favorable for natural recruitment of wild fish.

Metabolic scope experiments suggest that Striped Bass in the Ashley River should be able to manage the energetic costs associated with the extreme high temperatures and low dissolved oxygen concentrations observed in the Ashley River during the summer. These findings confirm

the results of temperature tolerance studies conducted on hatchery reared Striped Bass in previous studies.

The results of this project are encouraging for the future of the Striped Bass restoration effort in the Ashley River. We have determined the best size and age class of fish to stock (Phase II) to successfully increase abundance to a critical mass that might facilitate wild recruitment and have demonstrated survival of Striped Bass grown in both conventional freshwater rearing systems and brackish water pond systems. We have also determined that the environmental conditions within the river are sufficient for survival and that fish are becoming sexually mature and returning to the river to spawn. Continued monitoring over the next 5-10 years will be necessary to determine if the stocking effort was enough to restore this key indicator species to the Ashley River. Further, the methodology and results presented here make production and stocking of Striped Bass in coastal rivers a viable means of reducing the chance of this important species from being listed as a threatened species.

Monitoring Impacts of Yellow Pine Restoration on Avifauna in the SC Mountains (Federal Grant #: T-54-R-1 F10AF00443, Duration: 2010-2013) PIs: Curtis Walker (former graduate student, Clemson University) and J. Drew Lanham (Clemson University); Author: Mark Hall (SCDNR, retired)

Note: The thesis name of this project is *Avian Community Response to Prescribed Fire in Yellow Pine Stands in the Jocassee Gorges Region of South Carolina*.

Comparisons of avian communities were made between the burned treatment sites and reference control sites to examine community and priority species response to prescribed fire in the Jocassee Gorges in the mountains of SC. To assess the impacts of fire disturbance management on the avian community, 10-minute, 50 m radius point counts were conducted in treatment and control plots during the spring breeding seasons of 2011 and 2012. Values of species diversity, richness, and total number of individuals were found to be significantly higher in the burned treatment plots than in the control plots as a result of differences in structural complexity and the distribution of resources. The occurrence of focal species, as well as other species, was found to vary between sites. Species associated with early-successional and more open habitats—such as Eastern Wood-Pewees and Indigo Buntings—were observed more often in burned sites, while species requiring shrubbery and broad-leaved foliage on which to forage—such as Black-throated Green and Hooded Warblers—were observed more often in control sites. Models created using structural vegetation data identified characteristics of vegetation and landform that were found to be useful in predicting the occurrence of 6 of the 7 priority species at Jocassee. Differences in the occurrence of nesting and foraging guilds were related to differences in complexity of habitat structure and composition. This research suggests that fire management can be a useful tool to create wider variation across the landscape, providing increased opportunities for nesting and foraging resources for an array of bird species.

Using Citizen Science in the Study and Conservation of Breeding Painted Buntings (Federal Grant #: T-55-R-1 F10AF00444, Duration: 2010-2012) PIs: John Gerwin (NC Museum of Natural Sciences); Author: Derrell Shipes (SCDNR, retired)

This project was sub-contracted to Dr. John A. Gerwin of the North Carolina Museum of Natural Sciences in Raleigh, North Carolina. Collaborators included Dr. Jamie Rotenberg of the University of North Carolina – Wilmington and Laurel Barnhill formerly of SCDNR, now USFWS.

Painted Buntings (PABU) were banded at 45 sites during 135 banding sessions across NC/SC including 15 in NC, 15 in Coastal SC, and 15 in "interior" SC. Birds were banded with a unique USFWS aluminum band on one leg and a unique combination of 3 plastic color bands on the other leg. Age, sex, and breeding condition was determined and recorded. An internet-based reporting system for reporting of sighted birds was developed, and reporters were recruited using workshops, short newspaper articles, word of mouth and through the website. Volunteers were encouraged to report sightings of birds—banded and un-banded—to the website. A total of 1,379 PABUs (454 females, 395 males, 231 unknown) were captured and banded in South Carolina. Following banding, 34,705 reports of PABUs—banded and un-banded—were received at the website. Researchers found that PABUs appear to survive an average of 5-6 years and appear to exhibit philopatry. They did not find an over-abundance of Brown-headed Cowbirds at the feeder sites or in agricultural areas nearby. Habitat preference, management guidelines, and productivity information is contained in the larger report of the project.

Continued monitoring of recently established crab trap-based oyster reefs to document their values as essential fish habitat for a diverse fauna in South Carolina (Federal Grant #: T-56-R-1 F11AF00686, Duration: 2010-2015) PI and Author: Peter Kingsley-Smith (SCDNR)

This project focused on addressing a major source of marine debris by providing opportunities for the public to report and donate derelict and unwanted crab traps. This project engaged the general public either through a dedicated website (www.dnr.sc.gov/marine/crabtraps), which encourages the public to report derelict traps using either the Marine Debris Tracker smartphone application, created by NOAA's Marine Debris Program (http://marinedebris.noaa.gov/), or through a dedicated email address (crabtraps@dnr.sc.gov). More than 800 crab traps were gathered by this project, either through trap recoveries in the field or from trap donations by recreational and commercial crab fishers. Repurposed traps were deployed as oyster reef-building substrate both in support of this project as well as other grant-funded projects. Crab trap-based reef building efforts targeted areas where traditional restoration approaches using more dense substrates (e.g. bagged shell) are less well suited, primarily in low wave energy, pluff mud environments. Initially (2010-2011) small reefs (6 traps per reef) were created under private docks, with the intention of demonstrating increases in recreational finfish catches through rod-and-line sampling. As the availability of traps increased, however, larger reefs (23 traps per reef arranged in a checkerboard pattern) were constructed in open areas that could be sampled using a monthly drop net sampling technique. This method more effectively and comprehensively sampled the mobile finfish and crustaceans using the reefs as habitat at high tide. These larger (23-trap) reefs were created along intertidal shorelines at the SCDNR Marine Resources Research Institute at Fort Johnson, at the National Fish Hatchery at Bears Bluff on Wadmalaw Island, and in the ACE Basin NERR at Hutchinson Cut in 2012, as well as at 3 public parks in Charleston (Demetre Park, North Bridge Park, and Brittlebank Park) in 2013, with the goal of raising public awareness about both marine debris issues related to derelict crab traps and the ecological significance of oyster reefs as essential fish habitat. During the summer

of 2015, a new oyster reef comprising 100 traps was also created in the Ashley River, along with a new 50-trap reef at the Port Royal Sound Maritime Center. Monthly drop net sampling over several years has supported the premise that oyster reefs constructed using alternative materials support higher abundances and diversity of associated fauna than adjacent non-reef, control areas. During 2014-2015 at the Fort Johnson reef, for example, blue crabs and grass shrimp were collected in significantly greater numbers from the reef plot than from the control plot. Beginning in December 2013, video-based shorebird surveys were also added to the monitoring plans at three of the sites (Fort Johnson, Bear's Bluff, and Hutchinson Cut), although no differences were observed among habitat types, most likely as a result of the generally low numbers of birds observed. Throughout this project, volunteers assisted with drop net sampling and shorebird surveys and were all educated about the importance of oyster restoration in South Carolina in terms of its benefits to priority conservation wildlife species.

Herpetological Research and Survey in South Carolina (*Combined Report* for Federal Grants #: T-2-2, T-26-R-1, and T-57-R-1, Duration: 2004-2006 / 2006-2011 / 2011-2016) PI: Will Dillman (SCDNR); Author: Andrew Grosse (SCDNR)

Gopher Tortoises are state endangered in South Carolina and understanding the life history of this species will lead to more informed management and conservation decisions for this species. In spring 2003, 16 Gopher Tortoises were equipped with radio transmitters: 8 at the Tillman Sand Ridge (TSR) Heritage Preserve and 8 at a Public Service Authority (PSA) property nearby. These two properties are located on the same sand ridge and likely are part of the same population; however, ownership and management are different at the two sites creating two separate groups. In 2006, 11 previously tracked Gopher Tortoises, as well as 14 new Gopher Tortoises, were equipped with new transmitters. Overall, male tortoises had significantly larger home ranges than females. PSA individuals had smaller home ranges, likely due to less suitable habitat and forage because of lack of management. Gopher Tortoises generally selected burrow locations with 30-50% canopy cover, approximately 20% shrub cover, and lower basal area (total, pine, and oak) than in surrounding available habitats. Isotopic analysis made it difficult to determine plant forage species and preferences; however, fecal samples suggested: a) most likely have diverse diets comprised of numerous taxa; b) they may consume less wiregrass relative to herbaceous species and/or broadleaf grasses; and c) they potentially consume less wiregrass than expected based on its availability in the habitat. Clutch sizes were obtained for seven PSA nests and 20 TSR nests. Mean clutch size at PSA was 5.85 eggs (range: 2-9 eggs) and was 5.55 eggs at TSR (range: 2-9 eggs).

At the Aiken Gopher Tortoise Heritage Preserve, waif Gopher Tortoises were translocated and penned to determine the if waifs can be used to recover and enhance the current population. During 2011, 13 released Gopher Tortoises were radio-tracked bi-weekly to determine their site fidelity, movements, and home ranges. These tortoises were all waifs and had been maintained in a 2.5-acre pen on the AGTHP for 2 years prior to their release in 2009. Thus, these tortoises had been radio-tracked for 2 years post-release. All 13 tortoises were alive at the end of the 2011 activity season, and all had remained on the AGTHP property. Nests were found in the apron of burrows in pens with waif tortoises and pens with native South Carolina tortoises.

SCDNR began the "Gopher Tortoise Initiative for South Carolina" in January 2015, to provide population estimates for identified populations and to continue efforts to identify outlying groups and individual tortoises. During our initial efforts, we identified extant populations of tortoises at sandhills associated with the Savannah River (Tillman Sand Ridge area, sandhills associated with the Coosawhatchie River (Jasper, Hampton, Beaufort County), and a population along the South Edisto River in Aiken County. We have collected additional records of individual or small groups of tortoises from Bamberg, Allendale, Colleton, and Dorchester Counties, though most of these records are isolated individuals. The Aiken County population occurs on what is now the Aiken Gopher Tortoise Heritage Preserve and has been the subject of efforts to restore habitat and to restock tortoises to the site using waif tortoises from throughout the range. Two additional populations exist, one at the Savannah River Site that was translocated to the site from Georgia in the early 2000's, and a small group maintained by the Town of Hilda, SC.

Evaluation of American Shad Stocking in the Edisto River (Federal Grant #: T-58-R-1 F12AF01378, Duration: 2012-2015) PI and Author: Tanya Darden (SCDNR) *See also T-45-R-1*

A reduction in catch-per-unit-effort for American Shad in the Edisto River over the past few decades highlighted the need to obtain river-specific information for this system and assess the potential of responsible stocking as an effective management tool. Through a collaborative effort among SCDNR's Wildlife and Freshwater Fisheries Division, SCDNR's Marine Resources Division, and the USFWS (Bear's Bluff National Fish Hatchery), six year classes of American Shad larvae (2009-2014) have been produced/stocked and genetic markers have been optimized to allow for estimates of hatchery contribution using genetic parentage analysis.

Our initial genetic evaluation on juvenile samples collected in 2010-2011 found that even with low stocking levels (< 22,000 larvae), hatchery fry could be detected among the out-migrating juvenile American Shad (up to 3.5%). Using adult samples collected from 2012-2014, we further evaluated the effectiveness of the stock enhancement efforts by determining whether hatchery fish recruit into the adult reproductive pool (i.e. during their return spawning migration). A single hatchery individual from the 2010YC was detected during the 2013 spawning run for a ~1% contribution to the adult American Shad population. We now have documented evidence that stocked larval American Shad can survive to adulthood and return to reproduce, suggesting that stock enhancement does have the potential to be a viable fisheries management tool for American Shad restoration in the Edisto River.

Our initial evaluation of adult samples collected in 2008-2011 (pre-stocking) indicated that the genetic composition of the Edisto spawning run is temporally stable over short time frames, genetic diversity is high and inbreeding is low, and effective population size is relatively large and within the levels recommended to maintain the population's evolutionary potential. Using adult samples collected from 2012-2014 (post-stocking), we investigated any potential influences of hatchery fish on the genetic health of the wild Edisto River American shad population (e.g. reduction of genetic diversity, increase in inbreeding, decrease in effective population size, significant temporal differences between collection years). We found that genetic diversity and inbreeding measures did not change appreciably between collection years, there was no pattern of decline in effective population size between pre- and post-enhancement periods, and there was no significant genetic differentiation between collection years which might indicate changes in

allele frequencies. Therefore, we do not see any evidence that our experimental-scale stocking has had any unintended impacts on the genetic composition of the Edisto River American Shad spawning run, although population genetic parameters should continue to be monitored as other year-classes return to spawn.

Composition of American Eels in Freshwater Habitats of South Carolina and Their Infection Status by the Invasive Parasite Species, *Anguillicoloides crassus* (Federal Grant #: T-59-R-1 F12AF01381, Duration: 2012-2015) PI: Stephen Arnott (formerly SCDNR); Authors: Stephen Arnott (formerly SCDNR) and Isaure de Buron (College of Charleston)

A 2012 benchmark stock assessment of American Eels determined that the U.S. stock was 'depleted'. A South Carolina index of eel abundance was used as part of the assessment. The index, which was derived from a SCDNR electrofishing survey of estuarine waters, showed declining eel numbers in the State since 2002, when the survey began. In response to research recommendations from the stock assessment, the main objectives of this project were: (i) to quantify life history parameters of American Eels in South Carolina; and (ii) to quantify infection rates of a debilitating invasive swim bladder parasite, *Anguillicoloides crassus*.

We examined a total of 1,150 American Eels from 11 South Carolina river drainages, including 677 larger stages (yellow and silver eels) and 473 juvenile stages (glass eels and elvers). After validating our otolith aging methodology, we found that eel ages ranged from 1 to 11 years, with 50% female maturity occurring around 4.5 years and 379 mm total length. Males were generally smaller than females and matured at a smaller and younger (although more variable) size and age. Unlike the females, they were mostly absent from estuarine waters during spring months, but they were caught at other times of the year.

Approximately 65% of the yellow and silver eels were infected by *A. crassus* and ~12% of them had 'severe' swim bladder damage caused by the parasite, as assessed using a previously published evaluation method. This damage likely impairs the eel's ability to migrate to the Sargasso Sea, where spawning occurs. Among the juvenile stages, we found that parasite infection occurred within a few months of glass eels recruiting to coastal habitats from the Atlantic Ocean. For the first time in the American Eel's range, we also identified four species of fish that act as paratenic hosts of *A. crassus*. These hosts provide a mechanism of spreading the parasite between habitats. The host species were Silver Perch, Highfin Goby, Spot and Mummichog. The findings from our study will be provided at the next stock assessment of America Eels with the aim of enhancing the utility of SCDNR's electrofishing dataset within the assessment model.

Validation of Trammel Netting Monitoring Population Trends for Diamondback Terrapins in the Charleston Harbor Estuary (Federal Grant #: T-60-R-1 F12AF01382, Duration: 2012-2015) PI and Author: Mike Arendt (SCDNR)

A three-year study of Diamondback Terrapin distributional patterns in the Ashley River was conducted beginning in 2013. Twenty-six female and 18 male Diamondback Terrapins were tagged with acoustic transmitters, a small subset of the nearly 700 Diamondback Terrapins captured and marked during this research study. In the first two years of the study, telemetry

data emphasis was primarily placed on comparing residence and movement patterns between creek and river habitats and increased emphasis on characterizing along-river movements in the third year of the study. Acoustically-tagged Diamondback Terrapins were detected most frequently between April and June. Individual terrapins were typically (median) detected nine times as frequently in river habitats than in creek habitats, with significantly more river detections during nocturnal periods as well as increased frequency of creek detection during diurnal periods. In contrast to initial assessment in 2013, tidal influence on detection in river vs. creek habitats was not significant.

Given disproportionate time spent in river habitats where commercial crab traps are extensively deployed, the need for improving the probability of implementing bycatch excluder devices (BRDs) as a conservation measure for Diamondback Terrapins in South Carolina was apparent. As such, five BRD designs were systematically developed and tested in 2014 and 2015 in the hopes of identifying a superior alternative to BRD designs that were unsatisfactorily tested with commercial crabbers in South Carolina during 2006–2008. A total of 3,062 crab trap soak hours were recorded during 689 trap sets that were evenly distributed between traps fished without and with BRDs in each year. Trap sets captured 3,184 blue crabs (997 of which were legal-sized, 31%) and 68 Diamondback Terrapins, with greatest capture of legal-sized crabs after August but nearly exclusive capture of Diamondback Terrapins during April and May. BRD designs tested in 2014 captured significantly fewer legal-sized blue crabs than traps fished without BRDs; however, a non-significant difference in catch rates for legal-sized crabs across trap designs was associated with the BRD design tested in 2015. Traps fished with BRDs were associated with a slightly greater frequency of not capturing any legal-sized blue crabs; however, visual observations recorded for a graduate thesis revealed no difference in the physical ability of large (i.e., up to 7.5 in. carapace width) legal-sized blue crabs to traverse through BRDs. Given this observation, and nearly identical size distributions and sex ratios between control traps and all but one BRD design tested in 2014, reduced absolute catch in BRD traps may stem from increased rates of crabs escaping through rigid funnel openings when BRDs are present, and future BRD research should systematically attempt to reduce the occurrence of this behavior.

Decision Support Tools for Stream Conservation (Federal Grant #: T-61 F12AF01417, Duration: 2012-2013) PI and Author: Mark Scott (SCDNR)

Identifying and communicating the relationships between natural gradients, human activities, and aquatic habitat integrity is crucial to aquatic conservation. The SCDNR, in conjunction with Clemson University, has developed a novel, web-based South Carolina Stream Conservation Planning Tool that enables a spatially explicit understanding of how human activities affect the biological condition of wadeable streams. This is intended to support decisions about aquatic conservation actions. The web mapping application communicates findings from the South Carolina Stream Assessment (SCSA) to a broad audience, allowing users to visualize predicted biological conditions based on their status and severity across all South Carolina wadeable stream catchments. Additionally, an interactive catchment management tool allows users to explore and forecast the impacts of customized land management scenarios on aquatic resource indicators at any user-specified location across South Carolina and so engages users in the process of modeling and forecasting stream conditions.

We selected stream condition metrics from over 200 measurements taken at approximately 700 streams locations sampled during the SCSA from 2006 to 2011. Metrics were related to spatial predictor data created under the National Fish Habitat Assessment. We generated prediction models using the Random Forest machine-learning technique from the sample data, and applied the predictions to the entire population of wadeable stream reaches in the State. The mapping application provides users with a browser-based interface to modify predictors at the catchment (local) scale. A web service dynamically generates predictions based on these user inputs, and results are mapped at watershed (network) scales to display cumulative effects of the changes. The dynamic execution of models broadens the utility of the application and opens the forecasting process to a non-technical audience. By providing an accessible means of forecasting the effects of management decisions, the tool encourages a watershed perspective towards aquatic conservation. The application is targeted to stakeholders at the policy making and conservation planning levels. The approach described has been set up for South Carolina but is applicable to assessment programs at the regional and national levels.

Mapping and Classifying Tidal Freshwater Wetlands in the ACE Basin (Federal Grant #: SC-T-F13AF01180, Duration: 2013-2015) PIs: John W. Leffler (SCDNR), Denise Sanger (SCDNR), and Saundra Upchurch (SCDNR); Author: Denise Sanger (SCDNR)

The study area of this project was located in the tidal freshwater zone within the Ashepoo-Combahee-Edisto (ACE) Basin watershed. This area is approximately 284,200 acres, and about 247,000 acres is within Colleton and remaining acreage is in Beaufort and Charleston counties. The three objectives of the project were met. First, the automated mapping tool that applies LiDAR (Light Detection And Ranging) data and remote sensing data to delineate land features was developed. However, only Colleton County was mapped because the LiDAR data for Beaufort and Charleston counties were not made available before projected ended. Secondly, the new high resolution land cover maps were compared to the 1999 SCGAP maps, and areas of change were identified and mapped. We have not attempted to request a change to the 1999 SCGAP maps that are currently housed on the USGS website. Thirdly, instead of conducting training workshops, an instruction manual that walks the user through the steps of the mapping tool was prepared. The manual was designed to be a stand-alone document that guides the user through the mapping process and provides descriptions of the process performed at each step of the tool. Also, two presentations were made at the Marine Resources Division Conference that was held during March 2014 and 2015.

Identification and Distribution of Crayfishes in South Carolina (Federal Grant #: SC-T-F13AF01182, Duration: 2013-2014) PI: Jim Bulak (SCDNR, retired), SCDNR; Author: Arnie Eversole (Clemson University, retired)
Crayfish specimens collected by SCDNR as a by-catch of water and stream sampling programs were identified to lowest possible taxonomic unit, and the number of form I males, form II males, adult females, ovigerous females, juvenile males, juvenile females and unsexed juveniles were recorded for each taxa. Of the 2,883 crayfish specimens in 406 collection jars, adult crayfish comprised 40.5% of the samples of which only 9.5% were form I males. The other adults in the collection were form II males (11.0%) and females (20.0%). A small percentage of the adult females (3.6%) were ovigerous or had attached early instars. Small crayfish classified

as juveniles (59.5%) were frequently too small using existing diagnostic characters to identify beyond genus.

Three genera and 26 species were encountered in the SCDNR collections. Specimens in *Procambarus* (n = 14 species), *Cambarus* (n = 11), and *Fallicambarus* (n = 1) accounted for 52.8%, 47.1% and < 0.1% of the samples, respectively. The most frequently identified species *P. troglodytes* and *P. hirsutus* occurred in 21.8% and 16.9% of the samples, respectively. The exotic *P. clarkii* was encountered in three samples. Two genera and 11 South Carolina crayfish species were not represented in the collections. Crayfish identified to species and geo-located SCDNR collection sites were merged into existing crayfish distribution data (A. Eversole and J. Foltz, unpublished data). These crayfish records added 6.8% to the 4,000 state-wide crayfish museum and collection records. Spatial distribution maps of all 38 described crayfish species in the State are displayed and the conservation status and research needs are discussed in the final report.

Evaluation and Monitoring of the Santee River Basin Robust Redhorse Restoration Effort (Federal Grant #: SC-T-F13AF01183, Duration: 2013-2016) PIs:, SCDNR; Author:

Robust Redhorse (*Moxostoma robustum)* is a large-bodied and long-lived Catastomid with a native range that encompasses the major rivers from the Carolina's Pee Dee River south to the Altamaha River in Georgia, with the notable exception of the Santee River Basin. In an effort to increase the long-term viability of Robust Redhorse within its native range, we began a restoration effort for establishing a self-sustaining population in the Santee River Basin. Broodstock from the Savannah River were used to stock 72,000 juveniles from 9 year classes that involved 101 independent parental crosses during 2004-2013. Fingerlings were stocked in two Broad River segments and one Wateree/Congaree River section. Incidental electrofishing collection of adult fish began two years after stocking began. Males in spawning conditions were first observed in 2008, and the first spawning triad was encountered in 2010. To date, over 70 adults have been collected and adults in spawning condition have been encountered in every stocked segment. Spawning behavior has been documented in two segments. Over 150 mature adult Robust Redhorse have been observed ascending a fish ladder on the Broad River preceding spawning season. Telemetry studies have shown extensive movement and repeated seasonal use of the specific river reaches. Genetic tagging evaluation and population characterization using a suite of 10 microsatellite markers (64 individuals) confirms that stocked fish are surviving in the new population, movement behaviors are similar to native populations, many year classes are present, genetic health metrics are optimistic and similar to the source population, and successful wild-spawned recruitment is occurring. Monitoring of the new Santee River population will continue, but all initial indications are optimistic for the restoration effort.

Assessing the Status of MacGillivray's Seaside Sparrows (*Ammondramus maritimus macgillivraii*) in South Carolina (Federal Grant #: SC-T-F13AF01185, Duration: 2013-2015) PI: Chris Hill (Charleston Southern University); Author: Chris Hill (Charleston Southern University)

Because of the challenges of monitoring populations of marsh-nesting birds, the abundance and demography of MacGillivray's Seaside Sparrow (*Ammodramus maritimus macgillivraii*) along

the Southeast Coast of the United States are relatively poorly known. To update what we know about this subspecies' status, we conducted 5-minute listening surveys at 127 points in tidal marsh habitat across South Carolina in 2014 and 2015. Ninety survey points were in 16 randomly chosen marshes across the State (others were in known historical breeding sites), and we surveyed each point three times over one breeding season. We also conducted an intensive study of nesting MacGillivray's Seaside Sparrows in 2015 at Tom Yawkey Wildlife Center Heritage Preserve, a site known to support a breeding population of these sparrows.

We found that MacGillivray's Seaside Sparrows are very scarce in South Carolina marshes away from a handful of historically known sites. At randomly chosen marshes, an average of only 0.08 sparrows were detected per survey, and when sparrows were detected on one visit to a random point, most often they were not detected on subsequent visits. This indicates either that some "occupied" sites were only visited by transients, or that the occupied marshes had a very low density of nesting birds, lowering detectability. The sparse detections on our statewide survey contrast with both surveys in Georgia and surveys at Tom Yawkey Wildlife Center, where multiple birds were often detected singing on each visit. The intensive study of the breeding population at Tom Yawkey Wildlife Center indicated that nest survival was high (0.92 daily survival rate; 16 of 34 nests with known outcomes fledged young), that predators (likely marsh rice rats, *Oryzomus palustris*), not flooding, were the major cause of nest failure, and that sparrows nested in the greatest density in an impoundment with a mix of smooth cordgrass (*Spartina alterniflora*) and saltgrass (*Distichlis spicata*).

Enhancement of Upstream Passage for American Eels at the St. Stephens Dam, SC (federal Grant #: SC-T-F13AF01207, Duration: 2013-2015) PIs: Allen Hazel (SCDNR) and Bill Post (SCDNR). Author: Bill Post (SCDNR)

American Eel *Anguilla rostrate* are catadromous fish, meaning they live most of their lives in freshwater but spawn in the Atlantic Ocean. Historically, the American Eel was very abundant in East Coast streams, occurring from the estuaries to the headwaters of Coastal Plain streams and at least as far inland as the Fall Line in larger watersheds, including the Savannah, Santee and Pee Dee river basins. Presently, American Eel distribution and population size may be affected by dams and other impediments to migration, although the American Eel is capable of traversing many obstacles that restrict migration and dispersal of other fishes.

The South Carolina SWAP lists American Eel as a species of highest priority, stating that the species performs integral roles in the diverse habitats and ecosystems in which it resides during all portions of its complicated life cycle, and has faced impacts that have caused stock declines in river basins both in South Carolina and across the species' broader range. The Santee River Basin, at 17,000 square miles, is the second largest drainage area in the Eastern United States. The Lower Santee and Cooper rivers are the keystone corridors used by diadromous fish to access habitats in the Santee-Cooper Basin. The first blockages encountered by upriver migrating fish in these systems are the Santee-Cooper project dams (Santee/Wilson Dam on the Santee River, St. Stephen Dam on the Re-diversion Canal, and Pinopolis Dam on the Cooper River). These dams are located on the lower end of the Santee Basin Coastal Plain. As such, adequate passage beyond these dams is essential to diadromous fish restoration throughout the basin. Passage at these dams provides direct access to approximately 160,000 acres of impounded waters in Lakes

Marion and Moultrie and 134 miles of tributary rivers extending to the vicinity of Columbia Dam on the Broad River and to Wateree Dam on the Wateree River.

From 2004-2014, SCDNR operated experimental eel ramps at the St. Stephen Dam and demonstrated that American Eel passage was feasible; however, due to frequent equipment failure from materials exceeding the life span of those used continuously in water, limited water flow, and bird predation, the preexisting experimental ramps needed to be replaced with a more permanent structure. A SWG-funded eel ramp construction project completed in 2015 allowed for the continued capture and passage of elvers at St. Stephen Dam. Manufacturing and installation of the new 6061 marine-grade aluminum eel ramp was completed in September 2014, and the system has operated without malfunction since it was installed. Additionally, the new eel ramp has collected 6,078 elvers and demonstrated a similar effectiveness for collecting elvers as the experimental ramps in place from 2004-2014, thus allowing for continued data collection and long-term abundance analysis.

An Evaluation of Culturing Carolina Diamondback Terrapins for Responsible Stock Enhancement (Federal Grant #: SC-T-F13AF01208, Duration: 2013-2016) PI: Erin Levesque (SCDNR) and Andrew Grosse (SCDNR); Author: Erin Levesque (SCDNR)

During the 2014-2016 mating/nesting season (May through July), viable clutches (1,089 eggs total) from 130 Diamondback Terrapin females captured in trammel nets, and viable clutches from 24 land-captured terrapins were collected and incubated at either male-producing (27°C) or female producing (31°C) temperatures. There was no difference in hatching success between these groups ($p>0.05$). There was a positive correlation with larger females producing more eggs per clutch and a greater mean egg size. Growth of hatchlings in Year 1 fed one of three diets (fresh fish, ZooMed pellets, or Mazuri pellets) was assessed from October 2014 through April 2015 to evaluate feed type; both groups fed commercial pelleted diets grew significantly more than those fed fish only. An overwintering study in 2015-2016 season did not provide desired information on preferred habitat due to opportunistic predation on hatchlings by Raccoons. A total of 411 “headstarted” (juveniles raised in a hatchery to accelerate growth) terrapins and 227 hatchlings have been released into the Charleston Harbor Estuarine system since 2014. Seventy-seven individuals have been retained to confirm sex, and 23 remain in a culture pond at the Waddell Mariculture Center for future investigations of accelerated time to maturity of head-started individuals. Results from this study provided information about how to efficiently capture females, harvest eggs, and grow hatchlings/juveniles in order to supplement depleted wild populations. Access to the large number of hatchlings and juveniles that can be cultured in the laboratory also allows investigation of the biology of these naturally cryptic life stages that will allow us to better manage wild populations.

South Carolina Small River Planning Project (Federal Grant #: SC-T-F14AF01233, Duration: 2014-2020) PI and Author: Mark Scott (SCDNR)

Small rivers—those defined as draining watersheds between 150 km^2 and 2,000 km^2—comprise over 3,100 linear km in South Carolina and support a broad diversity of aquatic taxa. The Small River Assessment (SRA) was developed to extend and further the objectives of the South Carolina Stream Assessment (SCSA), which was limited to wadeable streams under 150 km^2 in

drainage area. The objectives of the SRA were to (1) design a sampling program to define the physical, chemical, and biological conditions in small rivers across South Carolina; and (2) implement a standardized data collection protocol at randomly-selected sites. This study followed the framework of the SCSA in obtaining data necessary to develop models that (1) rank influences on physical, chemical, and biological conditions; (2) identify stressor-response relationships; (3) predict and map population status from sample data; and (4) incorporate the modeled relationships into our decision support tool to allow definition of current and predicted future biological conditions in South Carolina's small rivers, including alternative scenario testing. The SRA represented the first-ever standardized, statewide assessment of small rivers in South Carolina.

One hundred randomly selected small river sites were sampled across South Carolina from 2016-2020, with site selection stratified according to ecobasins (ecoregion x river basin units) and drainage area. Sites were sampled following a standardized sampling protocol for fish assemblage composition, physical habitat, and water quality. Watershed land cover measures for each site were obtained from the 2016 National Land Cover Database in order to facilitate analyses of relationships between biological response measures and watershed factors.

Small rivers were particularly important in supporting freshwater fishes identified in the 2015 South Carolina SWAP as Species of Greatest Conservation Need (SGCN). Altogether, 44 freshwater and diadromous fish SGCN were observed in small rivers, representing 74% of the priority freshwater fish species identified in the SWAP. At least one freshwater fish SGCN was observed at 92% of the randomly selected small river sites, and 84% of sites yielded multiple SGCN. On average, more than four freshwater fish SGCN were observed at each river site, with as many as 11 SGCN observed in a single river site. The occurrence of SGCN was about twice as high in small rivers than wadeable streams, as they represented approximately one in every five fish species observed in small rivers compared with about one of every ten species encountered in wadeable streams. SGCN occurred in all ecobasins of the state; fish SGCN richness was generally higher in the uplands (Piedmont and Blue Ridge) than the Coastal Plain (Southeastern Plains and Middle Atlantic Coastal Plain), largely due to a greater diversity of range-restricted and endemic species in the uplands, many of which are SGCN.

Results of linear modeling suggested both natural and anthropogenic land cover gradients across South Carolina likely influence fish assemblages, including SWAP priority fish species. However, land use/cover appeared to be more important in the uplands. Richness of all native fish species primarily corresponded to elevation and urban land use gradients in the upland sites, whereas in the Coastal Plain native richness was related to gradients in dissolved oxygen (DO) and elevation. SGCN richness in the uplands was also positively related to dissolved oxygen as well as mean flow velocity, whereas in the Coastal Plain SGCN richness was positively related to elevation and DO. In terms of SGCN relative abundance, several predictors ranked high as predictors in the uplands, including water temperature, elevation, turbidity, forest cover, and DO. For the Coastal Plain, site characteristics such as DO, water temperature, and elevation again were more predictive of SGCN relative abundance than watershed variables.

Distribution, Population Ecology, Genetic Relatedness and Habitat Associations of Eastern Spotted Skunks in South Carolina (Federal Grant #: SC-T-F15AF00727, Duration: 2015-

2018) PI: Jay Butfiloski (SCDNR), David Jachowski (Clemson University); Author: from the thesis of Robin Yuet Ying Eng (Clemson University)

Eastern Spotted Skunks are a poorly understood mesocarnivore species that suffered a dramatic range-wide decline in the mid-1900s. Little is known about their current distribution or habitat needs, and in the southern Appalachians, where the Carolinas and Georgia converge, Spotted Skunks have never been studied. We investigated Eastern Spotted Skunk habitat selection to develop an understanding of their habitat and conservation needs in this region.

We used remote-camera surveys and occupancy modelling to evaluate factors hypothesized to influence the probability of Eastern Spotted Skunk detection and occurrence at the landscape scale. We detected Spotted Skunks at 55.6% of our sites and on 18.5% of sampling occasions. Our detection models supported predation risk, camera setup, and scent-based attractants as influential to detection probability but had poor predictive ability overall. Our top occupancy model had moderate predictive power and showed a negative relationship between elevation and occupancy probability. These results suggest Spotted Skunks in the southern Appalachians may be more widely distributed than previously thought but are also highly cryptic and in need of further investigation. In particular, there is a strong need for researchers to identify thresholds of habitat suitability for this species.

To evaluate fine-scale selection of rest site habitat by Eastern Spotted Skunks, we used VHF telemetry and discrete choice modelling. Over two summers we tracked 15 Spotted Skunks and collected habitat data for 233 rest sites and 233 random available sites. Our top model supported positive effects of understory cover and coarse woody debris (CWD), and a negative effect of distance to nearest drainage channel on rest site selection. Previous studies have identified understory cover as important for protection from avian predators; however, ours is the first to identify CWD and drainage channels as important to Spotted Skunk habitat selection. These attributes were hypothesized to be selected based on prey availability, but direct studies of Spotted Skunk diet and foraging strategies are needed. We also recommend further investigation regarding the importance of drainage networks to Eastern Spotted Skunks. Finally, we suggest that preservation of understory vegetation and CWD may benefit Eastern Spotted Skunk conservation in the southern Appalachians.

Using Citizen Science to Guide Statewide Management of Diamondback Terrapins (Federal Grant #: SC-T-F15AF00728, Duration: 2016) PI and Author: Mike Arendt (SCDNR)

A one-year study was initiated to increase awareness of Diamondback Terrapin management efforts in South Carolina. A comprehensive website was launched in mid-April and received over 5,000 unique page visits through December, with the greatest website visits coinciding with a barrage of media releases about terrapins in the fall. An online Diamondback Terrapin reporting form received 137 entries from across the State, but with disproportionately few observations reported north of Charleston County. Both of these deliverables will remain functional in future years and should require only nominal staff time for support and updating. Very few reports of injured or dead terrapins were received; thus, reliance on an existing (albeit sparse) network of authorized reptilian rehabilitation facilities appears to be sufficient for treating the few annual encounters reported by the public. Within-season recapture rates for

Diamondback Terrapins captured by a monthly trammel net survey in the Ashley River were less common in 2016 than during 2008 or 2009; however, overall population structure appears to have remained relatively stable in this system over the past decade. Continued efforts to refine a bycatch reduction device (BRD) show great promise from fishery-independent testing, but public reviews by commercial and recreational crabbers remain mixed. Several very favorable BRD reviews were reported in winter 2016-2017; thus, sustained emphasis on this important aspect of terrapin conservation is encouraged in future funding cycles.

Building Partnerships on State, Federal and Private Lands to Promote Conservation of Seabirds and Shorebirds (Federal Grant #: SC-T-F15AF00730, Duration: 2015-2017) PI and Author: Felicia Sanders (SCDNR)

Many seabird and shorebird populations are in decline. These birds face loss of habitat due to coastal development, sea level rise, armoring of the barrier islands and inlets, and increased recreational pressure along the coast. Nesting birds are especially negatively affected by human disturbance. In order to reverse the declines and stabilize these bird populations, it is necessary to protect nesting colonies and provide sanctuaries where birds can nest, rest, and feed with minimal disturbance. Posting signs and symbolic fencing around nesting areas gives nesting birds a buffer in which pedestrian traffic is restricted. This project built partnerships at 18 sites with managers of properties that have important seabird and shorebird habitat. At most sites, partners were staff or volunteers from the site's management organization. Partners were trained to identify, protect, and monitor beach-nesting birds.

Site visits were the most important activity that taught partners about the need and method to protect seabirds and shorebirds. Workshops and educational material were also used to educate partners. A workshop at Fort Johnson in the MRD auditorium was attended by over 100 participants including naturalists from coastal state parks, USFWS, and private lands. A training at Botany Bay Plantation started a Beach Stewardship program for volunteers. Also, a professional educational sign about shorebirds was purchased and installed at the beach at Botany Bay Plantation to assist beach stewards in educating visitors. A "Best Management Practices (BMPs) for Use of Vehicles" was published and distributed to partners who drive on the beach, especially those staff who also work on sea turtles. A "Breeding Birds of the South Carolina Coast" brochure was developed in partnership with the American Bird Conservancy. This brochure featured images of common coastal nesting shorebirds, seabirds, and wading birds. The brochure also had a conservation message about reducing disturbance to these birds and was distributed to partners.

Potential Mechanism of Thermal Stress Impairment for Striped Bass Populations (Federal Grant #: SC-T-F15AF00731, Duration: 2015-2018) PI and Author: Tanya Darden (SCDNR)
Striped Bass (*Morone saxatilis*) populations have declined throughout their range, and prevailing causal hypotheses are associated with increased summer temperatures. Unlike the northern anadromous populations of Striped Bass that move into coastal estuarine systems in the summer, southern populations tend to move into freshwater habitat for thermal refugia (Scruggs 1957; Combs and Peltz 1982; Bjorgo et al. 2000). Because of the increased temperature associated with global climate change and extreme temperatures of shallow coastal systems, it is possible that coastal populations of Striped Bass are crowded into available temperature refugia (thermal

niche squeeze) with detrimental results likely including direct mortality, decreased fecundity, and increased susceptibility to starvation, harvest, and parasites (Coutant 1985). We hypothesized that in addition to Coutant's (1985) individual-based impacts, thermal stress may result in evolutionary implications for Striped Bass populations, specifically through increased rates of telomere degradation. Telomeres are non-coding DNA regions composed of a conserved repetitive sequence that occur at the ends of linear chromosomes to protect the structural function of chromosomes as well as the DNA coding regions themselves. As the occurrence of organism-wide or critical tissue function loss can result in organismal death, increased net telomere loss rates have the potential to directly influence individual longevity (Barrett et al. 2013). Therefore, if thermal stress in Striped Bass results in higher telomere loss rates that are associated with decreased life spans, shifts in critical population life history traits (i.e. age and size at maturity, fecundity, etc.) would be expected.

Striped Bass remain an important and popular recreational fish species in South Carolina and represent a key indicator species for coastal ecosystems. As such, SCDNR continues to be interested in proactively improving our understanding of the factors currently impacting Striped Bass populations in order to develop management strategies to address potential continued declines. Our mariculture and genetic research teams have leveraged their expertise in both finfish production/husbandry and molecular tool development in conducting manipulative laboratory experiments to determine if thermal stress levels experienced in South Carolina coastal systems are capable of negatively influencing growth and telomere loss rates in Striped Bass. We initially hypothesized that thermal stress may result in evolutionary implications for Striped Bass populations, specifically through increased rates of telomere degradation. While potentially confounding factors in this study resulted in lower confidence in our comparisons of telomere length data between sampling time periods, we have demonstrated the significant effects that high temperatures and limited food have on Striped Bass growth and condition factor. Additionally, it appears Striped Bass may utilize regulation in telomerase activity to assist in reducing or minimizing impacts of potential stress sources that may increase telomere loss rates.

Although our project results have not identified a clear mechanism of thermal stress impacts in Striped Bass, the results are contributing substantially to our understanding of appropriate protocols and tools to evaluate telomere changes, such as incorporation of individual tracking and telomerase quantification with avoidance of short cut qPCR techniques, as well as increasing our knowledge of the complexity of cell replication processes and the influences of environmental factors on those processes. As average annual temperatures within the native Striped Bass range increase, we may expect to see an accelerated decrease in total area of thermal refugia for Striped Bass during the summer months, thereby presenting habitat constraint challenges for the already declining wild populations.

Assessing the status of the Eastern Black Rail in South Carolina (Federal Grant #: SC-T-F15AF00729, Duration: 2015-2017) PI and Author: Christy Hand (SCDNR)

This grant funded 2017 breeding season call-response surveys of Eastern Black Rails (*Laterallus jamaicensis jamaicensis*) at the Bear Island Wildlife Management Area (BIWMA) and the Tom Yawkey Wildlife Center (YWC) and the collection of data using motion-activated cameras (camera traps) during the 2016 breeding and post-breeding seasons. Over 75% of the survey

points where Black Rails were detected during the intensive 2015-2016 coast-wide survey efforts were located on BIWMA and YWC, two coastal wildlife management areas that are owned and managed by SCDNR. Continuing to survey these two properties on an annual basis increases our ability to promptly detect changes in occupancy. Across the two properties, 46 survey points were surveyed three or more times between 15 March and 30 June 2017 by SCDNR and USFWS employees. Black Rails were detected at 13 of the points surveyed (28.3%), including 12 points at the BIWMA and one point at the YWC. Black Rails were also detected at a total of 13 survey points at these two properties during 2016; however, they were detected at over twice as many points (29 points) during 2015. A summary of survey data collected during 2015-2017 is presented in the report. Using camera traps, Black Rail chicks were documented in two wetlands during the 2016 breeding season, allowing us to estimate the timing of incubation and chick rearing activities. Camera trap data collected during the 2016 post-breeding season provide the first documentation of the timing of definitive prebasic molt by Black Rails in Colleton County, South Carolina. During definitive prebasic molt, Black Rails are flightless and are particularly vulnerable to flooding events caused by storms or management activities. Determining the timing of nesting and molt will increase our ability to understand the potential effects of severe storm events and to make informed wetland management decisions.

Continuation of the Carolina Herp Atlas (Federal Grant #: SC-T-F15AF00207, Duration: 2015-2017) PI: Will Dillman (SCDNR) and Mike Dorcas (formerly Davidson College)

This project upgraded the existing Carolina Help Atlas that was first created under SWG grant T-37. The improvements included: optimizing the Atlas for mobile devices, thus allowing users to easily submit data from the field; redesigning the website interface for better compatibility with new web browsers; introducing new features for data accessibility and integration; and increased publicity for new and existing CRA resources.

Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (I) (Federal Grant #: SC-T-F16AF00707, Duration: 2016-2018) PIs and Authors: Felicia Sanders (SCDNR) and Christy Hand (SCDNR)

Many of the seabird, shorebird, wading bird and marsh bird species that utilize South Carolina's coastal habitats throughout the year are of conservation concern due small and threatened populations. This grant funded efforts to reduce human disturbance at key seabird colonies and to conduct nest counts and population surveys of many waterbird species. These count data are incorporated into a long-term database to allow the agency to make informed management decisions as well as contribute to regional and global knowledge of the species. Also funded was research on two high priority species: Red Knots and Black Rails. Survey, research, and management activities were shared on webpages, in press releases, and at outreach events so results were available to partners.

SCNDR staff coordinated with private, federal, state, and county-owned beach managers to close part of the beach for nesting seabirds and shorebirds at 20 beaches during summer months and at 2 during the winter. Educational signs were placed at boat ramps and at some beach entrances. Annual seabird nest counts were conducted for Black Skimmer, Brown Pelican, Common Tern, Forster's Tern, Gull-billed Tern, Least Tern, Sandwich Tern, and Royal Tern. Counts consisted

of walking transects through the colonies and/or using aerial photographic surveys primarily conducted from SCDNR Law Enforcement planes. In 2018, Unmanned Aerial Vehicles (UAVs or Drones), were also used for surveying colonial seabirds. Least Tern nests were monitored at natural beach sites and also on artificial sites mostly consisting of pebbled roofs in industrial areas.

All known active Wood Stork colonies were surveyed each year. We counted 2,480 and 1,730 Wood Stork nests during 2017 and 2018, respectively. During mid-June, flights were used to determine if storks were successful at raising chicks or if the colonies had failed during the nesting season. A sub-set of the stork nests were monitored in index colonies to determine how successful the storks are at raising young in South Carolina. During 2017, a total of 232 stork nests were monitored in 7 colonies, and an average of 1.7 chicks fledged per nest site. An average of 2.0 chicks fledged per successful nest site. In the 157 stork nest sites that were monitored during 2018, an average of 1.6 chicks fledged (2.2 per successful nest).

Black Rails were under consideration for federal listing at the time; thus, we focused research on this species to better understand monitoring techniques and conservation strategies. We investigated temporal vocalization patterns to develop effective survey techniques for Black Rails in the Southeastern United States. Acoustic recordings collected using autonomous recording units suggested Black Rails were most responsive to call-playback during the sunset and sunrise sampling periods. Camera trap data collected during the breeding season suggested that Black Rails exhibited diurnal/crepuscular activity patterns. We also determined that Black Rails are present in small numbers during the nonbreeding season in breeding habitat.

We continued to capture Red Knots in 2017 and 2018. The purpose of the capture was to retrieve previously placed geolocators and to place nanotags on knots. Location data from nanotagged knots suggest that two-thirds of the knots in State may fly directly to the Arctic after leaving South Carolina beaches in the spring. Additionally a Red Knot with a geolocator was recaptured. It also left directly from South Carolina to nest in the Arctic and wintered in South America.

Conservation of South Carolina Coastal Plain Reptiles and Amphibians (I) (Federal Grant #: SC-T-F16AF00708, Duration: 2016-2020) PI and Author: Will Dillman (SCDNR)

South Carolina is home to 143 species of reptiles and amphibians, making it exceptionally diverse for its size. Excluding the sea turtles, 11 reptile and amphibian species are listed as Threatened or Endangered by the State of South Carolina and 48 are identified in the 2015 revision of the State Wildlife Action Plan. Many of these species are also included as species petitioned for protection under the Endangered Species Act (ESA) or are candidate species.

Surveys were conducted on 22 properties across South Carolina for winter breeding amphibian species, focusing surveys on Gopher Frogs, Tiger Salamanders, Flatwoods Salamanders, and Dwarf Sirens; all of these are species identified in the 2015 State Wildlife Action Plan (SWAP) Supplemental Volume under the Pond Breeding Amphibians Guild. We detected no Flatwoods Salamanders or Dwarf Sirens during all survey activities at any site. We observed Carolina Gopher Frogs (breeding, choruses, and egg masses) at multiple locations on two properties from

2016-2020. Tiger Salamanders were detected on 4 properties, one of which had 14 wetlands occupied during the 2019-2020 breeding season.

Upland snake surveys were conducted on multiple properties across South Carolina, using driving surveys and 14 camera trap fences, focusing on detecting the presence of Pine Snakes and Southern Hognose Snakes, which are included in the Longleaf Pine Reptiles and Amphibian Guild in SCDNR's 2015 SWAP Supplemental Volume. In total we detected 29 Pine Snakes and 10 Southern Hognose Snakes from 2017-2020. Of the 29 Pine Snakes, 16 were detected with camera traps, 6 during driving surveys, and 7 records that were either detected during other survey work or reported to SCDNR. Additionally, camera trap fences documented at least 35 other species of reptiles and amphibians. In conjunction with the camera traps, the long-term snake study on the Webb Wildlife Center, initiated in 1994, was continued from 2016-2019 and documented 19 snake species and 5 turtles species, including the recently petitioned Eastern Diamondback Rattlesnake, which, since the inception of this survey, has been documented a total of 198 times, consisting of 146 individuals.

The Gopher Tortoise is listed as State Endangered in South Carolina and only found in the southern-most portion of the Coastal Plain. Only two populations are on properties owned and managed by the State, including the Aiken Gopher Tortoise Heritage Preserve, which is a population made up almost entirely of "waifs"—tortoises from unknown origins, former captives, etc. We radio-tracked 71 hatchling, one- and two-year headstarted Gopher Tortoises to gain a better understand of the survival and movements of these rarely surveyed and little-known age classes. Preliminary data showed that two-year headstarted gopher tortoises had the highest survivorship of the three age classes and that average distance moved was a significant factor in determining survival.

Northern Yellow Bat Roost Selection and Fidelity in South Carolina (Federal Grant #: SC-T-F16AF00598, Duration: 2016-2017) PI: Mary Bunch (SCDNR, retired) and Mary Socci (Palmetto Bluff Conservancy); Author: Jennifer Kindel (SCDNR)

The primary purpose of this study was to investigate the roost site selection and fidelity of the Northern Yellow Bat by mist-netting and radio-tracking individuals at Palmetto Bluff, as well as completing acoustic surveys, recording bats foraging on the property and initiating a public outreach program to educate the community on the project and the environmental needs of bats. During the 2016-2017 study year, 226 net nights were completed over three seasons, resulting in 118 unique captures representing 8 species. Three Northern Yellow Bats were captured, radio-tagged, and tracked to roost over a period of 18 days per bat, leading to 12 separate roost discoveries including 9 roosts within the dead fronds of Sabal Palmettos and 3 roosts within Spanish Moss on pines or oaks. Roost fidelity was calculated with the Shannon Index and used to quantify the diversity and evenness of roosts utilized, with two bats receiving scores under one, indicating higher roost fidelity, and the remaining bat receiving a score of 1.5, indicating lower roost fidelity. A single Southeastern Bat, a South Carolina species of concern, was also radio-tracked to a Sweetgum roost over 6 days, at which point adverse weather disrupted the remainder of the tracking period. Another South Carolina species of concern as well as Federally Threatened species, the Northern Long-eared Bat was unexpectedly represented during this study which was located outside of their known range. Two individuals were caught separately with

DNA confirmation completed on the first capture via a hair and fecal sample. These captures represent unprecedented extralimital occurrences, suggesting previously unrecognized coastal populations.

Acoustic monitoring was conducted over 27+ nights over three seasons, although several nights were omitted to limit results to the projected 11 nights. Recorded calls were analyzed with Bat Call Identification (BCID), which is currently unable to identify Northern Yellow Bat calls; however, manual vetting suggested that some calls identified as Hoary Bat may have been misidentified Northern Yellow Bat calls. These manually vetted Northern Yellow Bat calls suggest the presence of the species at widely varying locations and habitats across the study area. Acoustic data also supported the unexpected capture of Northern Long-eared Bats with calls identified to the species by BCID on 6 nights. Cumulative data showed seasonal variation in nightly activity patterns including differences in number of calls recorded and temporal concentrations.

Optimal Nesting Microhabitat for Diamondback Terrapins in South Carolina (Federal ID#: SC-T-F16AF00713, Duration: 2016-2021) PI: Erin Levesque (SCDNR) and Andrew Grosse (SCDNR); Author: Erin Levesque (SCDNR)

Nest temperatures and predators were monitored in known areas of Diamondback Terrapin nesting activity in Charleston, SC and at Botany Bay Heritage Preserve, Edisto Island, SC over a five-year period, 2017-2021. Study locations were either defined as natural (limited human activity) or disturbed (increased human activity) to assess differences between these areas and potential differential nest success. Predator identification was largely qualitative; however, predators detected on natural nesting beaches were numerous, potentially because shorebirds and sea turtles used these areas to nest and predators optimized that season to feed on eggs and hatchlings. In 2021, 18 clutches of eggs were buried on the open beach at Botany Bay (natural) and 9 clutches were buried in a landscaped residential neighborhood at Wappoo Creek in Charleston (disturbed). While all of the 9 clutches buried in the disturbed site made it the entire incubation period, 6 of the 18 nests buried on the natural beach on Botany Bay were depredated. Mean hatching success across 21 nests that endured the entire incubation period was 75.6% (Botany Bay 70.8% and Wappoo Creek 82.0%). A 100% hatch rate occurred in nests with mean daily temperatures between 27.3ºC-29.9ºC, a mean maximum no greater than 35.2ºC and a mean daily range no greater than 9.2ºC. Hatching rate decreased significantly with increasing mean maximum daily temperatures and mean daily range in temperatures. The mean, maximum, and range of daily temperatures were significantly higher at the Botany Bay site (unequal variances t-tests, $p<0.0001$), and hatching success was significantly lower there. There were no hatchling mortalities and no differences in growth by nest temperature in the first 83-111 post-hatch. The mean temperatures, mean maximum temperature, and mean temperature ranges recorded over the five-year study period in vegetated/open habitats and natural/disturbed habitat in areas with documented terrapin nests fell within the limits that would produce successful hatching; however, there were some nesting areas that were significantly hotter than the nests that produced highest hatching success. Furthermore, terrapin nests in natural and disturbed areas are each susceptible to predation.

Documentation of Horseshoe Crab Nesting Beaches and Egg Densities (Federal Grant #: SC-T-F16AF01121, Duration: 2016-2019) PIs and Authors: Peter Kingsley-Smith (SCDNR) and Michael Kendrick (SCDNR)

This project provided insight into the spatial variability of American Horseshoe Crab spawning activity and an ability to compare embryonic development between habitat types (i.e., beaches vs. salt marshes). Although salt marshes are widely thought to be sub-optimal for emryonic development of Horseshoe Crabs, eggs were seen to successfully develop to the trilobite stage in this habitat. Spawning and fertilization were successful, but a lower percentage of trilobites was observed in salt marshes compared to beaches. In another component of the study, relationships between shoreline migration characteristics (i.e. erosional vs. accretional) and geographic orientation on levels of the abundances of spawning horseshoe crabs on beaches were investigated. Higher densities of Horseshoe Crabs spawned on north-facing, accretional shorelines compared to south-facing, erosional beaches. The public reported Horseshoe Crabs spawning throughout the State of South Carolina. The continuation of long-term tag-recapture efforts partially supported by this project helped to demonstrate that a small proportion of tagged Horseshoe Crabs made substantial migrations between South Carolina and other states to the south (Florida) and north (Massachusetts and Connecticut).

Investigating the Impacts of Harvesting on Ribbed Mussel Communities (Federal Grant #: SC-T-F16AF00714, Duration: 2016-2017) PI and Author: Peter Kingsley-Smith (SCDNR)

The overall goal of this project was to investigate Ribbed Mussel (*Geukensia demissa*) populations locally in South Carolina and to gain a better understanding of their ecological role in the salt marsh community. Furthermore, this project aimed to determine ecological baselines for this harvested species that could be used in the support of the future management of this emerging commercial fishery. The study monitored the demographics of a local *G. demissa* population at the Folly Beach County Park on a monthly basis over the course of a year in order to gain a better understanding of the size-frequency and size-at-age relationship for this species at sites in South Carolina. This sampling indicated that the population was dominated by larger individuals, that recruitment occurred at low levels over an extended period of the year, and that *G. demissa* is estimated to reach 15 years of age. The demographics of *G. demissa* were also compared between an unharvested and harvested site within the ACE Basin National Estuarine Research Reserve (NERR) to assess the impacts of an emerging commercial fishery on this species. While little difference was observed in the demographics of *G. demissa* at these two sites, the results from a concurrent, year-long manipulative experiment indicate that disruptive harvesting practices may have lasting effects on *Spartina alterniflora* health and the potential for *G. demissa* to recolonize harvested patches; however, these effects may be mitigated by selective harvesting techniques (i.e. size-selective removal of *G. demissa*). Another aspect of this project focused on the habitat characterization of *G. demissa* in relation to elevation and salinity. This involved the development of a model based on presence-absence surveys along a salinity gradient in the Ashley River, SC. The model predicted that *G. demissa* is most likely to occur at an elevation of 0.17m below MHW at intermediate (~18 ppt) salinities. Finally, this project incorporated small-scale drop net sampling to compare the nekton assemblages between areas of the saltmarsh with and without *G. demissa* patches. Based on this sampling, no differences in nekton community composition were observed at the scale of the patches sampled.

Abundance and Community Composition of Intertidal Macrobenthic Invertebrates
(Federal Grant #: SC-T-F16AF00720, Duration: 2016-2018) PI and Author: Andrew Tweel (SCDNR)

This project set out to explore several aspects related to the invertebrate community occupying the intertidal zone of several South Carolina beaches (Intertidal Marine Invertebrates Guild/Intertidal Foraging Habitat Guild for Shorebirds). The objectives were: 1) to determine abundance and factors influencing variability of intertidal macrobenthic communities along a gradient of natural habitat types in South Carolina; 2) to compare macrobenthic organism abundance and composition at pristine and erosional beach habitats to heavily managed beach habitats; and 3) to ultimately inform sustainable management of threatened species such as the Federally Threatened Piping Plover (*Charadrius melodus*) that depend on these invertebrates as prey.

Marine benthic invertebrates provide a method of assessing overall habitat quality and are also a critical food resource for finfish and shorebirds (Intertidal Marine Invertebrates Guild/Intertidal Foraging Habitat Guild for Shorebirds, SC SWAP 2015). In addition to serving as a prey resource, these species play a significant role in the cycling of organic matter and nutrients in coastal systems. Benthic invertebrates are utilized worldwide in assessments of habitat quality because they provide an integrative, reliable, and sensitive means for examining the impact of anthropogenic disturbance on living resources. Reasons for this include limited mobility, ease of sampling, and well-documented responses to a wide array of environmental stressors. The intertidal beach community composition, which typically includes amphipod crustaceans, small bivalves, and large errant polychaetes (Nereididae, Glyceridae), can vary depending on a range of factors including anthropogenic disturbance, water quality, sediment composition, and wave energy.

The benthic community and associated sediment characteristics were sampled in two habitats at each of three South Carolina beaches: Deveaux Bank (SCDNR), Botany Bay (SCDNR), and Harbor Island (private, residential). On Deveaux Bank and Harbor Island, a sheltered mudflat and exposed beach were both sampled, and both sites were being utilized as foraging grounds for Piping Plovers at the time of sampling. Botany Bay served as an example of a highly erosional beach, and two areas were sampled: sandy exposed beach, which was visually comparable to nearby beaches such as Seabrook and Edisto, and relic salt marsh beach habitat exposed by recent storm events. The relic marsh habitat was heavily utilized by a variety of foraging shorebirds but not Piping Plovers. Additionally, as part of other ongoing research, data for impacted sites at Captain Sam's Inlet, Kiawah North End, and Hilton Head Island were also available for 2017.

A total of 3,662 organisms, including 56 unique species, were identified for this study. Overall benthic invertebrate densities varied widely between habitats and locations, with the greatest densities observed in Piping Plover-occupied beach habitats on Harbor Island, and the lowest densities appearing in the adjacent sheltered habitat also used by foraging birds. Reasonably strong associations between habitat type (sheltered/exposed), sediment type, and infaunal community were observed, with amphipods and the Coquina clam *Donax variabilis* occurring in higher densities along sandy, energetic exposed beaches and polychaetes dominating the sheltered habitats characterized by lower wave energy and the accumulation of finer sediments. Furthermore, areas inhabited by foraging Piping Plovers exhibited significantly greater prey

resources than nearby unoccupied areas. This was particularly notable with regard to densities of Haustorid amphipods, a known target prey of Piping Plovers. Similarly, Haustorid amphipods were observed in greater densities at unimpacted beaches as compared to impacted beaches, but further work is needed to better quantify these effects. Although *Donax* clams are also a known prey, density did not correlate with foraging status, suggesting that these may be consumed opportunistically rather than targeted. High densities of the polychaete *Alitta succinea* observed at the Deveaux Bank sheltered mudflat correlate well with the high level of foraging activity observed in that area. Despite these trends, however, some areas foraged by Piping Plovers, such as sheltered habitats on Harbor Island, exhibited relatively low prey densities. These areas are also relatively unimpacted by direct or indirect human disturbance and may indicate that prey resources are one of several aspects of site selection. Overall, the Intertidal Marine Invertebrates Guild (Intertidal Foraging Habitat Guild for Shorebirds, SC SWAP 2015) appears to adequately reflect the variety of prey resources available to foraging shorebirds. Future research should prioritize further refining the prey species list for Piping Plovers and other threatened and endangered species which exploit intertidal marine invertebrates, perhaps by relatively new methods such as DNA barcoding of fecal samples, as well as to better quantify the effects of shoreline modification and sea level rise on prey resources for these sensitive species.

Participation by South Carolina in the SEARS Program (Federal Grant #: SC-T-F17AF00122, Duration: 2016-2017) PI and Author: Anna H. Smith (SCDNR)

This project supported the administration and implementation of the regional Southeastern At-Risk Species (SEARS) Program initiative through the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) including development and implementation of conservation actions at a regional/multi-state level. To accomplish the SEARS Program's objectives, the annual contributions of each participating state's funding and matching funds supported third-party implementation of the SEARS Program through the SEAFWA main office. Cooperating states in the SEAFWA donated funding to a central pot of money in order to fund projects selected for that year's funding cycle. An Request for Proposals (RFP) announced the Program. (Funding for this work is the balance of contributed funding from each state, generally equivalent to 2% of the current fiscal year SWG apportionment for each participant, unless otherwise specified.) The three projects that were chosen for funding included:

1. "Population genetic assessment of MacGillivray's Seaside Sparrow (*Ammodramus maritimus macgillivraii*) as a potentially threatened taxon" [PIs: Dr. Stefan Woltmann, Austin Peay State University in TN; Dr. Christopher E. Hill, Coastal Carolina University in SC]
2. "Distributional surveys, taxonomic investigation, and conservation assessment of crayfishes in the Duck River Watershed of Tennessee and the Santee River Basin in North and South Carolina" [PIs: Dr. Zachary Laughman, West Liberty University in WV; Dr. Bronwyn Williams at the North Carolina Museum of Natural Sciences]
3. "Status Surveys for the Rattlesnake Master Borer Moth (*Papaipema eryngii*) in the Southeast Region" [PI: Dr. James Bess, Northland Environmental Services, LLC in MI]

Atlantic Coast Joint Venture – Catalyzing lack Rail Conservation Along the Atlantic Coast (Federal Grant #: SC-T-F17AF01249, Duration: 2017-2019) PIs: Amy Tegeler (SCDNR) and Christy Hand (SCDNR); Author: Amy Tegeler (SCDNR)

This grant funded the development of a draft Eastern Black Rail Conservation Action Plan. The Atlantic Coast Joint Venture (ACJV) adopted the Eastern Black Rail (*Laterallus jamaicensis jamaicensis)* as one of three flagship priority species, due to precipitous population declines and threats to its high marsh habitat throughout its coastal range. The Black Rail is a highly secretive marsh bird believed by researchers to be one of the most endangered birds along the Atlantic Coast. The Black Rail once occupied coastal areas from Texas north to Massachusetts, but its populations have declined precipitously resulting in a range contraction in the north of more than 450km and catastrophic declines and population collapses within historical population strongholds. Conservative estimates of Black Rail populations suggest that only 455 to 1,315 breeding pairs remain, a range-wide decline of >90% since the 1990s. Reasons for the precipitous declines, and how to address them, are poorly understood as research and conservation efforts are greatly hampered by the highly secretive nature and general inaccessibility of this species. The ACJV identified a critical need to improve the understanding of the factors most impacting Black Rail populations, and to develop a set of coordinated strategies to conserve the species. As such, the ACJV Management Board, representing State, Federal and non-governmental organizations (NGO) partners along the Atlantic Coast, agreed to focus their collective conservation efforts on implementing conservation actions to stabilize or reverse population declines. Atlantic Coast states within the ACJV, including the South Carolina Department of Natural Resources, contributed funds as part of the multi-state effort.

The ACJV coordinated many efforts that contributed to the development of the draft Black Rail Conservation Action Plan. The ACJV and Black Rail Working Group led a Black Rail Conservation Planning Workshop where representatives from State, Federal and Academic backgrounds developed and prioritized draft Black Rail conservation strategies. Several maps and data layers were also developed including a Black Rail conservation opportunity area map, a comprehensive high marsh spatial layer and a coastal impoundment layer for the Atlantic Coast, a derivative map of Black Rail priority areas and an irrigation mapper tool. All of the data layers and spatial mapping were incorporated into the draft Black Rail Conservation Action Plan. Work on the Plan will continue using funds from other sources.

Identifying Management Opportunities to Benefit Black Rails Nesting in Coastal South Carolina (Federal Grant #: SC-T-F17AF01208, Duration: 2017-2020) PIs and Authors: Amy Tegeler (SCDNR) and Christy Hand (SCDNR)

Managed tidal impoundments in coastal South Carolina have been found to host a substantial number of the remaining Eastern Black Rails (*Laterallus jamaicensis jamaicensis*) breeding in Atlantic Coast states and provide an opportunity to actively manage water levels to benefit Black Rails. The primary objective of this project was to develop targeted impoundment management techniques to increase nesting success and survival. Using camera trap arrays and water level loggers, we investigated the relationship between water level fluctuations, occupancy, and breeding success. As a result of this project, targeted management of water levels and vegetation structure focusing on meeting the habitat requirements of Black Rails was initiated or expanded

in 5 impoundments. Rails are also receiving greater consideration in management decisions throughout coastal SCDNR properties. In addition, we provided technical assistance to the ACE Basin National Wildlife Refuge and to the Nemours Wildlife Foundation, partnering with the US Fish and Wildlife Service Coastal Program, as they completed infrastructure improvements and targeted habitat management for Black Rails in impoundments on their properties.

Range, Life History, and Environmental Tolerances of the Waccamaw Crayfish (*Procambarus braswelli*) and the Hammock Crayfish (*Procambarus lunzi*) of Near-coastal Environments (Federal Grant #: SC-T-F17AF01207, Duration: 2017-2019) PI and Author: Michael Kendrick (SCDNR)

This project focused on two species listed in the SC State Wildlife Action Plan (SWAP), the Waccamaw Crayfish (*Procambarus braswelli*) and the Hammock Crayfish (*Procambarus lunzi*), both of which are known to occur in the Coastal Plain physiographic region. These species are of conservation priority, in part, due to their restricted distributions and relatively few known locations in the State. In addition, the geographic range, life history, and life cycle phenology of these crayfish are not well known but are important pieces of information for effectively managing such species. To build on our knowledge of the fundamental biology and ecology of these species, this project addressed two major goals: 1) To define the current range of the Waccamaw Crayfish; and 2) to document life history phenology and habitat characteristics of the Hammock Crayfish. Between October 2017 and March 2019, a total of 46 sites (17 in North Carolina and 29 in South Carolina) were surveyed in the Waccamaw, Great Pee Dee, and Little Pee Dee River drainages. A total of 21 Waccamaw Crayfish were collected across three locations, one in the Waccamaw and two in the Little Pee Dee, including five form 2 males collected on November 28, 2017 and one form 2 collected on January 24, 2018. The two sites in the Little Pee Dee where the Waccamaw Crayfish was found also contained the highly invasive Red Swamp Crayfish, *Procambarus clarkii*. The Red Swamp Crayfish was collected extensively during the sampling for the Waccamaw Crayfish and could be displacing the Waccamaw Crayfish, as well as other native crayfish species.

A study population of the Hammock Crayfish, *Procambarus lunzi*, was first identified in a wetland on a hammock island in Beaufort County. This wetland was surveyed over the course of a year to follow population dynamics and environmental conditions (e.g. water temperature, salinity, and dissolved oxygen). Temperature data demonstrated values and trends typical of seasonal changes, but salinity measurements were unusually high throughout the study and remained above those characteristic of freshwater habitats (> 0.5 psu). Salinity declined steadily over the course of the one-year project from 6 psu to ~1 psu. A total of 137 *P. lunzi* individuals were caught between October 2017 and November 2018. The highest catches of Hammock Crayfish occurred in February 2017 and November 2018. The majority of the individuals caught were juveniles (n = 105). Only one reproductively capable male (form 1) was caught. The overall low abundance of crayfish during each sampling event limited the ability to make accurate conclusions about the life history of this species. Environmental data, specifically the evidence of mesohaline conditions year-round in this wetland, however, coupled with the presence of *P. lunzi* during every sampling event, indicate that this species can tolerate salinities chronically higher than those typically characteristic of freshwater habitats.

South Carolina Bat Monitoring and Research Project (Federal Grant #: SC-T-F17AF01195, Duration: 2017-2020) PI and Author: Jennifer Kindel (SCDNR)

The purpose of this grant was to determine overall bat species richness and opportunistically radio-track Federally Threatened bat species, continue WNS surveillance and outreach, determine roosting requirements and foraging area characteristics of Northern Yellow and Northern Long-eared Bats on the Lower Coastal Plain of South Carolina (SC), initiate a South Carolina Citizen Science Bat Watch program, and to create a SCDNR bat database to efficiently house and share bat data.

The 2017 and 2018 SCDNR mist-netting seasons resulted in a netting effort of 404 net nights deployed over 48 total survey nights over 6 properties making up 5 study sites. A total of 269 bats were captured representing 10 different species. The Santee Coastal Reserve WMA had the highest capture rate per night, highest species richness, and was the only site where Northern Long-eared Bats were represented with 8 individuals captured. The Santee Coastal study site accounted for 83% of all *Myotis* species and 90% of Tricolored Bats captured. Chestnut Ridge HP accounted for the remaining 17% of Myotis species captured and, with Belfast WMA, the remaining 10% of Tricolored Bats captured. Five of the 8 Northern Long-eared Bats captured were radio-tagged and tracked to day roost sites. The adult male roosted in a Sweetgum cavity, and all females (sub-adult and pregnant) roosted under the bark of live, mature Longleaf Pines. We estimate the pup season for this population to be between late April and early May. In both years during summer, WNS swabs testing for *Pseudogymnoascus destructans* (*Pd*), as well as environmental samples and collected guano, were negative. In the winters of 2018 and 2019, a total of 30 hibernacula counts were conducted in caves, mines, rock shelters, and culverts, yielding a bat count of 160 bats. Five Tricolored Bats were observed in Oconee County with signs of WNS, and swabs testing positive for *Pd* were collected in 3 new counties: Cherokee, York, and Spartanburg.

In 2018 and 2019, 6 Northern Yellow, 7 Tricolored, and 2 Northern Long-eared Bats were radio-tagged and tracked to roost trees as part of a project to determine summer roosting requirements for these species. Northern Long-eared Bats were excluded from the results due to small sample size. Tricolored and Northern Yellow Bats were found to switch roosts every 1.3 days on average and used 3.8 and 4.5 trees per bat over the 5-9 day tracking period respectively. Tricolored Bats roosted in foliage while Northern Yellow bats roosted in dead palm fronds; both species roosted in Spanish Moss in hardwood trees. Acoustic surveys were also conducted to determine habitat usage and characteristics for these species.

We created the SCDNR Bat Watch Citizen Science Project to engage the public and collect state-wide data on bat emergence counts of summer maternity sites with the assistance of volunteers. Between 2018 and 2020, a total of 135 emergence counts were submitted from bat boxes, bat condos, buildings, and trees by 14 volunteers at 25 sites across the State for a grand total of 15,621 bats counted. We also held Halloween Bat Counts at Sunrift Adventures Inc. in 2018, 2019, and 2020, with a total of 180 people in attendance and 2,200 total bats counted emerging from boxes on the shop at Sunrift. We also set up an ArcGIS database and data entry forms utilizing Survey123 within our Heritage Trust database. Between 2017 and 2020, a total of 830 bat records were entered into our Heritage Trust database. All hibernacula and maternity

colony bat data was also submitted to the NABat online portal. These tools will allow us to more easily observe species trends such as population changes across the State.

Survey of Historic Flatwoods Salamander Localities (Federal Grant #: SC-T-F18AF00026, Duration: 2017-2019) PI: John Pallis (private researcher); Author: Andrew Grosse (SCDNR)

Frosted Flatwoods Salamanders (*Ambystoma cingulatum*) are known to occur in well-managed Longleaf Pine savannahs and flatwoods ecosystems in three southern states: South Carolina, Georgia, and Florida. This species is listed by South Carolina as a non-game State Endangered species and by the United States Fish and Wildlife Service as Federally Threatened due to loss of habitat and reduction in extant populations. Historically, the Francis Marion National Forest and Santee Coastal Reserve Wildlife Management Area were known to be the only public lands in South Carolina where they occurred. Annual survey efforts by the South Carolina Department of Natural Resources, and others, have failed to document Frosted Flatwoods Salamanders since 2010. Dipnet and minnow trap surveys were conducted in 2019 at 25 wetlands, when suitable breeding conditions occurred. This included all known and suitable historic Frosted Flatwoods Salamander breeding wetlands in both the Francis Marion National Forest and Santee Coastal Reserve Wildlife Management Area. Despite extensive surveys, no Frosted Flatwoods Salamanders were found.

Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (II) (Federal Grant #: SC-T-F18AF00961, Duration: 2018-2020) PI and Authors: Felicia Sanders (SCDNR) and Christy Hand (SCDNR)

Many of the seabird, shorebird, wading bird and marsh bird species that utilize South Carolina's coastal habitats throughout the year are of conservation concern due to small and threatened populations. This grant funded efforts from October 2018 – September 2020 to reduce human disturbance at key seabird colonies and to conduct nest counts and population surveys of many waterbird species. These count data are incorporated into a long-term data base to allow the agency to make informed management decisions as well as contribute to regional and global knowledge of the species. Survey, research, and management activities were shared on webpages, in press releases, and at outreach events so results are available to partners. Five scientific manuscripts were published.

SCDNR staff coordinated with private, federal, state, and county-owned beach managers to close part of the beach for nesting seabirds and shorebirds at 21 beaches during summer months and at two sites during the winter. Educational signs were placed at boat ramps and on some beach entrances. Annual seabird nest counts were conducted for Black Skimmer, Brown Pelican, Common Tern, Forster's Tern, Gull-billed Tern, Least Tern, Sandwich Tern, and Royal Tern. Counts consisted of on-the-ground estimates or estimates from aerial photographs taken from SCDNR Law Enforcement planes or Unmanned Aerial Vehicles (UAVs or drones). Least Tern nests were monitored at natural beach sites and on artificial sites that mostly consist of pebbled roofs in industrial areas. Peak statewide nest estimates for this project period are: Black Skimmer (2019) 1049, Brown Pelican (2019) 6109, Common Tern (2020) 9, Forster's Tern (2019) 12, Gull-billed Tern (2020) 182, Royal Tern (2019) 12,983, and Sandwich Tern (2019) 3562.

Wood Storks had a very productive nesting season during 2019. The number of nests counted (3,075 nests) far exceeded the previous record high count in South Carolina. During 2020, a statewide stork census could not be completed, but based on ground counts and the review of video footage, the nest numbers were probably within the same range as annual nest counts during the past decade (2,000-3,000 nests). At index colonies, individual stork nests were mapped as they were initiated and were monitored from a distance (using a spotting scope or binoculars) approximately once per week from the time that egg laying began until the chicks reached fledging age. During 2019, a total of 268 stork nests were monitored in 7 colonies. An average of 2.0 chicks fledged per nest site and 2.4 chicks per successful nest site. During 2020, a total of 139 nests were monitored in 4 colonies. An average of 1.6 chicks fledged per nest site and 2.4 chicks per successful nest site.

To determine the timing of arrivals/departures and the seasonal presence of Black Rails, Soras, Virginia Rails, and Yellow Rails in coastal South Carolina, 3 to 12 arrays of 5 camera traps were deployed and maintained throughout October 2018 – August 2020. Black Rails were detected in South Carolina during every month of the year; however, it is unclear if some or all these individual rails are year-round residents or migrants from northern states. Virginia, Sora, and Yellow Rails were also detected by camera traps during the nonbreeding season. Virginia Rails, which previously were not known to breed in South Carolina, were documented breeding in Georgetown County, South Carolina during 2018 and 2019. We captured 29 Ruddy Turnstones in spring 2019 and placed nanotags on them. Most of the turnstones were captured eating Horseshoe Crab eggs at Turtle Island WMA. All Ruddy Turnstones from this capture flew directly to Arctic habitat from South Carolina.

Investigating Dispersal of the Invasive Red Swamp Crayfish (*Procambarus clarkii*) and its Effects on the Distribution and Status of Native Crayfish Populations (Federal Grant #: SC-TF18AF00962, Duration: 2018-2022) PI and Author: Michael Kendrick (SCDNR)

In South Carolina, the introduced Red Swamp Crayfish (*Procambarus clarkii*) has been established since at least the 1970s. The existence of aquaculture ponds in the lower Pee Dee/Winyah watershed (near Georgetown, SC) in the 1970s and 1980s represent important potential sources for the Red Swamp Crayfish that are currently established in natural streams and wetlands in this area. The species is also located in the upper Waccamaw and Little Pee Dee watersheds, but it has been unclear if these Red Swamp Crayfish populations are the result of a series of human-mediated introductions, or if these populations resulted from a single introduction event, followed by subsequent dispersal throughout the watershed. Understanding the relative importance of these dispersal mechanisms is vital for developing effective strategies for mitigating the effects of nuisance species on native taxa. Genetic analyses and field surveys were used to better understand these dispersal patterns and the impacts of this species on native species. Results show a relative lack of population genetic structure in the Little Pee Dee and Waccamaw, as compared with the Winyah region, suggesting that natural dispersal is likely an important factor leading to the recent spread of the Red Swamp Crayfish in the Little Pee Dee and Waccamaw watersheds. Field surveys show that a quarter of all documented Coastal Plain Crayfish (*P. ancylus*) in the study region have been potentially extirpated by the spread of the Red Swamp Crayfish. Similarly, 14% of the Carolina Sandhills Crayfish (*P. pearsei*) and 19% of the Cedar Creek / Waccamaw Crayfish (*P. braswelli* / *P. chacei*) populations within the study

area appear to have been extirpated by the spread of the Red Swamp Crayfish across the upper Waccamaw and Little Pee Dee drainages. The hypothesis that the Red Swamp Crayfish populations are rapidly dispersing is supported by both field surveys and genetic analyses, and their ability to displace native taxa is also highlighted. The spread and impacts of the nuisance Red Swamp Crayfish threatens native organisms, especially those within South Carolina's Coastal Plain.

Concentrations of Organic Contaminants in Carolina (*Sphyrna gilberti*) and Scalloped (*Sphyrna lewini*) Hammerheads: Implications for Success and Survival in Nursery Habitats (Federal Grant #: SC-T-F18AF00964, Duration: 2018-2021) PI and Author: Bryan Frazier (SCDNR)

The main objectives of the study were to quantify a suite of legacy organic contaminant concentrations (83 compounds) in hepatic tissue of young-of-year (YOY) sharks of two hammerhead species, Scalloped Hammerhead (*Sphyrna lewini*) and Carolina Hammerhead (*Sphryna gilberti*). YOYs were sampled from across three states in the Atlantic Southeast, with most samples coming from South Carolina (n = 104), followed by Florida (n = 29) and Georgia (n = 13). As these are cryptic species, samples were genetically assigned post-hoc as either *S. lewini* (n = 56), *S. gilberti* (n = 74), or hybrid (n = 11), and contaminant concentrations and signatures were compared between species (and hybrids when analyses allowed). Samples that could not be genetically confirmed were removed from analyses (n = 5). Organic contaminants were grouped by class (i.e. polychlorinated biphenyls [PCBs], dichlorodiphenyltrichloroethane [DDT] and its metabolites [DDX], and non-DDT pesticides) and the sum of total organic contaminant (Sum OCs) concentrations were quantified for each sample. While overall Sum OCs did not differ between species, significant differences were found for DDXs and PCBs, with *S. gilberti* tending to have higher DDX concentrations and *S. lewini* having higher PCB concentrations. A Random Forest Analysis conducted only on *S. lewini* and *S. gilberti* was able to correctly identify species 85% of the time. Interestingly, when hybrid samples were included, the ability of the model to correctly predict *S. lewini* assignment increased and hybrids were overwhelmingly (81%) assigned as *S. gilberti*, which likely reflects maternal species identity. In general, Sum OCs were highest in the smallest (i.e. youngest) sharks with concentrations decreasing with length for both species, suggesting that growth dilution may account for the decrease in mean concentrations. To test if growth dilution could account for this decrease with length, we created two growth dilution models based on previously published allometry relationships for these species. In general, a larger proportion of *S. gilberti* than *S. lewini* appeared to have contaminant concentrations that exceeded their ability to undergo growth dilution as established by our models. This may possibly be attributed to *S. lewini* having an earlier purported parturition timeframe (i.e. more "growing days") than *S. gilberti*. When these individuals were removed from the data set, the inverse relationship between fork length and Sum OCs was abolished for *S. gilberti* only, possibly suggesting a decrease in fitness and removal from the population. The results of our study suggest that maternal offloading significantly shapes YOY contaminant signatures and may have implications for survival and fitness during the first months of life, the latter of which is yet to be empirically tested.

Addressing Crucial American Eel Life History Questions: Baseline Data on the Age and Sex Composition of American Eels in South Carolina, with a Comparison of Different

Aging Methodologies (Federal Grant #: SC-T-F18AF00965, Duration: 2018-2020) PI and Author: Brock Renkas (formerly SCDNR)

American Eel (*Anguilla rostrata*) are of concern both nationally and locally, being twice petitioned for listing as Federally Threatened or Endangered under the Endangered Species Act by the UU Fish and Wildlife Service and listed as a species of highest priority by the South Carolina State Wildlife Action Plan (SCDNR 2015). The 2015 SC SWAP also identified the need to "determine size, sex, and age structures for each sub-population of American Eels" as a conservation recommendation. Since before 2010, SCDNR has collected American Eel specimens for laboratory analysis of life history parameters, mostly through electrofishing surveys in both freshwater and estuarine habitats. The overall accomplishments of this project were to leverage currently collected histological gonad (n = 1,141) and otolith (n = 1,081) samples to address critical data gaps identified in recent American Eel stock assessments. Life history parameters such as size structure, age structure, sex ratio, size-at-maturity, and age-at-maturity were assessed for South Carolina eels. Additionally, otolith samples were processed via two separate techniques recommended by the Atlantic States Marine Fisheries Commission for American Eel aging, and results were then shared regarding the preferred method. Final metrics showed that the thin sectioned method currently used by SCDNR for aging eel is far more precise with less bias compared to the whole otolith aging method. The final report for this grant provides the most detailed region-specific life history data ever produced for American Eel in South Carolina, and it is therefore valuable at state and federal levels for management of the species.

NABat Acoustic Monitoring in South Carolina (Federal Grant #: SC-T-F18AF00972, Duration: 2018-2022); PIs: Susan Loab (Clemson University/US Forest Service), Dr. David Jachowski (Clemson University), Anna Siegfried (graduate student, Clemson University), and Jennifer Kindel (SCDNR); Author: Jennifer Kindel (SCDNR)

Many of South Carolina's bat species are species of concern and thus, monitoring their population trends and distribution is critical for long term conservation and management. South Carolina was one of the first states to implement the North American Bat Monitoring (NABat) Program. The program has continued each year since its initiation in 2015. The objectives of this project were to continue NABat monitoring across South Carolina and 1) compare models of bat occupancy based on site level characteristics to those based on cell level characteristics to determine the best methods for long-term monitoring and data collection across the State, and 2) determine trends in bat populations across the State and within regions from 2015-2020 based on mobile acoustic transect data. We acoustically surveyed 37 of the 38 established NABat cells across South Carolina in 2019 and 32 of the 38 established cells of priority in 2020. Trend analyses were based on mobile acoustic data we collected in 2019 and 2020 along with those collected from 2015 to 2018. We measured habitat structure at each of the point survey locations and used these data along with landscape level data obtained from various sources to model bat species or species group occupancy at the point and cell levels. We found that the addition of point level data, such as canopy closure and tree density, as well as distance to water and distance to roads, increased our ability to model occupancy for some species. However, cell-level variables were better for other species. This suggests that collecting site level data along with landscape level variables may be valuable for

future modeling efforts. Overall, relative population trends of bats across the State were stable or slightly increasing for most species despite the various threats, such as White-nose Syndrome, that have been impacting South Carolina's bats. However, we were only able to model 6 years of data, and better resolution of population trends will be obtained as more data are obtained.

Green Salamander Population Assessment and Connectivity Across a Gradient of Forest Disturbance (Federal Grant #: SC-T-F18AF00973, Duration: 2018-2022) PI: Will Dillman (SCDNR) and Kyle Barrett (Clemson University); Author: Will Dillman (SCDNR)

The Green Salamander (*Aneides aeneus*) inhabits rock outcrops embedded in mountainous forested landscapes. Green Salamanders are listed as "Near threatened with decreasing populations" by the IUCN Red List and ranked as "Critically Imperiled" in South Carolina by the Department of Natural Resources. This project addressed the objectives of the 2015 State Wildlife Action Plan related to Green Salamanders by 1) identifying suitable habitat features that could be used to derive estimates of occupancy probability of Green Salamanders;(2) estimating population size using a mark-recapture study across 21 sites; and 3) estimating genetic connectivity and inbreeding across 15 sites.

To identify suitable microhabitat features for Green Salamander occupancy, we evaluated features that contribute to microclimate and within-habitat connectivity, including crevice depth (cm), width (cm), length (cm), canopy cover (%), distance from the nearest tree (m), distance from the nearest crevice (cm), and crevice density within a 1 m^2 area. We actively searched for Green Salamanders while assessing these features. We surveyed 424 crevices across 5 sites and found Green Salamanders occupying 116 of the crevices. A global logistic regression model identified crevice width, canopy cover, and crevice density as significant predictors of Green Salamander presence. To estimate population size, we performed capture-mark-recapture methods across 21 sites. Sites were surveyed following the two-tiered procedure of the Pollock's robust design. Population abundances ranged from 3 to 27 individuals (mean = 14.05, SD = 7.33). Green Salamander abundances did not strongly correlate with site elevation or size but did show an increase related to south-facing aspect and the number of crevices present at a site. We assessed genetic connectivity and inbreeding status across 15 sites. We also quantified land cover change from 2001 to 2021 using the National Land Cover Database (NLCD) to compare the genetic connectivity of Green Salamanders to the gradient for land cover type available. Sampling locations showed low levels of genetic diversity and population subdivision. F_{ST} values ranged between 0.002 and 0.267 (mean = 0.07). Sampling locations also showed low levels of F_{IS} values ranging from -0.09 and 0.11 (mean = -0.05), indicating inbreeding is not occurring within sites. Comparative results from the 2001 and 2021 NLCD data showed the area of deciduous, evergreen, and mixed forest land covers decreased by less than 2% in the 20-year time span. Results are consistent with ongoing migration among sampling locations, or historically contiguous population structures.

We recommend rock outcrops with the following features be prioritized for Green Salamander conservation: outcrops with most crevice widths measuring < 3 cm, very high canopy coverage (≥ 99%), and high crevice densities of at least 7 crevices per m^2. Regarding our genetic results, we see no strong population structure across sites and there

is evidence to suggest sufficient gene flow is occurring to maintain similar allelic frequencies across the surveyed populations, and the lack of land cover change may indicate that movement throughout the generations is not hindered by a loss of habitat. Because Green Salamanders prefer rock outcrops with high canopy cover, we recommend preserving the forested land cover between and within known populations.

Environmental DNA Determination of the Distribution of the Patch-Nosed Salamander (*Urspelerpes brucei*) in South Carolina (Federal Grant #: SC-T-F19AF00717, Duration: 2020-2022) PI and Author: Cathy Jachowski (Clemson University)

The Patch-nosed Salamander (*Urspelerpes brucei*) is a small, lungless salamander (family Plethodontidae) that was first discovered in 2007 and was subsequently described as a new genus and species. As of 2020, the species was only known from a handful of headwater streams in a 24 km^2 region spanning a portion of the South Carolina-Georgia boundary and the mainstem Tugaloo River. At the onset of our study, the species was known from only one locality in South Carolina (Oconee County) and listed as a "Highest Priority Species" in South Carolina's 2015 State Wildlife Action Plan. A major challenge to conservation of the species is a lack of knowledge regarding its distribution in the State. In our first objective, we used existing data from occupied and unoccupied localities in Georgia and South Carolina to develop a preliminary predictive model of species occurrence. Our preliminary model suggested Patch-nosed Salamanders were most likely to occur in close-proximity of other known localities and in streams surrounded by relatively steep and rugged terrain. In our second objective, we used our model from Objective 1 to prioritize areas in South Carolina for future surveys. We collected water samples from 85 high priority localities and used a previously validated environmental DNA (eDNA) assay to assess each sample for genetic evidence of the species. We detected Patch-nosed Salamander DNA from only two of 85 samples (0.02%), both clustered near the confluence of a single tributary of the mainstem Tugaloo River, approximately 4.5 km northwest of the only other known locality in the State. In our third objective, we conducted ground-truthing surveys to compare effectiveness of survey methods and compare the distribution of Patch-nosed Salamanders in the two South Carolina localities. In total we detected 32 Patch-nosed Salamanders across both sites. Patch-nosed Salamanders had a low detection probability ($p \leq 0.15$) but were most likely to be detected with unconstrained active searches and aquatic leaf litter bags in spring (March-April). Additionally, the species was more homogenously distributed and about ten-times more common in one locality relative to the other, though the drivers of these patterns remain unclear. We conclude that Patch-nosed Salamanders are uncommon, and patchily distributed both among and within small headwater streams in a single 12-digit hydrologic unit code [HUC 12] (and perhaps bordering catchments) in the State of South Carolina.

Response of Bachman's Sparrow (*Peucaea aestivalis*) to Habitat Management in a Wiregrass-free Ecosystem (Federal Grant #: SC-T-F19AF00718, Duration: 2019-2021) PIs and Authors: Mikayla Thistle (SCDNR), Beth Ross (Clemson University), Mark McAlister (SCDNR), and Jamie Dozier (SCDNR)

Through much of its range, Bachman's Sparrow (*Peucaea aestivalis*) uses the wiregrass (*Aristida spp.*) dominant understory typical of Longleaf Pine (*Pinus palustris*) forest. The central South Carolina Coastal Plain, however, lies within the "wiregrass gap" where Longleaf Pine understories are absent of wiregrass and instead are dominated by bluestem grasses (*Schizachyrium spp.* and *Andropogon spp.*), Bracken Fern (*Pteridium aquilinum*), and shrubs. Habitat use by Bachman's Sparrow in this region has yet to be studied, and declining Bachman's Sparrow populations necessitate a better understanding of habitat selection processes and population dynamics across regional habitat types. The goal of this study was to describe breeding season habitat selection and breeding ecology of Bachman's Sparrow in the unique wiregrass-free Longleaf Pine ecosystem of Tom Yawkey Wildlife Center, Santee Coastal Reserve, and Washo Reserve, South Carolina to inform best management practices for Bachman's Sparrow.

We conducted repeated visit point count surveys at 95 sites and used open *N*-mixture models to estimate the effects of habitat management and forest stand characteristics (e.g. prescribed burns, basal area, stem density, pine species, canopy closure) on Bachman's Sparrow abundance, apparent survival probability, and recruitment rates during the 2020 and 2021 breeding seasons. We also located nests to identify vegetation composition and structure characteristics that Bachman's Sparrows select for nest-sites. To determine if habitat selection in the study population was adaptive, we monitored nests and related nest-site selection to nest survival rates by comparing habitat characteristics related to selection with those related to survival. Across the 9 primary sampling periods, we estimated the abundance of male Bachman's Sparrows within the study area to be between 23 and 49 individuals. Initial abundance and recruitment rates were strongly predicted by the proportion of Longleaf Pine to other pine species within the sample area, with abundance and recruitment rate increasing with Longleaf Pine dominance. Apparent survival probability decreased as the density of stems between 10 and 25 cm DBH increased. Nest site selection in the study population was non-adaptive. Bachman's Sparrows selected nest sites that had intermediate groundcover densities compared to available nest sites; however, nest survival rates decreased at intermediate groundcover densities. The results of this study can be used to inform region-specific management plans and restoration of degraded habitats, which often lack typical understory species like wiregrass, to increase Bachman's Sparrow abundance and reproductive success.

Effects of Forest Management on Early-successional Avian Species in South Carolina
(Federal Grant #: SC-T-F19AF00719, Duration: 2020-2022) PI and Author: Amy Tegeler (SCDNR)

Early-successional habitats are a critical habitat type for Ruffed Grouse (Bonasa umbellus) and Golden-winged Warblers (*Vermivora chrysoptera*). In the Southern Blue Ridge Ecoregion, early-successional habitats have declined over the last 70 years, and the extent of which Ruffed Grouse and Golden-winged Warblers occupy these habitats at the edge of their ranges is unknown. Understanding the factors that drive the presence or absence of these species in this region is critical to inform quality management of early-successional forests. Additionally, increased knowledge of these species will likely benefit other species of conservation concern that rely on early-successional forests, such as the Prairie Warbler (Setophaga discolor), Common Yellowthroat (*Geothlypis trichas*), Field Sparrow (*Spizella pusilla*), and Chestnut-sided Warbler (Setophaga pensylvanica). In this study, we examined multi-scale habitat factors to determine specific drivers of presence or absence of Ruffed Grouse, Golden-winged Warblers, and habitat indicator species. Additionally, we employed both human-observer and autonomous recording unit surveys to determine the efficacy of the two methodologies.

Our first objective was to examine the effects of landscape-scale habitat features on Ruffed Grouse occupancy. Ruffed Grouse in the Southern Blue Ridge Ecoregion seem influenced by habitats not typical of their northern range and occur more frequently in landscapes with higher mixed forest and woody wetland cover. In the absence of early-successional forests, Ruffed Grouse may be seeking habitats that act as structural mimics to early-successional forests. Our second objective was to examine the effects of multi-scale habitat parameters on Golden-winged Warbler, Chestnut-sided Warbler, Prairie Warbler, Common Yellowthroat, and Field Sparrow. As a whole, these species seem to be influenced by landscape and composition, ground cover metrics, vegetation structure, and elevation. Chestnut-sided Warblers may act as the most effective habitat indicator for Golden-winged Warbler habitat, as they exhibit similar preference for habitat features including elevation and vegetative visual obstruction. Our third objective was to examine the efficacy of human-observer surveys and autonomous recording unit surveys to detect Ruffed Grouse, Golden-winged Warbler, and early-successional habitat indicator species. Autonomous recording units performed comparably to human observers and may represent an efficient tool for future monitoring protocols.

This study represents the largest known effort to inventory Ruffed Grouse and Golden-winged Warblers in the State of South Carolina. We found low Ruffed Grouse and Golden-winged Warbler occupancy rates across two seasons (spring and summer 2020 and 2021), indicating the need for both robust monitoring protocols and targeted habitat management for the benefit of these species. Our results indicate unique habitat preferences of Ruffed Grouse in the Southern Blue Ridge Ecoregion. Additionally, our results provide insight into multiple parameters that drive early-successional songbird species occupancy. This project provides information that will aid in both habitat management and conservation of high priority, early-successional avian species. This project also provides context for efficient monitoring protocols.

Identification of Environmental and Biological Factors Limiting Occurrence of the Sandhills Chub (*Semotilus lumbee*) in South Carolina (Federal Grant #: F19AF00720, Duration: 2019-2021) PIs: Derek Crane (Coastal Carolina University) and Mark Scott (SCDNR); Author: Derek Crane (Coastal Carolina University)

The objectives of this project were to assess Sandhills Chub populations in South Carolina, identify environmental and biological features associated with healthy populations and depleted or extirpated populations, and develop a predictive model to guide Sandhills Chub conservation and restoration. The Sandhills Chub is categorized as a Highest Priority species under the SCDNR's 2015 State Wildlife Action Plan because its global distribution is limited to the Sandhills Ecoregion of north-central South Carolina and south-central North Carolina. It has been extirpated from several locations in South Carolina, and quantitative information on habitat use and biological associations are needed to guide conservation and restoration efforts. Habitat and fish data were collected at 115 sites during 2019-2020, and 431 Sandhills Chub were collected at 41 sites, including 26 sites where they had not been previously collected. Co-occurrence analysis and logistic regression were used to identify which biological and habitat features were associated with the presence and absence of Sandhills Chub. Co-occurrence analysis indicated positive relationships between Sandhills Chub and Dollar Sunfish (*Lepomis marginatus*), Creek Chubsucker (*Erimyzon oblongus*), and Margined Madtom (*Notorus insignis*) and negative relationships between Sandhills Chub and Largemouth Bass (*Micropterus*

salmoides), Bluegill (*Lepomis macrochirus*), Creek Chub (*Semotilus atromaculatus*), Eastern Mosquitofish (*Gambusia holbrooki*), and Lined Topminnow (*Fundulus lineolatus*). Sandhills Chub presence was positively associated with dissolved oxygen levels, instream cover, and the percent of substrates that were 6-11 mm. Additionally, when an extreme outlier HUC was removed from the analysis, a negative relationship was observed between Sandhills Chub presence and the number of impoundments within each 12-digit HUC. However, further investigation is required to determine the validity of this relationship. Results from this study will help guide future conservation and restoration efforts for Sandhills Chub.

Upstate Bridge Use by Highest Priority Bat Species (Federal Grant #: SC-T-F19AF00722, Duration: 2019-2020) PI and Author: Jennifer Kindel (SCDNR)

The goal of this project was to select bridges over Lake Hartwell, Lake Keowee, and the Chattooga River thought to be biologically important and/or in the State Transportation Improvement Program (STIP) and use acoustic devices to record bat calls to determine if and how SWAP bat species of highest concern utilize these transportation structures. From the end of May through mid-September, acoustic monitoring was completed for an average of 8 days apiece at 17 total bridge sites and 5 additional sites over open water near bridges. SCDNR staff recorded a grand total of 17,774 calls at 22 sites representing 10 species. Southeastern and Little Brown Bat calls were auto-classified by Kaleidoscope Pro but could not be verified as such when manually vetted. All calls auto-classified as Gray Bats were also manually vetted and were verified at one location: bridge #44. The bridges with the highest number of species recorded were #44, #16 and #27, with 8 species recorded per bridge. These bridges also recorded the highest number of priority species, with 5 species, 4 species, and 4 species recorded, respectively. Open water site #47 also had four high priority species recorded, and its proximity to bridges #44 and #16 supports species confirmation for those sites. The two bridges with the highest average number of calls per night were #13 at 475 calls per night, most of which were Brazilian Free-tailed Bats; and #31 at 384 calls per night, most of which were Tricolored Bats. The top 3 species recorded in the study area were Tricolored (54.3%), Brazilian Free-tailed (24.7%), and the Eastern Red/Seminole Bat complex (6.6%). The acoustic results from this study suggest that the Federally Endangered Gray Bat, which has never been recorded in South Carolina, may be roosting at or around bridge #44 in the Blue Ridge Ecoregion. They also suggest that the State Threatened Eastern Small-footed Bat is likely and could potentially be using expansion joints, corners located between beams, and/or other crevices on some of these surveyed bridges. No bat species were seen roosting on any bridges during this pilot survey.

Utilizing Trace Elements and Stable Isotope Analysis to Reconstruct Distribution of Scalloped and Carolina Hammerheads (Federal Grant #: SC-T-F19AF00723, Duration: 2019-2023) PI and Author: Bryan Frazier (SCDNR)

The main objectives of this study were to determine if spatial segregation of juvenile and adult hammerheads occurs and if there are patterns in life-stage specific habitat use for Carolina and Scalloped Hammerheads. These objectives were investigated using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) of vertebrae as well as stable isotope analysis (SIA) of eye lenses. Trace element concentrations (Sr, Ba, Mg, Mn, Li and Ca) from the LA-ICP-MS were collected across the whole vertebrae (total transect) and integrated across vertebrae

sections that were designated as life stages (in-utero, young-of-year (YOY) or nursery, early juvenile, late juvenile, and adult) through measurements of the vertebrae associated with age. Layers of eye lenses associated with general life stages were analyzed for $\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$ stable isotope analysis. Analyzing life stage signatures from both techniques provided the ability to estimate natal origin of juvenile and adult species, ontogenetic shifts in habitat by maturity or life stage for each species, and the extent of spatial segregation throughout life stages between species.

Nursery trace element signatures of Scalloped Hammerheads were different in Mg concentration between Bulls Bay and Cape Canaveral and between Tolomato River and Bulls Bay, while YOY Carolina Hammerheads significantly differed between Bulls Bay and Cape Canaveral in Sr and Mn. A Random Forest Analysis conducted on Carolina and Scalloped Hammerheads was able to correctly predict natal origin 71.9% of the time. When the model was employed for juvenile and adult individuals, 95% of these older hammerheads were predicted to have originated from Bulls Bay nursery, while only 4.4% and 0.06% likely originated from Tolomato River and Cape Canaveral, respectively. In-utero and YOY trace element signatures differed slightly between species (in Mg, Mn and Li), but there was a more defined species difference in element concentrations (Sr, Mg, Mn and Li) in early juveniles. The overall transect concentrations were assessed by hammerhead maturity stage and generally reflected patterns between vertebrae life stages for both species. Sr:Ca and Sr:Ba ratio concentrations indicate that an ontogenetic habitat shift occurs between YOY and early juvenile sharks for both Carolina and Scalloped Hammerheads, and suggests Carolina Hammerheads migrate to offshore waters at an earlier age and continually inhabit more offshore waters as late juveniles and adults than Scalloped Hammerheads.

Species-specific distinctions in Mn and Li suggest possible dietary differences, which can allude to habitat differences between species throughout their lifespan, though continued research will be needed to assess the extent of any differences. The results of eye lens stable isotope analysis generally confirm these results; that said, eye lens data may suggest Scalloped Hammerheads may have a more open ocean signal than Carolina Hammerheads. Given the disparities, it may be more likely that dietary differences are leading to the observed differences in trace element and stable isotope eye lens data. Unfortunately, Carolina Hammerheads remain rare in catches, and equal sample sizes could not be run during this study. Despite the conclusion of this grant, we will continue to add samples to these analyses, giving us greater ability to tease apart the differences observed in these species. These results allowed the first insights into species-specific trophic ecology of Carolina and Scalloped Hammerheads, data that will be critical to effective management of hammerheads in the United States.

Determining the Relative Importance of Coastal Habitat Types to Horseshoe Crab Reproduction and Migratory Shorebird Foraging in South Carolina (Federal Grant #: SC-T-F19AF00749, Duration: 2019-2022) PIs: Peter Kingsley-Smith (SCDNR) and Michael Kendrick (SCDNR); Author: Michael Kendrick (SCDNR)

The American Horseshoe Crab (*Limulus polyphemus*) is an ecologically- and economically important species found in the United States along the Atlantic and Gulf coasts. Information on locations where Horseshoe Crab spawning occurred was collected from statewide public reports

using an online reporting form, spawning surveys, and egg sampling surveys. Although difficult to discern with certainty based on GPS coordinates and location descriptions, 6 of the 55 reports appear to be of Horseshoe Crabs spawning in marsh habitats. Our spawning surveys in early April 2021 at Coffin Point documented, for the first time during standardized SCDNR spawning surveys, adult Horseshoe Crabs spawning in the salt marsh in South Carolina. In 2021, we found eggs/embryos at 5 out of 50 randomly selected beach sites and at 7 out of 50 randomly selected marsh sites (Fig. 2). There was no significant difference in the likelihood of finding eggs and embryos in either habitat. The likelihood of finding eggs in the entire core sample did not change with time at Otter Island but increased with time at Deveaux Bank. Multiple lines of evidence from this study indicate that Horseshoe Crabs in South Carolina use salt marsh habitats to spawn, potentially at similar densities as they spawn on the beach. These findings are important steps in understanding the role of salt marshes in Horseshoe Crab reproduction in South Carolina.

Ecology of Estuarine Sensitive Infauna Along a Stress Gradient (Federal Grant #: SC-T-F19AF00750, Duration: 2019-2020) PI and Author: Andrew Tweel

Benthic infauna, specifically members of the Estuarine Sensitive Taxa Guild (2015 SC SWAP), serve as a valuable indicator of estuarine habitat quality and environmental stress. Stormwater input is one form of environmental stress that occurs in estuarine systems. As part of an ongoing salinity impact study, this project aimed to quantify benthic infauna along a stormwater-development stress gradient in several tidal creek systems surrounding Charleston, South Carolina. Overall, several taxa were identified that may serve as indicators of degraded conditions, although some of these were observed in low abundances in general. *Mediomastus sp.*, a capitellid polychaete, was the most sensitive of all species observed, although at low abundances throughout, and was significantly inversely correlated to salinity drop, impervious cover percentage, as well as total pesticide concentrations. Annelids, both polychaetes and oligochaetes, generally showed the strongest relationship to development and position within creek (i.e. headwater or downstream), with the lowest abundances occurring at high development and/or headwater sites.

Integrating Crayfish into Aquatic Assessments from the Uplands to the Coast (Federal Grant #: SC-T-F00779, Duration: 2019-2022) PIs: Michael Kendrick (SCDNR) and Mark Scott (SCDNR); Author: Michael Kendrick (SCDNR)

Integrative watershed approaches to water quality have been shown to be effective and efficient ways of maintaining robust and healthy ecosystems across the continuum of aquatic habitats from the mountains to the coast, being used by governments across the world**.** Aquatic resource assessments such the South Carolina Stream Assessment (SCSA), Small River Assessment (SRA), and headwater streams assessments were developed to determine the status of aquatic resources in streams and rivers throughout the State using fish communities to assess resource condition. Crayfish are a representative invertebrate taxon that can be valuable to existing state-wide assessments through their sensitivity to environmental conditions and as priority conservation species in South Carolina.

In order to better assess the distribution and abundance of crayfish in the Savannah River Basin, SCDNR biologists have developed georeferenced locations of 145 potential sampling sites within the South Carolina portion of the Savannah River watershed, selected from previous

SCSA and SRA sampling locations. A subset of 55 sites were selected for sampling by teams of 2-3 biologists from January-March 2021, across all of South Carolina's physiographic regions. Field-assessed canopy cover was a significant driver of both richness and Shannon diversity. Land cover (National Land Cover Database) was not a significant driver of crayfish richness but was marginally significant for Shannon diversity. Physiographic province was a significant driver of crayfish richness and Shannon diversity with the Coastal Plain having greater crayfish richness compared with the Piedmont and Blue Ridge Ecoregions. For fish surveyed at these same sites, Land cover was also not a significant driver of fish richness or Shannon diversity. Physiographic province was not a significant driver of richness or Shannon diversity. In comparing patterns and drivers of crayfish assemblages in the Savannah basin, it becomes apparent that the underlying physiographic province is a strong predictor of both crayfish richness and diversity in the sampled sites. This contrasts with the richness and diversity of finfish assemblages where physiographic province was not a predictor of these metrics. The site-specific patterns of richness and diversity juxtaposed across fish and crayfish assemblages in this study provide the foundation for synthesizing biodiversity data from multiple taxa groups (e.g. fish, crayfish, mussels, insects) into biological assessments of aquatic resources.

Development, Testing, and Field Validation of an eDNA Tool for Robust Redhorse (Federal Grant #: SC-T-F19AF00780, Duration: 2019-2022) PIs: Dr. Tanya Darden (SCDNR) and Daniel Farrae (SCDNR)

This project has provided a new, powerful environmental DNA (eDNA) tool that will increase our passive detection capabilities for Robust Redhorse, a species that has historically evaded routine field efforts outside of their spawning season. The rigorously designed eDNA assay was tested for species specificity, efficiency, and sensitivity. A laboratory experiment was conducted to evaluate the influence of both fish density and sediment on DNA persistence, and sampling of production ponds allowed us to evaluate DNA accumulation using the new eDNA assay. We also successfully detected Robust Redhorse with the new tool during field validation sampling in two areas with known Robust Redhorse present. Collectively, our project activities provide a solid interpretation foundation for the application of this new eDNA tool for Robust Redhorse in the field. The new eDNA tool will allow for the detection of juveniles and/or adults in habitat reaches that are challenging to sample with traditional gears/methods, increasing our understanding of distribution and habitat use for Robust Redhorse. Improvement of passive detection tools such as the new eDNA assay will provide critical data in making the best management decisions during a critical period for the species' survival and regulatory status.

Microplastic Exposure for Key Ecological Species in Coastal South Carolina (Federal Grant #: F20AF11202-00, Duration: 2020-2023) PI: Tanya Darden (SCDNR) and Joey Ballenger (SCDNR); Author: Claire Benson (SCDNR)

While a range of anthropogenic activities threaten estuaries and tidal marshes, an emerging threat in these systems is the impact of microplastics. Field studies document microplastic presence and prevalence in fishes all over the world. However, major data gaps exist in many coastal areas of the globe with most studies focusing on urbanized estuaries. Herein, we conducted a study of microplastic occurrence in the guts of five estuarine fish species within the ACE Basin, SC, a non-urbanized, minimally-developed estuary neighboring the highly studied Charleston Harbor, SC, system. Species were chosen to represent different feeding ecologies: the planktivore

Atlantic Menhaden, the piscivore Southern Flounder, the detritivore/benthivore Striped Mullet, and the benthic omnivores Spot and Mummichog. Microplastics (MP) were present in 75% of fishes collected with an average of 17 MP $fish^{-1}$ and 1 MP g^{-1} of fish, although exposure varied among species. Mummichog possessed significantly more MP g^{-1} fish weight than other species, suggesting the benthic omnivore feeding ecology was particularly vulnerable to microplastic ingestion within the estuary. Among all species, foams had the highest selectivity of all microplastics present. However, fibers had the highest frequency of occurrence within most species. Overall, both the presence and prevalence of microplastics in finfish of the ACE Basin were reduced relative to the urbanized Charleston Harbor estuary, suggestive of decreased point sources in the ACE Basin region.

Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (III) (Federal Grant #: F20AF11231-00, Duration: 2020-2022) PIs and Authors: Felicia Sanders (SCDNR) and Christy Hand (SCDNR)

Many of the seabird, shorebird, wading bird, and marsh bird species that utilize South Carolina's coastal habitats throughout the year are of conservation concern due small and threatened populations. This grant funded efforts to reduce human disturbance at key seabird colonies and to conduct nest counts and population surveys of many waterbird species. These count data are incorporated into long-term databases to allow the agency to make informed management decisions as well as contribute to regional and global knowledge of the species. Additionally, research on the federally listed Black Rail was funded. Survey, research, and management activities were shared on webpages, in press releases and at outreach events so results are available to partners.

SCDNR staff coordinated with private, federal, state, and county-owned beach managers to close part of the beach for nesting seabirds and shorebirds at 27 beaches during summer months and at 2 during the winter. Educational signs were placed at boat ramps and on some beach entrances. Annual seabird nest counts were conducted (in 2021 and 2022) for Black Skimmer (789; 560), Brown Pelican (5978; 5332), Common Tern (6; 9), Forster's Tern (2; 15), Gull-billed Tern (216; 278), Least Tern (965; 1052), Sandwich Tern (2775; 2651), and Royal Tern (7163; 6260). To minimize disturbance to nesting birds, staff used binoculars or spotting scopes to count the number of adults sitting in incubation postures as a proxy for nest counts or used aerial photographic surveys primarily conducted from SCDNR Law Enforcement planes. Least Tern nests were monitored at natural beach sites and on artificial sites mostly consisting of pebbled roofs in industrial areas.

All known active Wood Stork colonies were surveyed each year. We counted 3,493 and 3,928 Wood Stork nests during 2021 and 2022, respectively, setting a record high number of stork nests for the State. A sub-set of the stork nests were monitored in index colonies to determine how successful the storks are at raising young in South Carolina. During 2021, a total of 191 stork nests were monitored. An average of 1.8 chicks fledged per nest site and 2.3 chicks per successful nest site. During 2022, a total of 346 nests were monitored. An average of 2.2 chicks fledged per nest site and 2.4 chicks per successful nest site.

We attempted to determine if Black Rails are present in substantial numbers in coastal South Carolina during the nonbreeding season and the timing of arrival and departure of wintering rail species. Nonbreeding season call-response surveys for Black Rails were completed during September – October 2022, and Black Rails were detected at 4 of the points. Between 1 October 2020 – 1 March 2021, SCDNR deployed 10 or more camera traps. Black Rail detections sharply declined during November – January (days with detections: October = 16; November = 4; December = 0; January = 4).

Range and Roost Sites of Northern Long-eared Bats in South Carolina (Federal Grant #: F20AF11283-00, Duration: 2020-2023) PI and Author: Jennifer Kindel (SCDNR)

The purpose of this grant was to provide more information on the range and roost sites of the Northern Long-eared Bat in South Carolina through hibernacula counts, mist netting, radio-tagging, and acoustic bat call recording using our established South Carolina NABat acoustic project framework. Strengthening our volunteer base was an additional goal to enhance public engagement and facilitate statewide bat monitoring including winter culvert surveys. With the wide variety of these survey types, we were also able to obtain important information on South Carolina's bat species of "highest" concern as defined in South Carolina's 2015 State Wildlife Action Plan.

During the winters of 2020/21 and 2021/22, a total of 79 culvert surveys were completed across 16 different counties in all ecoregions (Blue Ridge, Piedmont, Upper and Lower Coastal Plain). In 17 culverts across 9 counties, a total of 51 hibernating bats of 5 different species were counted. During the summers of 2021 and 2022, the total mist-netting effort totaled 137 net nights deployed over 80 survey nights at 8 properties across the lower Piedmont and Southeastern Plains Ecoregions, resulting in 302 bats captured representing 10 different species. Of the 8 properties, Santee Coastal Reserve WMA had the highest capture rate per night, highest species richness, and was the only property where Northern Long-eared Bats were captured, leading to the discovery of the first known Northern Long-eared Bat Coastal Plain maternity colony record in the State of South Carolina. Of the 4 Northern Long-eared Bats captured at Santee Coastal Reserve WMA, 3 were radio-tagged and tracked to 10 unique roost trees including 8 live Longleaf Pines and 1 dead Longleaf Pine snag which was established as a maternity colony via emergence count. Eight additional bats of 2 South Carolina species of "highest" conservation concern were also radio-tagged and tracked to their roost locations at 3 other properties.

To keep our long-term, statewide South Carolina NABat acoustic program running, 37 cells were surveyed from late May through mid-July in 2021; 13 cells were surveyed with both mobile and stationary surveys, 13 with mobile only, and 11 with stationary only. A total of 11,216 bat calls identifiable to species were recorded and auto-classified using KPro software, representing 13 species. In 2022, we were able to obtain WNS Grants to States (FY21) funding for a technician to work with statewide volunteers to run South Carolina NABat acoustic surveys instead of only relying on volunteers. Thus, results from the NABat data collected by that grant can be found in the White-nose Syndrome Grants to States and Tribes, SC-E-F21AP03494 report entitled "South Carolina White-nose Syndrome State Support FY21." However, the focus of this objective was to continue to run and strengthen South Carolina's NABat project and volunteer network by

recruiting partners and volunteers, providing reports to landowners in a timely manner, creating partner hubs, and replacing the Anabat SD2 devices with newer, more efficient Anabat Swift devices while providing an updated protocol and training video to continue running NABat into the future. All these tasks were completed through this grant by 2022.

Understanding Salt Marsh Loss Through Investigation of Periwinkle Fronts and Other Causes Across Multiple Spatial Scales (Federal Grant #: F21AF02397-00, Duration: 2022-2023) PI and Author: Andrew Tweel (SCDNR)

Salt marshes are one of the dominant features of the coastal landscape in South Carolina. As a habitat, salt marshes directly support 40 SWAP-listed fish and invertebrate species, and many more indirectly through their role in maintaining water quality and the production of organic material as part of the overall estuarine ecosystem. Coastal marsh loss (also referred to as die-off, dieback, submergence, or collapse) has been reported worldwide, including in South Carolina, and the identified or presumed causes, as well as spatial scales, vary widely. Periwinkle Snails, *Littoraria irrorata*, a listed 2015 SWAP species, have been identified as a potential mechanism for top-down control, and determinations of its role in vegetation cycling and die-off are stated Conservation Recommendations in its SWAP profile (SCDNR 2015).

The study consisted of a series of field experiments to assess the potential for top-down control via a series of field manipulations (snail additions/exclusions/marsh transplanting) in already-impacted areas as well as new areas. Secondly, a remote-sensing analysis addressed the landscape-level extent of marsh loss in certain areas, timing, and trajectory of these changes. In year one of the study, two site types within the experimental marsh were selected: a die-off area with a snail front and non-die-off ("normal" marsh) area without a snail front. Within each site type, three replicate paired 1-m^2 plots were installed—one control plot marked with PVC at the corners and one experimental plot enclosed in an open-topped cage constructed from galvanized wire mesh 24-in high with 0.5-in openings. At snail front sites, cages acted as exclosures and snails were removed from the plot. At non-snail front sites, cages served as enclosures and snails were added to reach densities similar to those seen in the high-density areas to mimic a snail front.

Stem densities were significantly higher in low snail concentration plots than high snail concentration plots, ignoring site type. At the site level, normal marsh plots had significantly higher stem densities in the low snail concentration plots than the high concentration plots. Plants transplanted into areas with Periwinkle Snails had a 44% failure rate after one month, while plants inside cages had a 100% success rate. These results suggest that snail density can play a significant role in regulating primary producers in the marsh, but the extent to which this occurs at a larger scale was not determined here. There appears to be different responses in already stressed marshes versus seemingly healthy marshes which may suggest an environmental trigger or other factor not investigated here.

Conservation of South Carolina Coastal Plain Reptiles and Amphibians (II) Plus Blue Ridge Herps (Federal Grant #: F21AF03242-01, Duration: 2021-2026) PI and Author: Andrew Grosse (SCDNR)

In progress.

Determining the Importance of the South Carolina Coast to the Overwintering Survival and Reproductive Output of the Monarch Butterfly (*Danaus plexippus*) (Federal Grant #: F21AF03274-00, Duration: 2021-2022) PI and Author: Michael Kendrick (SCDNR)

Monarch Butterflies (*Danaus plexippus*) are native to the western hemisphere and are well-known for their long-distance migrations but have experienced significant population declines in recent decades. Here we use a 5-year capture-mark-recapture dataset to compare Monarch distributions, mating activity, and larval host plant use between two Coastal Plain habitats in South Carolina, USA. We observed seasonally specific habitat use, with maritime habitats serving as overwintering areas while nearby inland swamps support significant breeding in spring, summer, and fall seasons due to an abundance of Aquatic Milkweed (*Asclepias perennis*). We also observed mating activity by fall migrating Monarchs and their use of Swallow-wort (*Pattalias palustre*) in the spring as an important larval host plant in maritime habitats. This phenology and habitat use of Monarchs diverges from established paradigms and suggest that a distinct population segment of Monarchs may exist, with significance for understanding the conservation status of Monarch Butterflies and associated habitats in eastern North America.

Developing Genetic Sequences for Benthic Prey Resources of Migratory Piping Plover and Red Knot (Federal Grant #: F21AF03426-00, Duration: 2021-2022) PIs: Denise Sanger (SCDNR), Andrea Bowman (SCDNR), and Andrew Tweel (SCDNR); Author: Andrew Tweel (SCDNR)

Shorebirds depend on a variety of marine invertebrates while overwintering or migrating through coastal South Carolina. Understanding which prey species are important to diet and which habitats are occupied by those species is a key part of management of shorebirds. In order to quantify these relationships, shorebird diet must be better understood. A variety of genetic tools are available to inform this process, but these are dependent on global reference databases, such as GenBank. Existing infaunal species were explored in GenBank to identify which species were not well represented. A targeted effort was made to sequence these species for addition to this database. A total of 56 organisms were sequenced, representing 33 unique haplotypes. These results greatly aid management efforts both here and in other areas important to migratory Piping Plover and Red Knot, among others.

Occupancy and Distribution of SWAP-listed Freshwater Mussel Species (Federal Grant #: F21AF03593-03, Duration: 2021-2024) PI: Morgan Kern (formerly SCDNR) and Ericah Beason (SCDNR); Author: Ericah Beason (SCDNR)

Freshwater mussels from the order Unionida are unique organisms that live discreetly in the substrate of rivers and lakes and serve as a crucial trophic link between the water column and the benthos (Vaughn and Hakenkamp 2001). Unfortunately, freshwater mussels throughout North America have continued to decline in diversity, abundance, and range. The causes of these declines are complex, but anthropogenic at their source. In 2022, South Carolina was home to 26 SWAP listed mussel species, 13 of which were “highest priority” species of greatest conservation need (SGCN). As such, there is a need for the South Carolina Department of Natural Resources to effectively manage and conserve freshwater mussel populations to continue

to meet the expectations of the public as well as maintain the viability of the freshwater mussels within the State. The purpose of this project was to provide updated distribution data on SWAP listed species to update the Natural Heritage Database and inform management decisions. This project was accomplished, in part, by completing 45 catch per unit effort (CPUE) field survey sites for freshwater mussels. Individual mussels were collected through visual and tactile searches. All data was recorded and submitted to the Natural Heritage Database for statewide management. Surveying efforts across 45 field sites yielded a total of 5,667 individual mussels representing 15 different species across 8 different basins. Only 10 individuals with a "highest priority" SCGN ranking were collected, with 8 being collected from the Savannah River Basin sites. A total of 22 sites had 0 mussels found with most sites being in the Broad River Basin. Observations at sites across the State show habitat degradation due to urbanization and agriculture. Streams in these areas are incised, dominated by loose sand substrate, and have steep banks. Additionally, several streams were noted as having no riparian buffer and allowing livestock to enter streams. Completion of this project allowed researchers to visit 25 historical occupancy survey sites and 20 survey sites that were selected from the South Carolina Stream Assessment project across the State of South Carolina. Although only 10 individuals of "highest priority" SGCN were collected, we were able to collect updated general habitat condition parameters and occupancy data that can be used to aid in conservation and management efforts of freshwater mussels across the State.

Determining the Effects of Human Disturbance on the Ecology and Conservation Status of Populations of At-Risk Crayfish in the Genus *Distocambarus* (Federal Grant #: F21AF03627-02, Duration: 2021-2025) PI and Author: Michael Kendrick (SCDNR)

In progress.

Eastern Brook Trout Restoration in Pig Pen Branch and Lick Log Creek, Oconee County, South Carolina (Federal Grant #: F21AF03715-00, Duration: 2021-2023) PI: Dan Rankin (SCDNR); Author: Hailey Goyette (SCDNR)

The Eastern Brook Trout restoration project on Pig Pen Branch and Lick Log Creek began in 2021 and finished in December of 2023. Pig Pen Branch and Lick Log Creek held a large population of Creek Chub, *Semotilus atromaculatus*, that were displacing the native Eastern Brook Trout, *Salvelinus fontinalis*. SCDNR's goal was to restore a reproducing Eastern Brook Trout population in approximately 5.8 kilometers of stream by removing Creek Chub using a piscicide called Antimycin.

The USFWS and United States Forest Service (USFS) removed Burrell's Pond Dam in March of 2022. Logs and stumps removed from the preexisting dam were strategically placed along the stream banks to reduce erosion downstream. Dr. Jeremy Pike, with Clemson University, conducted aquatic community collections, habitat assessments, and in situ water quality measurements over 6 sites. Surveys were conducted at each station on September 5, 2023, October 5, 2023, and September 5, 2024. SCDNR performed longitudinal fish sampling using backpack electro-fishers over the entire reach of Pig Pen Branch and Lick Log Creek (5.8 km) to determine treatment areas. SCDNR collected 75 Eastern Brook Trout from Pig Pen Branch

through electrofishing. Fish were transported to Walhalla State Fish Hatchery to be held during Antimycin treatment.

Twelve Antimycin stations were established based off fish presence and had no more than 75 feet of elevation separating one station from the next. Flow measurements were taken prior to Antimycin treatment and used to calculate amounts of chemical needed at each station. Antimycin treatment was conducted on Pig Pen Branch and Lick Log Creek in the fall of 2023. In total, over the 9 days of treatment, 19.4 units of Antimycin were used to treat Pig Pen Branch and Lick Log Creek. A detox station running Potassium Permanganate was set up downstream at the Chattooga River to neutralize the Antimycin from Pig Pen Branch and Lick Log Creek to prevent impacts to non-target fish and insects.

Fifty Eastern Brook Trout were reintroduced into Pig Pen Branch after treatment on November 7, 2023. SCDNR and the Center for Aquatic Technology Transfer (CATT) crew conducted in-stream habitat census for the entire length of Pig Pen Branch and Lick Log Creek using the Basin Visual Estimation Technique (BVET). BVET surveys indicated Pig Pen Branch and Lick Log Creek lack both large woody debris (LWD) and pool habitat. USFS and SCDNR are awaiting Eastern Brook Trout establishment in Pig Pen Branch and Lick Log Creek before any habitat enhancement efforts are made.

Coastal Maternity Roost Sites of Five High Priority Bat Species (Federal Grant #: F22AF03331-01, Duration: 2022-2025) PI and Author: Jennifer Kindel (SCDNR)

In progress.

Conservation of Seabirds, Shorebirds, Wading Birds, and Marsh Birds in South Carolina (IV) (Federal Grant #: F22AF03386-00, Duration: 2022-2024) PIs and Authors: Felicia Sanders (SCDNR), Christy Hand (SCDNR), Janet Thibault (SCDNR), and Mary Catherine Martin (SCDNR)

Many of the seabird, shorebird, and wading bird species that utilize South Carolina's coastal habitats throughout the year are of conservation concern due to small and threatened populations. This grant funded efforts from October 2022 – September 2024 to reduce human disturbance at key seabird colonies and to conduct nest counts and population surveys of many waterbird species. These count data are incorporated into a long-term database to allow the agency to make informed management decisions as well as contribute to regional and global knowledge of the species. Survey, research, and management activities were shared on webpages, in press releases, and at outreach events so results were made available to partners. Four scientific manuscripts were published.

SCNDR staff coordinated with private, federal, state, and county-owned beach managers to close part of the beach for nesting seabirds and shorebirds at 29 beaches during summer months and at 2 sites during the winter. Educational signs were placed at boat ramps and on some beach entrances. Annual seabird nest counts were conducted for Black Skimmer, Brown Pelican, Common Tern, Forster's Tern, Gull-billed Tern, Least Tern, Sandwich Tern, and Royal Tern. Counts consisted of on-the-ground estimates or estimates from aerial photographs taken from

SCDNR Law Enforcement planes or Unmanned Aerial Vehicles (UAVs or drones). Least Tern nests were monitored at natural beach sites and on artificial sites that mostly consist of pebbled roofs in industrial areas. Peak statewide nest estimates for this project period were: Black Skimmer (2023) 767, Brown Pelican (2024) 4,285, Common Tern (2024) 9, Forster's Tern (2024) 26, Gull-billed Tern (2024) 244, Royal Tern (2024) 7,354, Sandwich Tern (2024) 2,325, and Least Tern (2023) 989.

Wading birds—including egrets, herons, ibis, and storks—were surveyed and monitored in colonies throughout the Coastal Plain. Wood Storks had a very productive nesting season during 2023. The number of nests counted (3,935 nests at 28 active colonies) far exceeded the previous record high count in the State. During 2024, approximately 1,000 fewer nests (2,915 nests in 29 colonies) were counted compared to the record highs set in 2022 and 2023, but numbers were still relatively high compared to pre-2020 surveys. At index colonies, individual stork nests were mapped as they were initiated and were monitored from a distance (using a spotting scope or binoculars) approximately once per week from the time that egg laying began until the chicks reached fledging age. During 2023, a total of 266 stork nests were monitored in five colonies. An average of 1.1 chicks fledged per nest site. During 2024, a total of 92 nests were monitored in two colonies. An average of 2.2 chicks fledged per nest site, exceeding the recovery criteria of 1.5 fledglings per nest.

Taonomic Revision of Procambarus Crayfishes in South Carolina (Federal Grant #: F22AF03387-02, Duration: 2022-2024) PI and Author: Michael Kendrick (SCDNR)

The Southeastern United States (US) is a global hotspot for crayfish diversity, with the majority of the >350 species known in the US occurring here. Crayfishes in the genus *Procambarus* are common in lower gradient lotic and lentic systems of the Southeast, but from both a taxonomic and systematic perspective, this genus is largely neglected in comparison to other crayfish genera. The aim of this study is to clarify the taxonomic status of two conservation priority crayfishes from the Southeastern US by testing the hypothesis that *Procambarus braswelli* (Cooper 1998) and *Procambarus chacei* (Hobbs 1958) are distinct species. We conducted a geometric morphometric analysis of these species, including 17 morphological metrics across 51 specimens throughout the ranges of these species in North Carolina and South Carolina. We then isolated, extracted, and sequenced a fragment of the COI gene and used maximum likelihood phylogenetic analysis to determine genetic distinctness. Results of multivariate analyses show overlapping morphologies between species and genetic structure that does not co-vary with original species determinations. Together, the available morphological and genetic information indicates that *P. chacei* and *P. braswelli* be synonymized. Additional taxonomic, life history, and ecological work is sorely needed for *Procambarus* crayfishes of the species-rich Southeastern US.

High Resolution Acoustic Telemetry Array in the Edisto and Savannah Rivers (Federal Grant #: F22AF03590-00, Duration: 2022-2023) PIs and Authors: Bill Post (SCDNR) and Ellen Waldrop (SCDNR)

A multi-year telemetry study funded by the National Marine Fisheries Service focused solely on sturgeon movements in coastal rivers in North Carolina, South Carolina, and Georgia and

reinforced findings from previous sturgeon studies. It also discovered two previously undocumented behaviors—Atlantic Sturgeon making inland movements indicative of spawning behavior in the fall, and Shortnose Sturgeon using the Atlantic Ocean to migrate between river basins. Additionally, many sturgeon transmitted by other researchers coastwide continued to be detected. Because active transmitters remained in many sturgeon, SCDNR decided to maintain South Carolina's ~300 receiver array through alternative funding sources. This would allow for continued collection of long-term detection data for any transmitted animals. Locations were concentrated in two main areas within the existing array that no longer received funding or support: the ACE Basin (specifically the Edisto River), and the Savannah River (specifically upriver of Interstate Hwy 95).

This project had two main objectives, 1) replace and maintain up to 13 missing receivers in the Edisto River (54% coverage of the original array); and 2) replace and maintain up to 22 missing receivers in the Savannah River (40% coverage of the original array). Both objectives of the study were met. All receivers were purchased and distributed as necessary to fill any gaps within the Edisto River and Savannah River arrays. Several receivers were not deployed and held as replacements to cover future loss in these areas. Each deployed receiver was tethered in the mid-water column and attached to a stainless steel cable, high tensile rope, or chain which was anchored to the bottom using proven techniques. Researchers maintained any downloaded detection in telemetry databases and using Innovasea's VUE and Fathom software to keep track of receivers, transmitted sturgeon, and movement data. All downloaded data was maintained by SCDNR and was shared with both cooperative tagging networks (FACT and ACT [Atlantic Cooperative Telemetry]). Species detected as of the date of this submission were Atlantic Sturgeon (*Acipenser oxyrinchus*) and Shortnose Sturgeon (*Acipenser brevirostrum*), both South Carolina 2015 SWAP species of "highest" concern. Future detection data will be distributed to cooperative tagging networks and participating researchers.

Edisto River Flow Effects on Summertime Water Temperatures: Are Thermal Tolerances of SWAP Fishes Exceeded at Low Flows? (Federal Grant #: F22AF03676-01, Duration: 2023-2025) PIs: Jason Bettinger (SCDNR), Troy Farmer (Clemson University), Luke Bower (Clemson University)

In progress.

Seasonal Patterns of Horseshoe Crab Spawning and the Relative Importance of Horseshoe Crab Eggs Within the Diets of South Carolina Shorebirds (Federal Grant #: F22AF03703-01, Duration: 2023-2025) PI and Author: Daniel Sasson (SCDNR)

In progress.

Horizontal Movements of Carolina Hammerheads (*Sphyrna gilberti*) in the Western North Atlantic Ocean (Federal Grant #: F22AF03703-01, Duration: 2023-2025) PI and Author: Bryan Frazier (SCDNR)

In progress.

Pilot Project to Document Presence of Sea Turtles in South Carolina Estuarine Waters in and Effort to Reduce Impacts of Watercraft on Endangered and Threatened Sea Turtles (Federal Grant #: F22AF03776-00, Duration: 2023) PI and Author: Michelle Pate (SCDNR)

SCDNR initiated a pilot project to document the presence of sea turtles in South Carolina estuarine waters and improve outreach efforts to reduce negative impacts of watercraft interaction with endangered and threatened sea turtles. No direct, formal estuarine survey exists for determining the full extent of sea turtles inhabiting our waters, but rather opportunistic data collection relies on bycatch from SCDNR fishery-independent monitoring, stranded turtle counts from the South Carolina portion of the federally established Sea Turtle Stranding and Salvage Network (STSSN) managed by the Marine Turtle Conservation Program (MTCP), and anecdotal observations reported by biologists and the public. There is a need to expand our knowledge of the presence of sea turtles in interior estuarine areas and establish partnerships with businesses such as marinas and docks as well as ecotour operators who operate within the inshore estuarine environment. Through collection of additional data on healthy live sea turtles, we can enhance management of waterways with greater knowledge of the habitats they occupy. To accomplish this, signage was created to raise awareness about the presence of threatened and endangered sea turtle species inhabiting South Carolina's tidal waters. Signage also provided easy access, by way of a QR Code, to an updated MTCP sea turtle reporting form that utilized the ArcGIS Survey123 program. Signage was distributed among coastal stakeholder groups and via selected placement at high-traffic, popular coastal marinas and boat landings. Signs were printed in various formats to accommodate availability of space at facilities and distributed to 24 locations throughout coastal South Carolina. Results of this project include improved reporting of sea turtles occupying coastal and estuarine water through expansion of outreach efforts, along with building awareness in South Carolina of sea turtle conservation and providing guidance about conservation needs.

Genetic Characterization of Monarch Butterflies in Coastal South Carolina (Federal Grant #: F23AF02951-01, Duration: 2023-2025) PI and Author: Michael Kendrick (SCDNR)

In progress.

Assessing the Occurrence and Habitat Associations of Six Priority Small Mammal Species in High Elevation Appalachia Forests in South Carolina (Federal Grant #: 2023-2026, Duration: 2023-2026) PI: David Jachowski (Clemson University)

In progress.

Exploration of Subtidal Oyster Presence in Areas Historically Identified as Supporting Subtidal Populations (Federal Grant #: F23AF03154-01, Duration: 2023-2025) PI and Author: Andrew Tweel (SCDNR)

In progress.

Using Unmanned Aerial Systems (UAS) Technology to Understand the Relationship of Microhabitat to Estuarine Fish Species (Federal Grant #: F23AF03206-01, Duration: 2023-2026) PI and Author: Joseph Ballenger (SCDNR)

In progress.

Innovative Fish Aging Methods Using Near-infrared Spectroscopy Techniques to Understand Changes in Population Demography: Calibration Model Development for Bonnethead Shark (Federal Grant #: F23AF03212-01, Duration: 2023-2025) PI and Author: Joseph Ballenger (SCDNR)

In progress.

Distribution and Roost Sites of Gray Bats in Northwestern South Carolina (Federal Grant #: F24AF02859-01, Duration: 2024-2026) PI and Author: Jennifer Kindel (SCDNR)

In progress.

Conservation of Seabirds, Shorebirds, and Wading Birds in South Carolina (V) (Federal Grant #: F24AF02999, Duration: 2024-2026) PIs: Felicia Sanders (SCDNR) and Christy Hand (SCDNR)

In progress.

Exploration of a New Emerging Threat: Microplastics in Water, Sediment, and SWAP-listed Species in Charleston Harbor (Federal Grant #: F25AF00610, Duration: 2025-2026) PI and Author: Jimmy Kilfoil (SCDNR)

In progress.

Closing the Loop on the Horseshoe Crab Life Cycle for Eggs to Adults: Surveying Horseshoe Crabs Across Life Stages in Coastal South Carolina (Federal Grant #: F25AF00262, Duration: 2025) PI and Author: Daniel Sasson (SCDNR)

In progress.

South Carolina Horseshoe Crab Genetic Health Reassessment (Federal Grant #: F25AF00609, Duration: 2025-2026) PIs: Richard Harrington (SCDNR), Tanya Darden (SCDNR), Daniel Sasson (SCDNR), Lengzog Yong (SCDNR)

In progress.

TABLE 9-2: Competitive State Wildlife Grants from 2005-present. The lead state is designated in **bold**.

Federal Grant No.	Duration	Project / Grant Title
SC-U2-F14AP00958	2014-2017	Carolinas Acoustic Bat Survey [NC, **SC**]
SC-U2-F15AP00050	2014-2019	Relative Abundance and Trophic Ecology of Two Sympatrically Distributed Sphyrnids, the Scalloped Hammerhead (*Sphyrna lewini*) and the Recently Discovered Carolina Hammerhead (*Sphyrna gilberti*) Within Known Nurseries off the East Coast of the United States [FL, GA, **SC**]
SC-U2-F14AP00997	2014-2019	Development and Implementation of an Environmental DNA (eDNA) Monitoring Tool for Blackbanded Sunfish (*Enneacanthus chaetodon*) [GA, **SC**]
SC-U2-F15AP01096 ***(See also SC-U2-F15AP00051)***	2015-2019	Multistate Sandhills / Upland Longleaf Ecological Restoration Project (Phase 3): Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina [AL, **GA**, FL, MS, LA, SC] [Note: SC was involved in U2-1-HM-1 / F09AP00301 from 2009-2012 (Phase I) but the project failed. SC was not involved in Phase II either.]
SC-U2-F16AP00113	2015-2019	Cooperative Conservation of the Green Salamander in the Southeast United States [GA, MS, NC, SC, TN, **VA**]
SC-U2-F16AP00581	2017-2021	Increasing the Probability of Persistence for Robust Redhorse Through Improved Management and Monitoring [**GA**, NC, SC]
SC-U2-F19AP00051 ***(See also SC-U2-F15AP01096)***	2018-2021	Multistate Sandhills / Upland Longleaf Ecological Restoration Project (Phase 4): Alabama, Georgia, Louisiana, and South Carolina [AL, **GA**, LA, SC]
SC-U2-F20AP00258	2019-2023	Multistate Habitat and Population Restoration of Gopher Frogs in Alabama, Georgia, and South Carolina [AL, **GA**, NC, SC]
SC-U2-F20AP00291-02	2020-2024	Basin-wide Planning for "Bartram's" Redeye Bass in the Savannah River [GA, **SC**]
SC-U2-F20AP00255-02	2020-2024	Identification and Optimization of a Disomic Microsatellite Panel for Use in Population Genetics of Shortnose Sturgeon [**SC**]
F21AP00690-03	2020-2024	The Suitability of Alternative Nesting Habitats for the American Horseshoe Crab, *Limulus polyphemus* [**SC**]
F22AP00563-00	2022-present	Black Rail Habitat Creation and Restoration – Designing Management Techniques to Expand the Black Rail Population Along the Atlantic Coast [**FL**, NC, SC, VA]
F22AP00564-01	2022-present	Advanced Conservation and Restoration of Brook Floater and Associated Freshwater Mussels [**MA**, NJ, SC, VA]
F22AP00568-01	2022-present	Conservation Planning for Geographically Restricted Headwater Species, the Sandhills Chub [**NC**, SC]
F23AP00075-01	2023-present	Adaptively Managing for Robust Redhorse: A Range-wide Collaboration to Address Data Gaps and Implement Conservation Actions [**GA**, NC, SC]
F23AP03502-00	2024-present	Developing a Proactive Conservation Planning Tool for Stream Fishes of Greatest Conservation Need in the Carolinas [NC, **SC**]
F24AP00198-00	2024-present	Advancing Conservation and Management of the Spotted Turtle (*Clemmys guttata*) in the Southeastern United States: Addressing Data Gaps, Refining Approaches, and Building Capacity [**GA**, SC, VA, WV]
F25AP00566-01	2025-psresent	An Integrative Conservation Assessment of SGCN Crayfishes in North Carolina, South Carolina, and Georgia to Fill Critical Needs for Conservation Planning [GA, **NC**, SC]
F25AP00567-00	2025-present	Characterizing the Suitability of Salt Marsh Habitat for Spawning Horseshoe Crabs, *Limulus polyphemus*, and Foraging Shorebirds, Including the Rufa Red Knot, *Calidris canutus rufa* [DE, **SC**]

C-SWG Project Summaries

Carolinas Acoustic Bat Survey (Federal Grant #: SC-U2-F14AP00958, Duration: 2014-2017)
PI: Mary Bunch (SCDNR, retired); Author: Jennifer Kindel (SCDNR)

SCDNR staff ran the NABat program in North and South Carolina in 2015 and 2016, sampling a total of 95 grid cells. In South Carolina in 2015 and 2016, we established surveys in 38 grid cells: mobile transect surveys were established in 30 cells, and stationary point surveys were established in 25 cells. In the stationary cells, a total of 44 unique locations were created. In 2015, 35 total cells were surveyed; 15 with mobile transects only, 6 with stationary points only, and 14 with both methods. During this time, stationary points were surveyed on 147 occasions.

In 2016, 38 total cells were surveyed; 13 with mobile transects only, 8 with stationary points only, and 17 with both methods. During this time, stationary points were surveyed on 200 occasions. Using acoustic data collected from these efforts, over 400 calls were identified through bat call software and manual vetting, resulting in ten species and three species groups identified. Four species were found outside their known range (including the Federally Threatened Northern Long-eared Bat), with only one species known to occur in South Carolina not detected during our surveys. Detection probabilities were also determined for both survey methods, with stationary surveys showing higher detection probability than mobile surveys. Lastly, calls identified through Echoclass 3.1 and Kaleidoscope 3.1.5 programs were compared to manual vetting, and false-positive and false-negative errors were shown to exist in both programs, varying depending on species identification, survey duration, and survey method. Thus, manual vetting of call identifications must be done regardless of the program used for call classifications.

In North Carolina in 2015 and 2016, we visited 57 highly ranked NABat grid cells and developed mobile transect surveys for 41 grid cells and stationary point surveys for 40 grid cells. Through over 300,000 acoustic files, we generated NABat grid cell-specific presence/no detection information. Fourteen species of bats were detected, and both mobile and stationary surveys revealed similar general patterns of bat distributions in North Carolina. We also generated species-specific activity density maps via ArcGIS mapping. For federally listed species, Indiana Bats were concentrated mainly in the Cherokee National Forest near the North Carolina/Tennessee border; Gray Bats were mainly distributed along the Appalachian Mountains between Asheville and Boone; and more Northern Long-eared Bats were found in the Coastal Plain Ecoregion than the rest of North Carolina. We suggest that the future implementation of NABat should involve multiple partners with a centralized coordinator to facilitate participation and integrate data. We also have issues of concern that need to be addressed in the future.

Relative Abundance and Trophic Ecology of Two Sympatrically Distributed Sphyrnids, the Scalloped Hammerhead (*Sphyrna lewini*) and the Recently Discovered Carolina Hammerhead (*Sphyrna gilberti*) Within Known Nurseries off the East Coast of the United States (Federal Grant #: SC-U2-F15AP00050, Duration: 2014-2019) PI and Author: Bryan Frazier (SCDNR)

We created a diagnostic panel of single nucleotide polymorphisms to readily identify Scalloped (*Sphyrna lewini*) and Carolina (*S. gilberti*) Hammerheads. We characterized the relative abundance, relatedness, stock structure, genetic diversity, effective number of breeders, diet, and trophic ecology for young-of-the-year (YOY) of both species. Carolina Hammerheads were found to be most abundant in Bulls Bay, SC, although they were found throughout the Southeastern US, with the exception of the Tolomato River, FL, where only Scalloped Hammerheads were identified. Temporal differences in parturition may occur between the two species, and Scalloped Hammerheads are born, on average, 50 mm larger than Carolina Hammerheads. Environmental variables (salinity, and dissolved oxygen) had no effect on abundance of YOY Scalloped Hammerheads but may influence abundance of Carolina Hammerheads. There was significant overlap in the diet of YOY Scalloped and Carolina Hammerheads, indicating no partitioning of food resources in nursery areas. Results from analysis of stable isotopes that reflect maternal diet in YOY hammerheads indicate that adult

female Carolina Hammerheads likely reside further offshore, and feed at higher trophic levels than adult female Scalloped Hammerheads. An unexpected result was the finding of hybridization and backcrossing between the two species. Hybridization appears to be unidirectional, and when documented, female Carolina Hammerheads had produced offspring sired by male Scalloped Hammerheads. Overall, the results of this study found that the nursery area in Bulls Bay, SC is critically important to Carolina Hammerheads, although other nurseries contribute to the population. In the Southeastern US, Carolina Hammerheads have lower genetic diversity, and half the effective number of breeders as Scalloped Hammerheads. While this study focused on YOY hammerheads, our results give some insights into potential spatial and/or resource partitioning between adults of the two species. Our results, coupled with documented unidirectional hybridization, indicate that the Carolina Hammerheads population is relatively small compared to Scalloped Hammerheads, and could be much more susceptible to overfishing or habitat degradation of nursery areas. Future research will be needed to determine aspects of habitat utilization and life history information for juvenile and adult Carolina Hammerheads. Based on the results of this research, Carolina Hammerheads should be added to the Species of Greatest Conservation Need (SGCN) lists in North Carolina, South Carolina, Georgia and Florida.

Development and Implementation of an Environmental DNA (eDNA) Monitoring Tool for Blackbanded Sunfish (*Enneacanthus chaetodon*) (Federal Grant #: SC-U2-F14AP00997, Duration: 2014-2019) PI and Author: Tanya Darden (SCDNR)

The fragmented nature of Blackbanded Sunfish (*Enneacanthus chaetodon*) distribution and its apparent population decline are of conservation concern, particularly in the southern portion of its range. Accordingly, the species is designated as a Species of Greatest Conservation Need in both the South Carolina and Georgia State Wildlife Action Plans (2015). Our completed project represents a rigorous assessment of the current distribution, relative abundance, and population health of *E. chaetodon* throughout the southern portion of its range, providing critical baseline data for this species. The developed eDNA tool provides a time and cost-effective means for *E. chaetodon* monitoring in the remainder of its range as well as future monitoring in South Carolina and Georgia. Although project results provide justification for continued concern for populations in Georgia, South Carolina appears to represent a regional stronghold for *E. chaetodon,* suggesting the Carolina region is perhaps the most robust of the four historic population centers for this species. Overall, project results have provided substantially improved distribution and relative abundance data necessary for managers to protect *E. chaetodon* populations and their habitats. Additionally, genetic characterization of current populations throughout the range of *E. chaetodon* provides excellent baseline metrics of their genetic health as well as important information about population connectivity for guiding conservation priorities and actions.

The data collected during our project has provided guidance for the development of recommendations for additional conservation measures for *E. chaetodon* at both state and site-specific levels. We also updated *E. chaetodon* accounts for each state's SWAP, updated online resources with *E. chaetodon* data, and produced an information brochure for private landowners to promote conservation of *E. chaetodon* and their habitats. Data obtained will lead to better informed adaptive management of *E. chaetodon* and will be useful in monitoring current and

future population impacts. While application of the direct project products will be restricted to management within the Southeastern US, results of the research will also be relevant to management agencies in the northern portion of *E. chaetodon*'s range. Additionally, due to the frequent impacting of freshwater wetland habitats, *E. chaetodon* represents a valuable indicator species for these habitats; increased knowledge of distribution, connectivity, and population health of *E. chaetodon* within these systems is a valuable resource for effective conservation for these ecosystems.

Multistate Sandhills / Upland Longleaf Ecological Restoration Project (Phase 3): Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina (Federal Grant #: SC-U2-F15AP01096, Duration: 2015-2019) PI: Will Dillman (SCDNR); Author: Andrew Grosse (SCDNR)

See SC-U2-F19AP00051 for summary of all years.

Cooperative Conservation of the Green Salamander in the Southeast United States (Federal Grant #: SC-U2-F16AP00113, Duration: 2015-2019) SEAFWA; PIs: Andrew Grosse (SCDNR) and Kyle Barrett (Clemson University); Author: Abstract from Dr. Kyle Barrett's manuscript: *A resurvey of historical green salamander locations in South Carolina*

Green Salamanders, *Aneides aeneus*, are habitat specialists found in narrow crevices of rock outcrops and under flaky bark of trees. The species is of high conservation priority throughout its range and has been negatively affected by habitat loss, climate change, disease, and over-collection. Many historical locations for this species have not been visited since the 1980s or earlier in portions of the Blue Ridge Escarpment population. Across three counties in South Carolina, we conducted visual encounter surveys of rock outcrops and used binoculars to conduct arboreal surveys. We detected Green Salamanders at 30 of the 61 sites surveyed (49.2%). We collected a variety of habitat variables and compared a suite of N-mixture models using an AIC framework. Detection probability was positively influenced by time of day. A model of abundance that included aspect, habitat size, and elevation had the most support. Specifically, Green Salamanders were more abundant at larger sites with lower elevations and south-facing slopes. We conducted a follow up survey on a subset of sites in the fall of 2018 to better understand the influence of season and season-related variables on detection probability. Detections for Green Salamanders were marginally higher during the fall surveys. Knowledge of factors that influence population abundance and survey success will help guide future efforts to protect the species in the southern portion of its range.

Increasing the Probability of Persistence for Robust Redhorse Through Improved Management and Monitoring (Federal Grant #: SC-U2-F16AP00581, Duration: 2017-2021) PI and Author: Tanya Darden (SCDNR)

Successful monitoring is critical for determining population status, the effectiveness of management actions, and ultimately whether or not Robust Redhorse populations will persist into the foreseeable future. The comparative approach to Robust Redhorse surveys allowed us to evaluate the limitations and benefits of each method as well as their potential applicability to specific river systems. Our research efforts suggest quantitative visual surveying of adult

spawning populations is a viable, non-invasive method of providing meaningful information about reproductive population size, recruitment, and spawning window. However, this methodology is only applicable in rivers like the Savannah, where base-flow turbidity is low enough to observe spawning activity and distinguish between individuals. Electrofishing surveys were conducted in the Altamaha, Ogeechee, Broad (GA), Santee, and Pee Dee systems during the project, resulting in captures in all systems except the Ogeechee and Broad rivers. We also implemented acoustic tagging with passive and active tracking within the Savannah River population to provide new information on seasonal movement patterns. Although the most invasive method (transmitter implants), acoustic telemetry could be implemented in multiple rivers with established acoustic arrays. Updates on spawning site activity in all systems was reported.

Over the course of this project, a total of 300 Robust Redhorse contemporary field-collected tissue samples were archived, genotyped and analyzed as part of our genetic monitoring of Robust Redhorse. Sixty previously collected samples (2001-2007) from the Oconee River were genotyped for the purpose of identifying the genetic origin of the contemporary samples collected in the Ocmulgee River. Additionally, 200 tissue samples from the Pee Dee River hatchery program were analyzed to determine parental contribution and to genotype before release. A total of 500 historic tissue samples from a variety of collections (1998-2007) were transferred to SCDNR for long-term storage.

Our project team attempted to implement an adaptive management framework to provide quantitative guidance for future Robust Redhorse conservation efforts. However, given the assumptions and lack of quantitative data to inform the modeling, the Robust Redhorse Conservation Committee (RRCC) membership concluded that in its current form, it is not a useful decision-making tool and further work is needed when new data becomes available.

The propagation and stocking of Robust Redhorse into the Pee Dee River has been a huge success. From 2017 to 2021, four different year classes of Robust Redhorse were produced and stocked, totaling 13,280 individuals. The catch per unit effort (CPUE) has increased substantially since augmenting the population with hatchery-reared fish. Since 2016, we have consistently collected and observed more fish on the spawning grounds. To date, we have seen very little recruitment, but hopefully this should improve over the next several years as progeny from the hatchery-stocked fish reach maturity and begin utilizing the spawning shoals.

Extensive partnership and outreach efforts were allocated toward the issue of fish passage at Juliette Dam as well as the development of a new Candidate Conservation Agreement with Assurances (CCAA) for Georgia Power. Although these avenues were not completed during the project period, substantial progress was achieved and worth noting here, and there are plans to continue both activities into the future.

Multistate Sandhills / Upland Longleaf Ecological Restoration Project (Phase 4): Alabama, Georgia, Louisiana, and South Carolina (Federal Grant #: SC-U2-F19AP00051, Duration: 2018-2021) PI and Author: Andrew Grosse (SCDNR) *See also SC-U2- F15AP01096*

Competitive State Wildlife Grants (C-SWG) funds were awarded in four phases to six southeastern states within the range of the Gopher Tortoise (*Gopherus polyphemus*)—Alabama, Florida, Georgia, Louisiana, South Carolina, and Mississippi—to restore habitat and increase populations of Gopher Tortoise and other longleaf/sandhill wildlife. The conservation and restoration of these habitats has been identified as a critical component of the long-term persistence of the Gopher Tortoise and other associated species. Many of these areas have been degraded due to lack of management practices and become unsuitable for many sandhill and Longleaf Pine-associated species of conservation concern.

The objectives were to enhance or restore current Gopher Tortoise habitat at the SCDNR's Tillman Sand Ridge Heritage Preserve (TSRHP). The TSRHP is home to the largest protected population of tortoises in South Carolina and represents one of the most robust populations at the northern edge of the species' range. Additionally, TSRHP represents the highest quality habitat in a greater sand ridge complex, mostly in private ownership, and may serve as a refuge for tortoises in the area as land uses and timber management fluctuates. The SCDNR conducted a Line Transect Distance Sampling survey of the TSRHP in Fall 2015, and analysis of that data indicates this is a population that meets Minimum Viable Population criteria and has the highest tortoise density known in South Carolina (N=232 (95%CI: 169-320) and has a tortoise density of 1.43tortoise/hectare. This site represents a stronghold for tortoises in South Carolina and at the northern edge of the species' range. Any activities that may increase the carrying capacity of the site may serve to buffer this species from extirpation. Additionally, providing more high-quality habitat on the greater Tillman Sand Ridge increases the ability for this site to receive tortoises displaced from adjacent lands.

Some portions of the TSRHP have not been subject to the same management practices as the major interior upland portions of the site and have experienced fire suppression. This has led to high basal areas, shading, and habitat that is not utilized by sandhill species although soils are suitable. We focused restoration activities on these areas of the property and, over the course of five years (2016-2021), achieved the following restoration goals:

Year 1 (October 1, 2015 – September 30, 2016) Accomplishments

- We identified the area and scope of restoration activities at Tillman Sand Ridge Heritage Preserve.
- We worked with preserve managers and the SCDNR forester to identify areas that could be improved with restoration effort to produce an increase in available habitat at TSRHP.
- We performed Line Transect Distance Sampling (LTDS) of the tortoise population at TSHP as part of a different project. The tortoise population is estimated at N=232 (95%CI: 169-320) and a tortoise density of 1.43 tortoise/hectare, making this the highest density site known in SC. This population nearly meets MVP status and is an excellent candidate for habitat restoration to increase the population on site.
- We delineated approximately 184 acres for timber sale to reduce basal areas and or remove hardwoods. Several different approaches have been selected from thinning a longleaf plantation, fuel chipping hardwoods and potential invasives, to intensive cuts with leave-trees marked to drastically reduce basal area and promote herbaceous understory.
- The timber sale was packaged for public notice.

Year 2 (October 1, 2016 – September 30, 2017) Accomplishments

- The timber sale was successfully bid on 2/15/17.
- Logging began on June 2017 and was mostly complete by the end of September 2017.
- All logging operations (including log deck clean-up via tub grinding) concluded Winter/Spring 2018.
- 43.5 acres were treated with herbicide on 10/6/17 to control hardwood resprouts in the initial longleaf planting area.
- 319 acres were prescribed burned 5/17/17.
- An additional parcel (65 acres) was selected for thinning to improve habitat quality (harvesting was scheduled for Winter 2017-18).
- A custom blend of sandhills ecotype seed (6 native grasses and 23 native forbs) for ground cover restoration was purchased.

Year 3 (October 1, 2017 – September 30, 2018) Accomplishments

- All logging operations were completed as of March 2018, including the additional winter cut encompassing 65.3 acres and tub grinding of log deck debris.
- We planted approximately 100 lbs. of native ground cover seed mix on roughly 1/3 of 31 acres in a planted Longleaf Pine stand in May 2018.
- We installed a plot for monitoring germination of seed mix in May 2018.
- A site prep burn of 31 acres before planting the seed mix occurred in May 2018.
- We planted 12,000 Longleaf Pine seedlings on 43.5 acres of restoration cut area in March 2018.
- We planted 200 wiregrass plugs on 43.5 acres of the restoration cut area in March 2018.
- We applied herbicide to 43.5 acres to control woody vegetation in the restoration cut area.
- We added two desired future reference plots to capture more variety of existing tortoise habitat to include one swale/wetland plot and one fire shadow plot.
- 14 known “pioneer” tortoises have already moved into the restoration area.
- We developed plot data signage for our reference pictures.
- We took quarterly photos of each reference plot.

Year 4 (December 1, 2018 – December 31, 2019) Accomplishments

- 305 acres were contract-burned by the South Carolina Forestry Commission (SCFC) within existing interior Gopher Tortoise habitat May 2019 adjacent to the restoration area.
- Wiregrass plugs and Longleaf Pine seedlings were purchased for Spring 2020 planting.
- A Xeric Sandhills Seed Mixture was purchased for Spring 2020 planting.
- We conducted a backpack herbicide release on 138.9 acres.
- Quarterly photos were taken of each reference plot.
- We monitored germination of the xeric seed mixture in the 31-acre planted Longleaf Pine stand.
- “Pioneer” tortoises continued to colonize the restored habitat.

- Burn plans were developed for all new restoration areas ahead of dormant season site prep burns.

Year 5 (January 1, 2020 – December 31, 2020) Accomplishments

- 117.5 acres of restoration habitat was burned by SCDNR staff in March 2020.
- 94.5 acres of wiregrass plugs were planted in the restoration areas.
- 87.8 acres of Longleaf Pine seedlings were planted in the restoration areas.
- Quarterly photos were taken of each reference plot.
- 15 "pioneer" tortoises were observed colonizing the restored habitat.

Year 6 (January 1, 2021 – December 31, 2021) Accomplishments

- 279 acres were contract-burned by the SCFC within existing interior Gopher Tortoise habitat in May 2021 adjacent to the restoration area.
- Native Wiregrass Seeds order was purchased for dispersal in the restoration areas.
- Quarterly photos were taken of each reference plot.
- 20 "pioneer" tortoises were observed colonizing the restored habitat.
- 6 lbs. of native wiregrass seeds were dispersed across the restoration areas.

Basin-wide Planning for "Bartram's" Redeye Bass in the Savannah River (Federal Grant #: SC-U2-F20AP00291-02, Duration: 2020-2024) PIs and Authors: Mark Scott (SCDNR) and Tanya Darden (SCDNR)

The endemic riverine black basses of the Southeastern US are among the most important 'umbrella species' for rallying public support for whole-ecosystems and the biological diversity they support. "Bartram's Bass" and "Altamaha Bass", two closely related and provisionally recognized species historically known as Redeye Bass, are range-restricted to Atlantic Slope river systems in South Carolina and Georgia. These species' native rivers were impounded in the latter 20th century, and invasive Alabama Bass were subsequently introduced into the reservoirs. Over the ensuing decades, Alabama Bass rapidly displaced the endemics through introgressive hybridization and direct competition. In fact, evidence to date suggests endemics have been entirely extirpated from reservoirs, and the few remaining 'pure' populations are now restricted to only a handful of disconnected tributary systems. Accordingly, Bartram's Bass in SC, and both species in GA, are considered of greatest conservation need, as addressed in their respective State Wildlife Action Plans. Both states recognize the imminent threats of extirpation posed by invasive species and habitat change.

To answer key knowledge gaps needed for conservation of Bartram's Bass and Altamaha Bass, for this grant we conducted six investigations under the TRACS objective of Research, Survey, Data Collection and Analysis. First, we completed the taxonomic description of these two provisional species to provide impetus for continued conservation programs for these recognized species. Second, we identified spatial distributions of the strongholds of genetically pure endemic bass throughout their Atlantic Slope range, and focusing on the Savannah Basin, developed predictive models of these refugia for Bartram's Bass. Third, we quantified spread rates in a Savannah tributary undergoing invasion to understand how dispersal processes set the context for effects of habitat quality on hybridization that may be occurring in these streams.

Fourth, we quantified dispersal rates based on observation of actual fish movement to understand invasion dynamics, particularly from downstream reservoirs, as well as basic life-history of Bartram's Bass. Fifth, we used information from Investigations 2-4 to develop a conservation planning map for prioritizing restoration efforts that will benefit all aquatic species. Finally, because genetic diversity is a crucial factor affecting the long-term sustainability of a population, we quantified the basin-wide genetic structure of Bartram's Bass, including population differentiation, inbreeding rates, and effective population sizes. Additional objectives met under this grant include training and education, outreach and communication, stakeholder involvement, and technical assistance.

Identification and Optimization of a Disomic Microsatellite Panel for Use in Population Genetics of Shortnose Sturgeon (Federal Grant #: SC-U2-F20AP00255-02, Duration: 2020-2024) PI and Authors: Tanya Darden (SCDNR) and Daniel Farrare (SCDNR)

The Federally Endangered Shortnose Sturgeon (*Acipenser brevirostrum*) was an initial member of the Endangered Species Act in 1973 largely due to overharvest for caviar, a shrinking population range, range-wide habitat degradation, and limited access to historic gravel bed spawning grounds due to the construction of dams. The use of genetic data to interpret patterns of population structure would vastly improve our ability to manage for population-specific threats and guide recovery efforts for the species. Currently, the only published genetic markers for Shortnose Sturgeon are mitochondrial markers and a set of polysomic microsatellites. The presumed hexaploid nature of Shortnose Sturgeon has made the development of standard disomic microsatellite markers challenging. Microsatellites remain the most affordable and tested method for analyzing genetic health and estimating population structure across a species' range. We utilized genomic sequencing from the Sterlet Sturgeon and Shortnose Sturgeon to identify a high number of microsatellites, which we screened to identify functionally disomic loci. A total of 693,511 conserved microsatellites were identified across both sturgeon genomes. The project team screened 664 of these microsatellites using Shortnose Sturgeon samples from across their range, with a total of 16 markers identified as putatively functionally disomic. Following further testing in two South Carolina data sets, the final multiplexed marker suite includes 13 microsatellites as well as the recently published sex identification marker. Project results suggest that our panel should be useful for genetically characterizing populations of Shortnose Sturgeon, although more research is needed to clarify underlying causes of observed deviations from Hardy-Weinberg Equilibrium (HWE) and potential presence of null alleles prior to interpretation of genetic data for management and conservation purposes. These observations would be expected in populations that experienced a severe historic bottleneck, which is consistent with our observed patterns in long-term N_e, contemporary N_{eb}, and Garza-Williamson Index (G-W) estimates. We did not detect genetic differences between the Winyah Bay and Savannah River data sets with the new marker panel; additional investigation into potential influences of movement patterns and collection biases are needed. From a genetic health perspective, project results would be consistent with a population of Shortnose Sturgeon that underwent a severe bottleneck historically and are slowly recovering. Supporting evidence includes contemporary N_{eb} estimates showing an increasing trend over long-term N_e estimates, a moderate level of retained genetic diversity, no indication of inbreeding, and low levels of outbreeding. Although further marker validation is needed, we are highly optimistic that the new genetic tool will provide important information for future conservation and monitoring of

Shortnose Sturgeon throughout their range. Our work has addressed specific goals and recommendations outlined in the National Marine Fisheries Service (NMFS) Recovery Plan for Shortnose Sturgeon and the South Carolina SWAP by providing improved tools for Shortnose Sturgeon conservation and recovery.

Multistate Habitat and Population Restoration of Gopher Frogs in Alabama, Georgia, and South Carolina (Federal Grant #: F20AP00258, Duration: 2019-2023) PI and Author: Andrew Grosse (SCDNR)

The objectives of this Competitive State Wildlife Grant (C-SWG) were to expand and integrate conservation management projects for the Gopher Frog and other amphibian Species of Greatest Conservation Need (SGCN) across four of the five states that encompass the Gopher Frog species' range: Alabama (AL), Georgia (GA), North Carolina (NC), and South Carolina (SC). Specifically, this C-SWG focuses predominantly on implementing and evaluating two actions – wetland restoration and population augmentation/reintroductions. In South Carolina, three isolated, ephemeral wetlands, encompassing 12 acres, and their surrounding uplands were restored to historical conditions. Canopy and midstory hardwoods and pines were removed from the wetland basin using a combination of either heavy equipment or hand tools and treated with herbicide and/or prescribed fire. Additionally, over 300 headstarted gopher frog metamorphs were released in wetlands and surrounding uplands once restoration was complete. Post-restoration, all wetlands showed a shift to more herbaceous, graminoid and other ground cover vegetation, as well as an increase in anuran species diversity.

The Suitability of Alternative Nesting Habitats for the American Horseshoe Crab, *Limulus polyphemus* (Federal Grant #: F21AP00690-03, Duration: 2020-2024) PIs: Daniel Sasson (SCDNR) and Michael Kendrick (SCDNR); Author: Daniel Sasson (SCDNR)

The American Horseshoe Crab, *Limulus polyphemus*, was long believed to use beaches as their primary spawning habitat, in large part because the environmental conditions in sediments of other habitats, such as salt marshes, was considered inhospitable for embryonic development. This project used adult spawning surveys, egg surveys, reciprocal transplants, and assays of embryonic development to compare the use of beaches and salt marshes as spawning habitat in three states – South Carolina, Connecticut, and New Hampshire – with genetically distinct populations of Horseshoe Crabs. It was found that Horseshoe Crabs spawned in similar densities in both habitats, but eggs were more likely to be found in marsh habitats than beach habitats. Furthermore, eggs laid in salt marsh habitats developed relatively well, contrary to assumptions that these eggs would be inviable. These findings indicate that salt marshes may be critical habitat for Horseshoe Crab recruitment should be considered in the management and conservation of this species. *Note: At the time of this writing (June 2025), the transcriptomics portion of this study are still being analyzed.*

Black Rail Habitat Creation and Restoration – Designing Management Techniques to Expand the Black Rail Population Along the Atlantic Coast (Federal Grant #: F22AP00563-00, Duration: 2022-present) PI and Authur: Christy Hand (SCDNR)

In progress.

Advanced Conservation and Restoration of Brook Floater and Associated Freshwater Mussels (Federal Grant #: F22AP00564-01, Duration: 2022-present) PI and Author: Ericah Beason (SCDNR)

In progress.

Conservation Planning for Geographically Restricted Headwater Species, the Sandhills Chub (Federal Grant #: F22AP00568-01, Duration: 2022-present) PI and Author: Derek Crane (Coastal Carolina University)

In progress.

Adaptively Managing for Robust Redhorse: A Range-wide Collaboration to Address Data Gaps and Implement Conservation Actions (Federal Grant #: F23AP00075-01, Duration: 2023-present) PI and Author: Tanya Darden (SCDNR0

In progress.

Developing a Proactive Conservation Planning Tool for Stream Fishes of Greatest Conservation Need in the Carolinas (Federal Grant #: F23AP03502-00, Duration: 2024-present) PI and Author: Mark Scott (SCDNR)

In progress.

Advancing Conservation and Management of the Spotted Turtle (*Clemmys guttata*) in the Southeastern United States: Addressing Data Gaps, Refining Approaches, and Building Capacity (Federal Grant #: F24AP00198-00, Duration: 2024-present) PI and Author: Andrew Grosse (SCDNR)

In progress.

An Integrative Conservation Assessment of SGCN Crayfishes in North Carolina, South Carolina, and Georgia to Fill Critical Needs for Conservation Planning (Federal Grant #: F25AP00566-01, Duration: 2025-present) PI and Author: Michael Kendrick (SCDNR)

In progress.

Characterizing the Suitability of Salt Marsh Habitat for Spawning Horseshoe Crabs, *Limulus polyphemus*, and Foraging Shorebirds, Including the Rufa Red Knot, *Calidris canutus rufa* (Federal Grant #: F25AP00567-00, Duration: 2025-present) PI and Author: Daniel Sasson (SCDNR)

In progress.

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CHAPTER 10: SOUTH CAROLINA – A REGIONAL PERSPECTIVE

In 2018, the Association of Fish and Wildlife Agencies (AFWA) adopted a resolution on landscape conservation that recognized "the importance of collaborating at landscape scales to help fish and wildlife agencies meet their statutory and regulatory responsibilities to conserve fish and wildlife and their habitats." In response to the resolution, AFWA established a President's Task Force on Shared Science and Landscape Conservation Priorities in 2020, which recommended that State Wildlife Action Plans (SWAPs) serve as a framework for regional coordination and collaboration.

Within this Plan, South Carolina has identified Species of Greatest Conservation Need (SGCN) and outlined strategies to sustain them, including conservation actions to promote species recovery and prevent federal listings under the Endangered Species Act. But to sustain the species that are South Carolina's responsibility to protect—and that also reflect the rich biodiversity, culture, and history of the State—South Carolina must consider its role and the influences of the larger Southeast landscape.

This chapter examines regional, landscape-scale considerations for South Carolina and serves as a means for the State to find potential collaborations to best support the State's SGCN and Regional SGCN (RSGCN). Additionally, some of the threats that impact SGCN (e.g. climate change) have consequences locally, statewide, and regionally. Addressing these threats effectively requires aligning conservation strategies across state boundaries. By using consistent regional information shared by other states to inform their own SWAPs, South Carolina can better contribute to regional conservation priorities, identify potential landscape-level threats, and help connect the Southeast Region's lands and waters.

South Carolina's Conservation Portfolio: Connecting the Region's Lands & Waters

South Carolina supports a wide diversity of habitats, culturally and historically significant landscapes, and ecosystems that provide benefits to the State as well as the broader Southeast Region. South Carolina plays an important role in connecting the lands and waters of the Southeast Region, as well as hosting regionally important ecosystems and habitat types like salt marsh and longleaf pine. Many regional and local partners and partnerships are working with the South Carolina Department of Natural Resources (SCDNR) to help conserve the State's iconic landscapes. The Nature Conservancy's South Carolina Chapter (SC TNC) manages the best available dataset depicting protected conservation lands within the State. Based on this dataset, more than 3.1 million acres (15%) of the State are considered protected with more in queue for protection. This includes important landscapes like National Wildlife Refuges, National Forests, State Wildlife Management Areas (WMAs) and Heritage Preserves (HPs), State Parks, and private conservation easements.

In addition to contributing to the conservation landscape of the Southeast, South Carolina's lands and waters also benefit the State's economy. In 2023, the Bureau of Economic Analysis

estimated that the outdoor recreation economy generated $8.6 billion in value for the State's Gross Domestic Product and another $4.2 billion in wages and salaries (US Bureau of Economic Analysis for Outdoor Recreation 2024). Beyond providing recreational value, natural landscapes also support working lands such as agriculture and timber. As of 2023, South Carolina supported more than 4.6 million acres of farmland across 22,600 farms, and crop production alone was valued at more than $908 million (US Department of Agriculture 2024).

Birdwatching is one of the most popular ecotourism activities in the world (Schwoerer and Dawson 2022).

Fly fishing in the Congaree River just below the confluence of the Broad and Saluda Rivers. Photo by Stewart Grinton, SCDNR, ret.

South Carolina and the Southeast Conservation Adaptation Strategy (SECAS)

The Southeast Conservation Adaptation Strategy (SECAS) is a regional conservation initiative that spans the Southeastern United States and Caribbean. SECAS brings together diverse partners around an ambitious goal: a 10% or greater improvement in the health, function, and connectivity of Southeastern ecosystems by 2060. The Southeast Conservation Blueprint is the primary product of SECAS. The Blueprint is a living, spatial plan that identifies priority areas where conservation action would make an impact toward creating a connected networks of lands and waters, based on a suite of natural and cultural resource indicators and a connectivity analysis.

As of May 2025, more than 2,500 people from over 650 different organizations have been actively involved in developing the Blueprint. At least 37 staff from SCDNR alone have participated in workshops to review and improve the Blueprint, along with many other conservation practitioners from across the State. Since 2014, the Blueprint has been used by a broad suite of partners to inform many different conservation actions across the State. For example, since 2018 the Blueprint has been used to help inform the South Carolina Conservation Bank, a statewide land authorization and funding source. South Carolina DNR staff have used the Blueprint to guide the creation of this SWAP's Conservation Opportunity Areas and where to focus land protection efforts through various acquisition grant programs.

Maps of the Blueprint (v. 2024) and other regional data are provided within this chapter. These maps also include a boundary that extends beyond the State (a "bleed-over") and includes watersheds where South Carolina shares a conservation or species management interest with its neighboring states. This boundary was developed by identifying all watersheds (HUC 8) within 1.5 kilometers of the State boundary and then selecting shared watersheds of conservation interest with SCDNR staff and partners from the Southeast Aquatic Resources Partnership (SARP). By looking beyond the State's boundaries, South Carolina can consider how to best align conservation actions and identify cross-jurisdictional opportunities with neighboring states to maximize benefits for SGCN with wider ranges.

The Blueprint recognizes more than 10.64 million acres, or roughly 51% of the State, as a priority for connecting the region's lands and waters (Table 10-1, Figure 10-1). About 5.18 million acres are rated as highest or high priority. An additional 4.3 million acres are rated as medium priority. An additional 1.15 million acres are considered priority connections, or key linkages (corridors) between priority areas that can help facilitate the flow of species and ecological processes within the State while also considering connectivity within the broader region. Together, these classes represent important areas for shared conservation action to connect lands and waters and improve ecosystem health. The Blueprint includes about 60 indicators that represent both natural and cultural resources and collectively represent ecosystem health, function, and connectivity across terrestrial, freshwater, coastal, and marine systems. Examples include imperiled aquatic species, cores of intact natural habitat, natural floodplain landcover, prescribed fire frequency, and more. Indicator data is available on the Blueprint page of the SECAS Atlas.

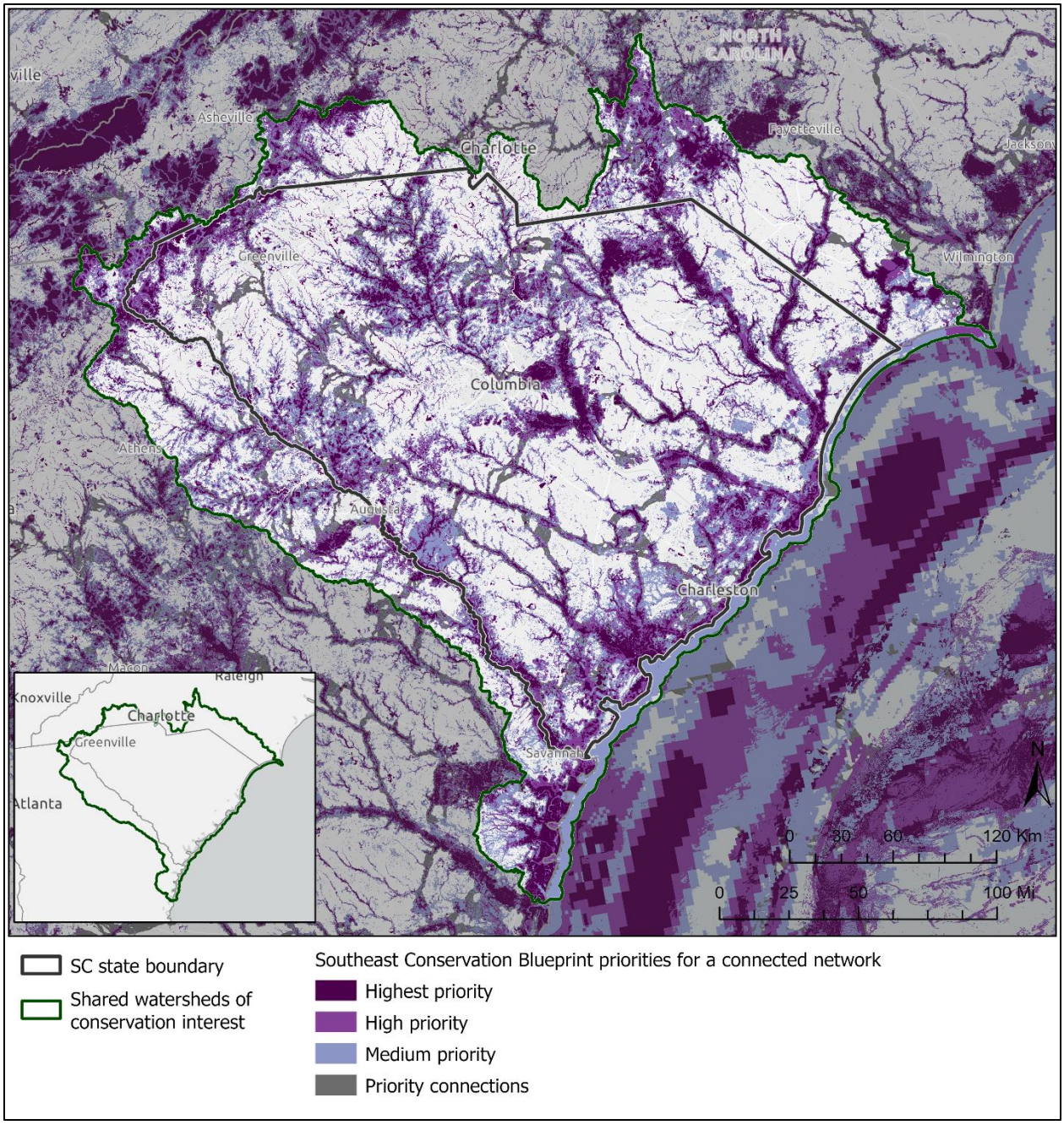


FIGURE 10-1: Southeast Blueprint (v. 2024) priorities within South Carolina and surrounding watersheds of conservation interest shared with Georgia and North Carolina.

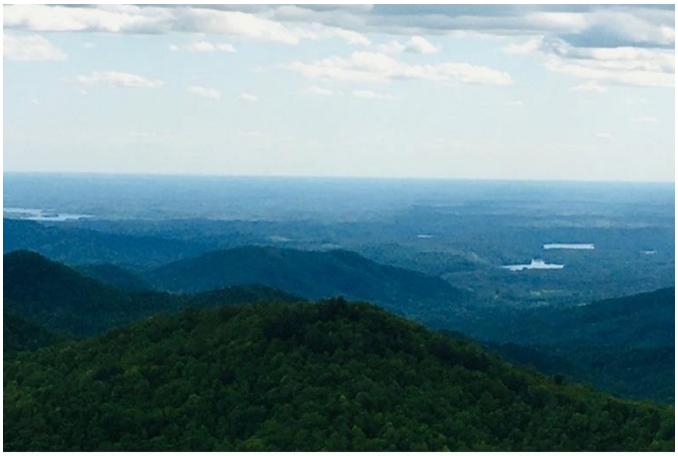
Based on the conserved lands database that is managed by SC TNC, the vast majority (88%) of the States's conserved lands are identified within the Blueprint as a priority for a connected network of lands and water (Table 10-1). This means that while these conserved areas are contributing to the State's conservation portfolio—and represent unique habitats and locally important areas—they are also contributing to a wider regional conservation strategy. The State's conservation portfolio exemplifies a complementary landscape-scale approach to conservation that links local actions with conservation outcomes that contribute at a broader geographic scale.

TABLE 10-1: Lands and waters considered protected within South Carolina. These numbers are estimates based on the Conserved Lands Database managed by SC TNC (accessed January 27, 2025) and may not reflect the most up-to-date information.

Priority for a connected network	Acres of each Blueprint (v. 2024) priority category within SC	Acres of conserved lands (SC TNC) prioritized in the Blueprint and their percentage of total protected lands
Highest	2,189,951 (10.7%)	1,019,339 (34%)
High	2,994,812 (14.6%)	802,619 (26%)
Medium	4,309,630 (21%)	771,028.17 (25%)
Priority connections	1,150,540 (5.6%)	79,452 (3%)
Lower priority	9,850,093 (48.1%)	368,488 (12%)
Total	**20,495,027 (100%)**	3,040,926 **(100%)**

The Southeast Blueprint also includes a least-cost path connectivity analysis that identifies corridors that link coastal and inland areas and span climate gradients. The corridors connect hubs across the shortest distance possible, while also routing through as much Blueprint priority as possible. The hubs that anchor the connectivity analysis are large patches of highest priority Blueprint areas and/or protected lands. About 6.7 million acres (33%) are considered either a hub or a corridor, providing opportunities to support species movement and migration—an important strategy for helping wildlife adapt to landscape-level changes (Figure 10-2).

Ensuring landscape connectivity across jurisdictional boundaries is becoming increasingly important for species management as changes in land use, climate, and weather patterns shift species distributions. Collaborating with the neighboring states of Georgia and North Carolina to identify cross-boundary species migration and habitat pathways can increase regional connectivity for state SGCN.



The Blue Ridge Mountains of South Carolina. Photo by Anna Smith, SCDNR

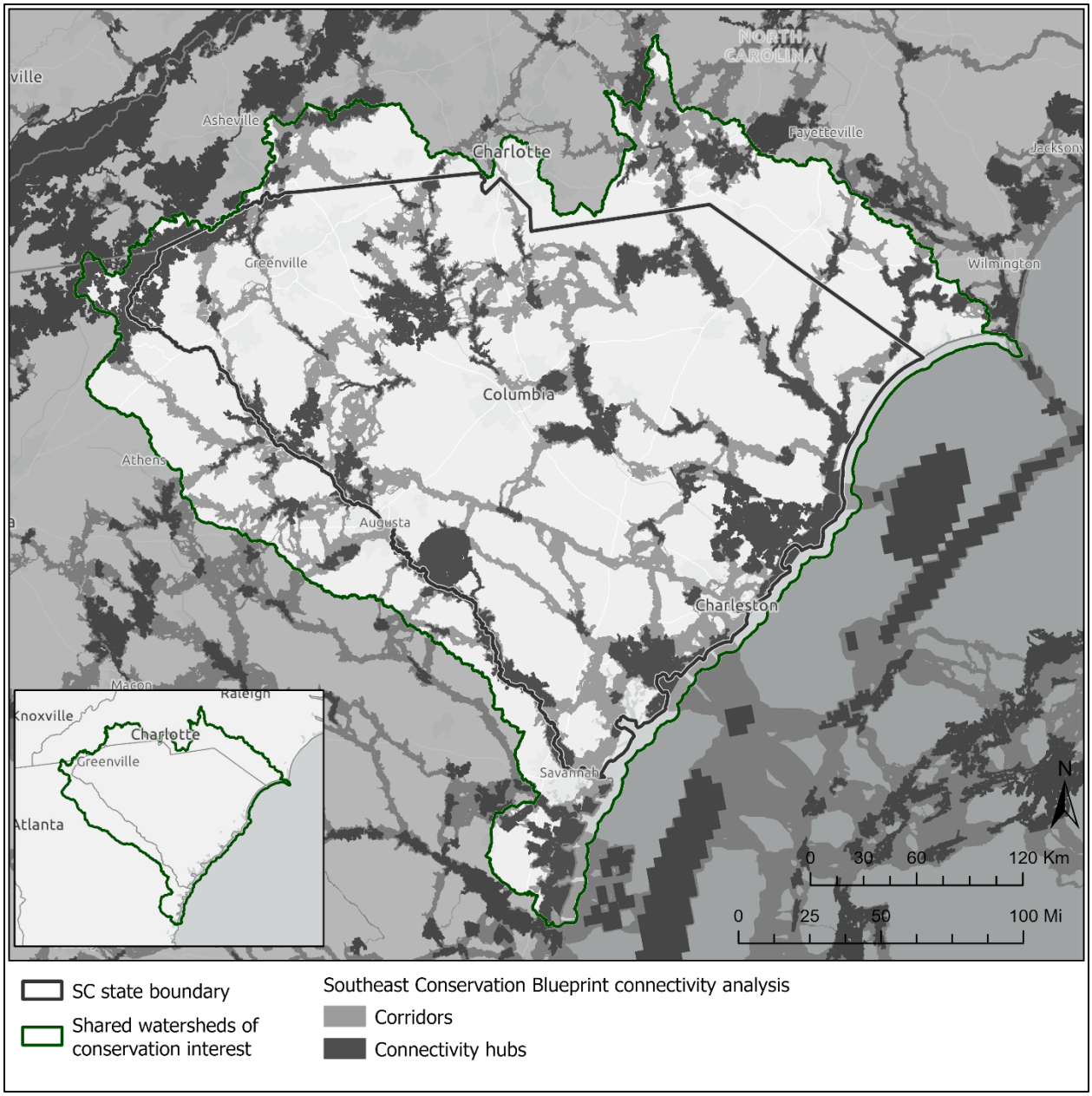


FIGURE 10-2: Southeast Blueprint connectivity analysis (v. 2024) showing hubs and corridors in South Carolina and surrounding watersheds shared with Georgia and North Carolina. The Blueprint uses a least-cost path connectivity analysis to identify corridors that link hubs across the shortest distance possible, while also routing through as much Blueprint priority as possible. In the continental Southeast, hubs are large patches (~5,000+ acres) of highest priority Blueprint areas and/or protected lands.

One lens to characterize the landscape of South Carolina is by its ecoregions, as defined in Chapter 2. Ecoregions are identified by analyzing areas where ecosystems and the type, quality, and quantity of environmental resources are generally similar. Evaluating ecoregions that South Carolina shares with its neighbors is one way to identify cross-boundary conservation opportunities, as these areas share similar mosaics of biotic, abiotic, terrestrial, and aquatic ecosystems. The table below show how much of each ecoregion within the State is prioritized in

the Southeast Blueprint. In particular, the Blue Ridge and Coastal Zone ecoregions support significant Blueprint priorities.

TABLE 10-2: Amount of ecoregion prioritized by the Southeast Blueprint (2024).

South Carolina ecoregions	Acres of ecoregion prioritized by the Blueprint	Percent of ecoregion within SC prioritized by the Blueprint
Blue Ridge	263,617.10	89%
Piedmont	3,491,609.88	51%
Sandhills	1,387,638.49	58%
Coastal Plain	3,805,040.91	43%
Coastal Zone	1,076,588.42	82%

South Carolina and the SECAS Goal

Through SECAS, partners work together to design and achieve a connected network for the benefit of ecosystems, species, and people, and to achieve the SECAS goal: a 10% or greater improvement in the health, function, and connectivity of Southeastern ecosystems by 2060. The work of SCDNR and conservation partners within the State help advance this goal. In addition to the Southeast Blueprint, SECAS releases an annual report—Recent Trends in Southeastern Ecosystems—that assesses progress toward the SECAS goal using the best available data. This report assesses progress toward the SECAS goal using information from existing monitoring programs and is intended to facilitate discussion around conservation actions needed to meet the goal.

Recent Trends in Southeastern Ecosystems (2024) synthesizes 13 different assessments to evaluate 20 indicator trends. Some assessments, like eBird, inform multiple indicators. Assessments encompass a range of sources from remotely sensed data like the National Land Cover Database to long-term citizen science monitoring programs like eBird. States can use this SECAS goal report to assess their own progress (Table 10-3) and overall trends for the broader Southeast Region. However, not all SECAS goal indicators can be assessed at the state level because they do not apply to the geography or because of limitations with the source information used to inform the indicators. Out of the total 20 SECAS goal indicators, 14 are assessed for the State. Tables 10-4, 10-5, 10-6, and 10-7 then go into the species driving Southeastern states' progress towards the four bird category goals.

Like other states in the Southeast, South Carolina has:

- Increases in forested wetland birds, longleaf pine area, upland forest birds, working lands conservation, and water quality.
- Declines in areas without invasive plans, beach birds, grassland and savanna area, grassland and savanna birds, salt marsh area, landscape condition, undeveloped land in corridors, and natural landcover in the floodplain.

Unlike other states in the Southeast, South Carolina has:

- A decline instead of increase in forested wetland area.

- Much smaller increases in forested wetland birds, longleaf pine area, and upland forest birds.
- Greater increases in water quality. Of the 15 states and territories assessed, only 8 had improvements. South Carolina, North Carolina, and Georgia had the largest improvements.

TABLE 10-3: Overview of recent trends in ecosystem indicators comparing South Carolina and the Southeastern US. Indicators shown in green are on track to meet the goal (≥1% increase every 4 years); indicators shown in yellow (<1% increase) and red (declines) are not.

Ecosystem	Type	Indicator	South Carolina yearly % change	Southeast yearly % change
Terrestrial				
	Health	Areas without invasive plants	0.25% decline	0.33% decline
		Beach birds	1.67% decline	1.42% decline
		Forested wetland area	0.03% decline	0.08% increase
		Forested wetland birds	1.65% increase	2.85% increase
		Grassland & savanna area	0.55% decline	0.31% decline
		Grassland & savanna birds	2.1% decline	2.2% decline
		Longleaf pine area	1.63% increase	4.5% increase
		Salt marsh area	0.01% decline	0.03% decline
		Upland forest birds	0.18% increase	0.98% increase
	Function	Working lands conservation	7.24% increase	11% increase
	Connectivity	Landscape condition	0.02% decline	0.02% decline
		Undeveloped land in corridors	0.03% decline	0.02% decline
Freshwater				
	Health	Natural landcover in floodplains	0.01% decline	0.008% decline
	Function	Water quality	0.03% increase	0.003% increase

TABLE 10-4: BEACH BIRDS. Goal status by state for each beach bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (RSGCN) associated with this habitat and with sufficient data for eBird trend analysis.

	American Oystercatcher	Black Skimmer	Gull-billed Tern	Least Tern	Piping Plover	Royal Tern	Willet
AL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | Low	Decline | Off track | High
AR				Decline | Off track | High			
FL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High
GA	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
KY				Decline | Off track | Low			
LA	Increase | On track | Low	Decline | Off track | High	Increase | On track | High	Decline | Off track | High		Increase | On track | High	Decline | Off track | High
MO				Decline | Off track | High			
MS	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
NC	Increase | On track | Low	Decline | Off track | High	Increase | On track | Low	Increase | Off track | Low	Decline | Off track | High	Increase | On track | High	Decline | Off track | High
OK				Decline | Off track | High			Decline | Off track | High
SC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
TN				Decline | Off track | High			

TX	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Increase | On track | High	Decline | Off track | High
VA	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High
PR	Increase | On track | High		Increase | On track | Low	Increase | On track | High		Increase | On track | High	Decline | Off track | High
VI	Increase | On track | High			Increase | On track | High		Increase | On track | Low	

TABLE 10-5: FORESTED WETLAND BIRDS. Goal status by state for each forested wetland bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (RSGCN) associated with this habitat and with sufficient data for eBird trend analysis.

	Prothonotary Warbler	**Swainson's Warbler**	**Swallow-tailed Kite**	**Yellow-throated Warbler**
AL	Increase | On track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
AR	Increase | On track | High	Increase | On track | High		Increase | On track | High
FL	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Increase | On track | Low
GA	Increase | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
KY	Increase | On track | High	Increase | On track | High		Increase | On track | High
LA	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
MO	Increase | On track | High	Increase | On track | High		Increase | On track | High
MS	Increase | On track | High	Increase | On track | High	Increase | On track | High	Increase | On track | High
NC	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
OK	Increase | On track | High	Increase | On track | High		Increase | On track | High
SC	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High

TN	Increase | On track | High	Increase | On track | High		Increase | On track | High
TX	Increase | On track | High	Increase | On track | High	Increase | On track | High	Increase | On track | High
VA	Decline | Off track | Low	Increase | On track | High		Increase | On track | High
WV	Increase | On track | High	Increase | On track | High		Increase | On track | Low

TABLE 10-6: GRASSLAND & SAVANNA BIRDS. Goal status by state for each grassland and savanna bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (SGCN) associated with this habitat and with sufficient data eBird trend analysis.

	American Kestrel	**Eastern Meadowlark**	**Grasshopper Sparrow**	**Loggerhead Shrike**	**Northern Bobwhite**	**Prairie Warbler**	**Red-cockaded Woodpecker**	**Scissor-tailed Flycatcher**
AL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High
AR	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Decline | Off track | High
FL	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	
GA	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High
KY	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
LA	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High
MO	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
MS	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High

NC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | Low	Increase | On track | Low
OK	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
SC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low
TN	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
TX	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | Off track | Low	Increase | On track | Low	Decline | Off track | High
VA	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | High	Decline | Off track | High
WV	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High		Decline | Off track | High
PR	Decline | Off track | Low		Decline | Off track | High					
VI	Decline | Off track | Low							

TABLE 10-7: UPLAND FOREST BIRDS. Goal status by state for each upland forest bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (RSGCN) associated with this habitat and with sufficient data for eBird trend analysis.

	Cerulean Warbler	**Louisiana Waterthrush**	**Wood Thrush**	**Worm-eating Warbler**
AL	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
AR	Increase | On track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | Low
FL		Decline | Off track | Low	Increase | On track | High	
GA	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High

KY	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
LA		Increase | On track | Low	Increase | On track | High	Increase | On track | Low
MO	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Decline | Off track | High
MS	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High
NC	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
OK	Increase | On track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High
SC	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
TN	Decline | Off track | High	Increase | Off track | Low	Increase | On track | High	Decline | Off track | High
TX		Increase | On track | High	Increase | On track | High	Increase | On track | High
VA	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
WV	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High

Regional Species of Greatest Conservation Need

Each State's wildlife action plan identifies SGCN, or the species most in need of proactive conservation attention (see Chapter 6 for a list of South Carolina's SGCN). After the 2015 SWAP revisions, nearly 6,700 SGCN were identified by the states and territories of the SEAFWA region (Rice et al. 2019).

However, many SGCN occur across multiple states. Effectively managing and conserving these species requires actions and management strategies that will best allow for species movement and ensure the availability of key ecological attributes provided by different habitats across the landscape at different times. To help support long-term conservation goals for imperiled plant and animal species, conservation partners have developed Regional Species of Greatest Conservation Need (RSGCN) lists.

Animal RSGCN

In 2019, the National Wildlife Federation, as part of the Vital Futures project funded by the US Geological Survey, prioritized the large number of SGCN collectively identified in the previous iteration of 15 Southeastern SWAPs. Across the 15 Southeastern states, the combined lists of SGCNs totaled nearly 6,700 species (Rice et al. 2019, National Wildlife Federation 2023).

The Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Wildlife Diversity Committee collaborated with the National Wildlife Federation and other partners to evaluate

these species and produce a final list of 960 regional priority species (1,034 including subspecies), or animal RSGCN. A report, "Regional Species of Greatest Conservation Need in the Southeastern United States," was written to detail the methodology used to develop the RSGCN list (Rice et al. 2019). A dataset for the RSGCN list is available online (Georgia Department of Natural Resources 2024). This effort aligns with the Northeast Association of Fish and Wildlife Agencies' similar project to develop a RSGCN list for the Northeast Region.

Identifying animal RSGCN drew upon a collaborative process among Southeastern state fish and wildlife agencies and partners that involved more than 100 experts and used a set of consistent criteria to review current scientific information and evaluate state-identified SGCN. Species were evaluated based on several primary factors, including: 1) the level of conservation concern (i.e. extinction risk), 2) regional stewardship responsibility (i.e. importance of the Southeast in conservation of the species), and 3) biological or ecological significance (e.g. unique evolutionary lineages). The regional assessment focused on species in key taxonomic groups, including vertebrates (mammals, birds, reptiles, amphibians, and fishes) as well as several better-known groups of invertebrate animals (freshwater mussels, crayfish, and bumblebees) (Table 10-8). Scientific experts in each of these groups convened to evaluate and identify those species that warranted identification as a regional priority. Additionally, the science teams characterized the level of conservation concern for each regional priority, ranging from "moderate" to "high" to "very high" concern. Through this established process, the RSGCN list can be updated as the States' SGCN lists change over time.

The number of RSCGN that are considered the stewardship responsibilities of each state varies widely. These patterns reflect the underlying diversity of species in each state—particularly the number of imperiled and/or limited range species—which is also influenced by a state's size and diversity of habitats. These patterns are also influenced by the "regional stewardship responsibility" criterion in the assessment of priority species.

Nearly 70% of regional priority species are endemic to the 15-state SEAFWA region. Overall, more than half (55%) of RSGCN are shared by three or more states, presenting opportunities for cross-state conservation collaboration. The remaining 45% of RSGCN have narrow ranges and are found in just one or two states. By taxa, fish and crayfish represent 47% of all RSGCN within the region. Many aquatic habitats and ecosystems within the Southeast are highly fragmented, resulting in severe limitations to ecosystem integrity and species persistence regionwide. Habitat fragmentation in rivers and streams is a determining factor in the decline in abundance of numerous species such as Eastern Brook Trout, freshwater mussels, and amphibians such as Eastern Hellbender.

TABLE 10-8: List of Southeast animal RSGCN by taxa and their level of concern ("very high", "high", or "moderate"). Fish have the most species categorized as "very high concern" and represent 30% of all RSGCN within the Southeast region.

Animal RSGCN taxonomic group	Very high concern	High concern	Moderate concern	Total
Amphibians	30	52	34	116 (11%)
Birds	10	56	18	84 (8%)

Bumblebees	2	1	2	5 (.4%)
Crayfish	53	86	34	173 (17%)
Fishes	101	120	96	317 (30%)
Mammals	18	37	30	85 (8%)
Mussels	69	55	13	139 (13%)
Reptiles	18	58	39	115 (11%)
Total	**302**	**466**	**266**	**1,034 (100%)**

Plant RSGCN

The Southeast is home to more than 11,000 native plant species, 30% of which are endemic, meaning they are found only in the Southeast). In 2023 the Southeast Plant Conservation Alliance (PCA) released the first plant RSGCN list in the nation. The PCA worked with a broad coalition of partners including the Atlanta Botanical Garden, NatureServe, and Terwilliger Consulting, and received funding from the US Fish and Wildlife Service. This list narrows down the vast number of plants native to the Southeast to 1,824 species that are a regional conservation priority based on criteria such as rarity, threats, and needed conservation actions. The plant RSGCN list complements the Southeastern animals RSGCN list developed in 2019 to create a more complete picture of the region's exceptional biodiversity.

To develop a pool of potential species to draw from, the PCA worked with NatureServe to compile a list of more than 10,000 vascular plants native to any of the SEAFWA states considering each species' G-Rank (global rarity), S-Rank (subnational or state rarity) and endemism. Unfortunately, due to data limitations, plants native to Puerto Rico and the US Virgin Islands could not be included.

The full list received extensive review from botany experts, a technical team composed of representatives from each state, and NatureServe. Based on partner feedback, the technical team assigned each species a level of conservation concern rating ranging from "low" to "very high" or "manual review needed" (Figure 10-3). Any plant scoring "moderate" or above was ultimately considered an RSGCN. After cleaning the data to remove redundancies, the complete Southeastern plant list evaluated 9,271 species and prioritized 1,824 as RSGCN with 72% of the plant RSGCN are endemic to the Southeast.

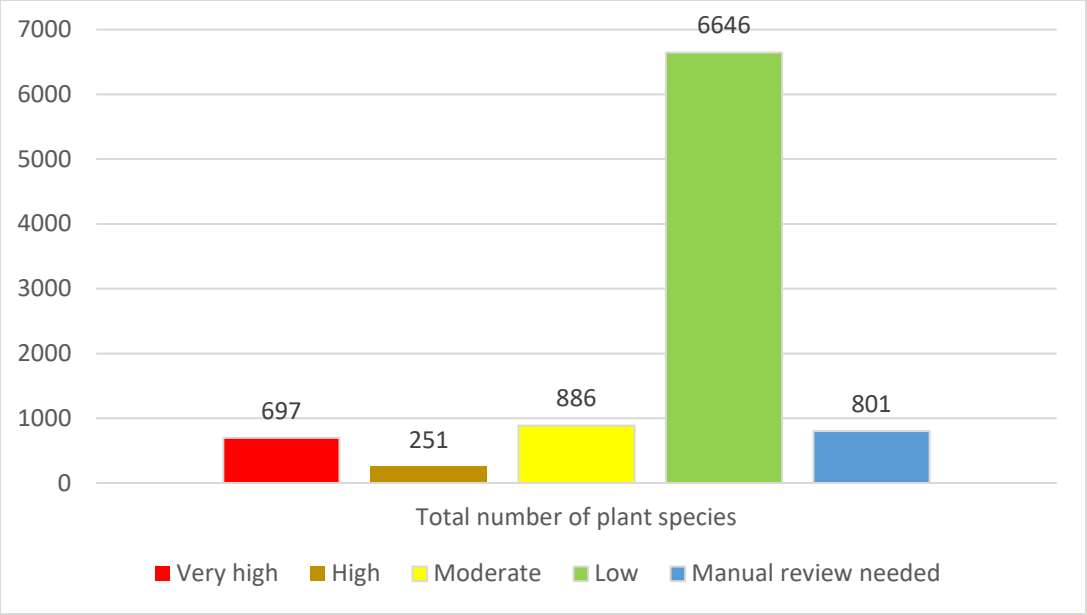


FIGURE 10-3: Plants with a very high, high, or moderate level of conservation concern are considered plant RSGCN

To better understand shared plant needs and threats at the ecosystem level, the PCA cross-walked each plant RSGCN to its primary habitats using US National Vegetation Classification (USNVC) "Groups" (Tables 10-9 and 10-10). The USNVC provides a widely used, standardized system of classifying vegetation types and habitats. The distribution of RSGCN across ecosystems demonstrates their diversity and broad geographic extent. A total of 31 USNVC Groups contained at least 10 plant RSGCN, indicating that many of the region's ecosystems support plant species of conservation need. As many of these same habitats tend to provide crucial habitat for animal RSGCN as well, conserving these ecosystems can safeguard regional biodiversity more broadly.

TABLE 10-9: The top 15 U.S. National Vegetation Group Assignments for all Southeast plant RSGCN, showing longleaf ecosystems supporting this highest number of priority plants.

USNVC groups serving as primary habitat	Number of plant RSGCN
Wet-Mesic Longleaf Pine Open Woodland	80
Xeric Longleaf Pine Woodland	43
South Florida Slash Pine Rockland	29
Central Interior Alkaline Open Glade & Barrens	29
Appalachian - South-central Interior Mesic Forest	28
Tamaulipan Dry Mesquite & Thornscrub	28
South Atlantic & Gulf Coastal Plain Pondshore & Wet Prairie	22
Blackland & Coastal Tallgrass Prairie	21
Florida Xeric Scrub	18
South Atlantic & Gulf Coastal Dune & Grassland	17
Atlantic & Gulf Coastal Plain Seep	16
Southern Coastal Plain Mixed Evergreen Swamp	13
Southern Mesic Beech - Oak - Mixed Deciduous Forest	12
Southern Appalachian Rocky Outcrop	11
Southeastern Coastal Plain Barrens & Glade	9
Central Interior-Appalachian Riverscour Barrens & Prairie	9
Caribbean Hardwood Hammock & Coastal Strand Forest	9
Coastal Live Oak - Hickory - Palmetto Forest	9
Appalachian Mafic Barrens	8
Central & Southern Appalachian Seep	8

TABLE 10-10: The USNVC groups serving as primary habitat that support the most plant RSGCN within South Carolina ("very high" and "high" concern only).

USNVC groups serving as primary habitat	Number of plant RSGCN
Wet-Mesic Longleaf Pine Open Woodland (G190)	34
Appalachian - South-central Interior Mesic Forest (G020)	12
South Atlantic & Gulf Coastal Plain Pondshore & Wet Prairie (G915)	11
Xeric Longleaf Pine Woodland (G154)	10
Atlantic & Gulf Coastal Plain Seep (G187)	6
Piedmont-Coastal Plain Oak Forest & Woodland (G165)	4
Southern Appalachian Rocky Outcrop (G670)	4
Southern Mesic Beech - Magnolia - Oak Forest (G007)	3
Southeastern Coastal Pocosin & Shrub Bog (G186)	3
South Atlantic & Gulf Coastal Plain River & Basin Freshwater Marsh & Wet Meadow (G188)	3

By far the USNVC group that supports the most plant RSGCN within the State is wet-mesic longleaf open woodland. These wet open woodlands occur within coastal plains and include wet

pine flatwoods and wet pine savannas (NatureServe Explorer 2024). These habitats are dominated by longleaf pine with grassy understories (NatureServe Explorer 2024).

Several regional datasets can help South Carolina identify lands and waters that support both animal and plant RSGCN and find opportunities to collaborate with other states. For example, habitat maps at the species level from the USGS Gap Analysis Project (GAP) are available for approximately 290 animal species and 90 sub-species on the RSGCN list. While GAP does not include species habitat maps for invertebrates or plants, it does include a high percentage of vertebrate RSGCN (93% of amphibians, 92% of birds, 76% of mammals, and 77% of reptiles). Using GAP species habitat models in combination with other tools, like the Southeast Blueprint, can help identify areas where conservation actions are likely to yield co-benefits for other species, habitats, and ecosystem services. All data, including model inputs, are available from the USGS Gap Analysis Project Species Habitat Maps on ScienceBase.

Using available habitat maps from GAP for specific RSGCN, along with regional conservation plans like the Southeast Blueprint, can also help to identify not only a species' habitat across its range, but areas where conservation action can achieve multiple co-benefits. For example, using GAP data for animal RSGCN that fall within the Southeast Blueprint can help visualize and highlight important areas for species conservation across multiple jurisdictions. As recommended by AFWA, cross-jurisdictional or regional strategies can enhance ecosystem resiliency, function, and connectivity, especially in the face of climate change.

South Carolina's Stewardship of Animal RSGCN

Within the Southeast Region, 223 animal RSGCN occur within South Carolina. The most common RSGCN taxa represented in South Carolina are fish (64) and birds (58) (Figure 10-4). While South Carolina shares stewardship of their SGCN and RSGCN with multiple other states, it has the most in common with Florida, Georgia, North Carolina, and Virginia. However, South Carolina also shares many animal RSGCN considered "very high" concern with North Carolina, Virginia, and Louisiana (Figure 10-5).

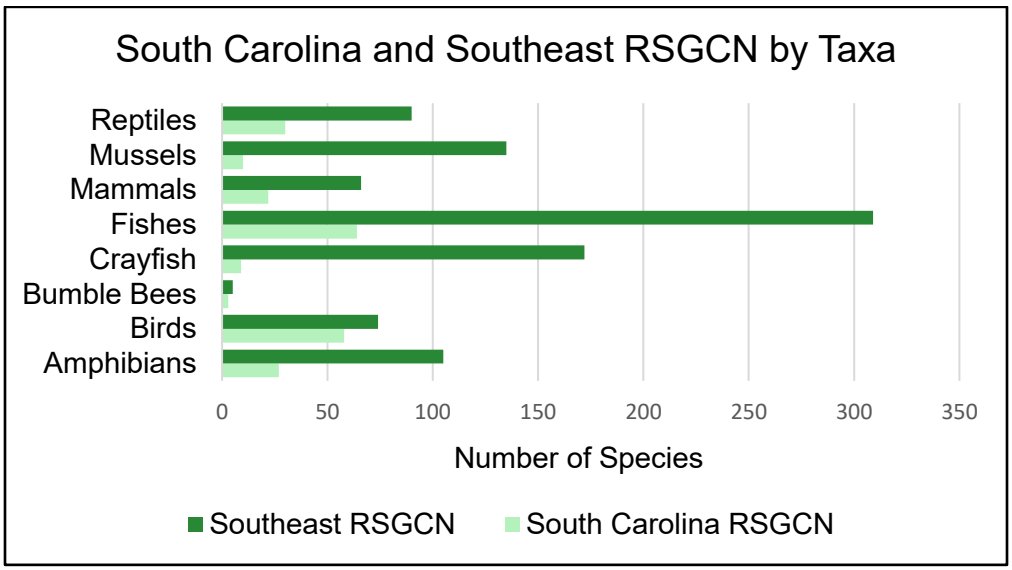


FIGURE 10-4: RSGCN taxa represented in South Carolina.

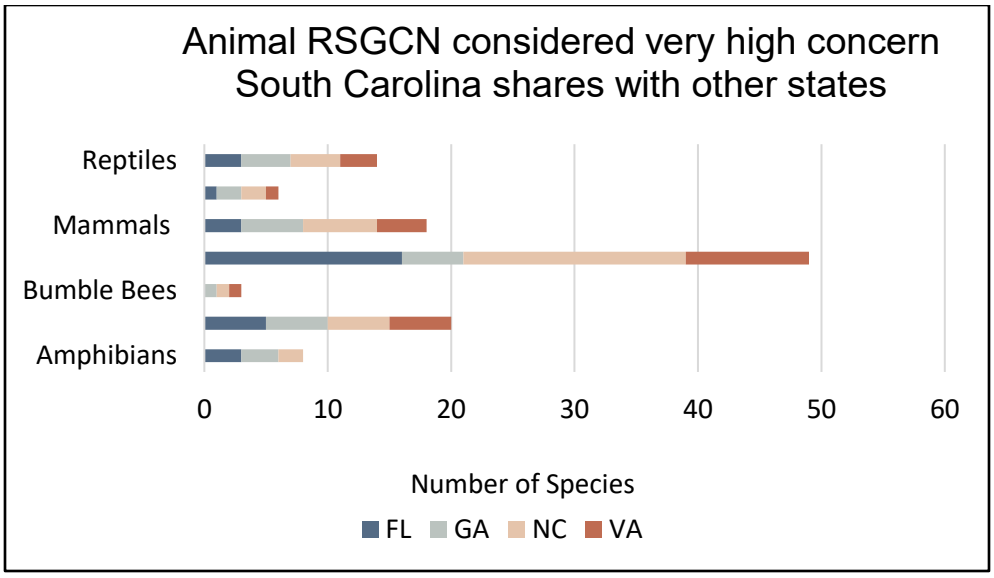


FIGURE 10-5: Animal RSGCN considered very high concern that South Carolina shares with Florida, Georgia, North Carolina, and Virginia.

South Carolina is also home to multiple species that are not only endemic to the SEAFWA region but are also found in only one other state. By identifying shared RSGCN, South Carolina can prioritize conservation actions that not only provide benefits within its boundaries but also support a regional landscape. For example, South Carolina can identify conservation strategies aimed at improving aquatic connectivity that also improve water quantity and quality in watersheds and streams that cut across state lines.

A Changing Climate

Many factors impacting the Southeast regional landscape are often too pervasive for any one agency to address independently, like sea-level rise, changing weather patterns, and habitat loss. While South Carolina must evaluate the impact of landscape level stressors and threats like climate change and land use change within its own boundaries, management efforts must also be coordinated on a regional scale. The AFWA 2022 (2nd Edition) Voluntary Guidance for States to Incorporate Climate Adaptation into State Wildlife Action Plans provides recommended steps for developing and implementing adaptation strategies. Much of the guidance includes taking a broader, regional approach to incorporating climate adaptation into SWAPs.

Temperature Changes

Projections of Earth's future surface temperatures depend primarily on future emissions and how sensitive the climate system will be to these emissions. Projections of climate change can be examined using two approaches: 1) global warming levels (GWLs); and 2) scenarios. GWLs are defined levels of warming for Earth's average temperature that correspond to increases of 2.7 °F (1.5 °C), 3.6 °F (2 °C), 5.4 °F (3 °C), and 7.2 °F (4 °C) degrees above pre-industrial levels (IPCC2018, Arias et al. 2021). A scenario-based approach can be used to explore plausible climate outcomes under a coherent future trajectory of greenhouse gases and other anthropogenic forcings (Leung et al. 2023). The Fourth National Climate Assessment (NCA4) used projections created with Representative Concentration Pathways (RCPs) to project and talk about future

climate in the United States (USGCRP 2018), while instead, the Fifth National Climate Assessment (NCA5) used newly developed climate projections created with Shared Socioeconomic Pathways (SSPs) that represent plausible trajectories of GDP and population growth plus trends of economic and technological progress globally for the 21st-century (USGCRP 2023). The climate projections used in the NCA5 were created using global climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) that were statistically downscaled to translate largescale changes in the climate under a given SSP or GWL to local scales for impact assessment and planning (Basile et al. 2023). Three of the SSPs used with the new climate models from the CMIP6 correspond to three of the RCPs used with the past global climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) in their overall forcing levels (SSP1-2.6 corresponds with RCP2.6, SSP2-4.5 with RCP4.5, and SSP5-8.5 with RCP8.5) (Leung et al. 2023). Therefore, we can use scenarios to inform us when the planet will reach a certain global warming level and will use a mix of the SSPs and GWLs hereafter to show climate impacts throughout this section.

Using available climate change data and information that assumes a specific Global Warming Level (GWL) or SSP-based scenario can allow land managers to consider possible future conditions. Exactly when and if we reach a particular GWL depends on the trends of Global emissions and how sensitive the climate system is to these emissions (Figure 10-6).

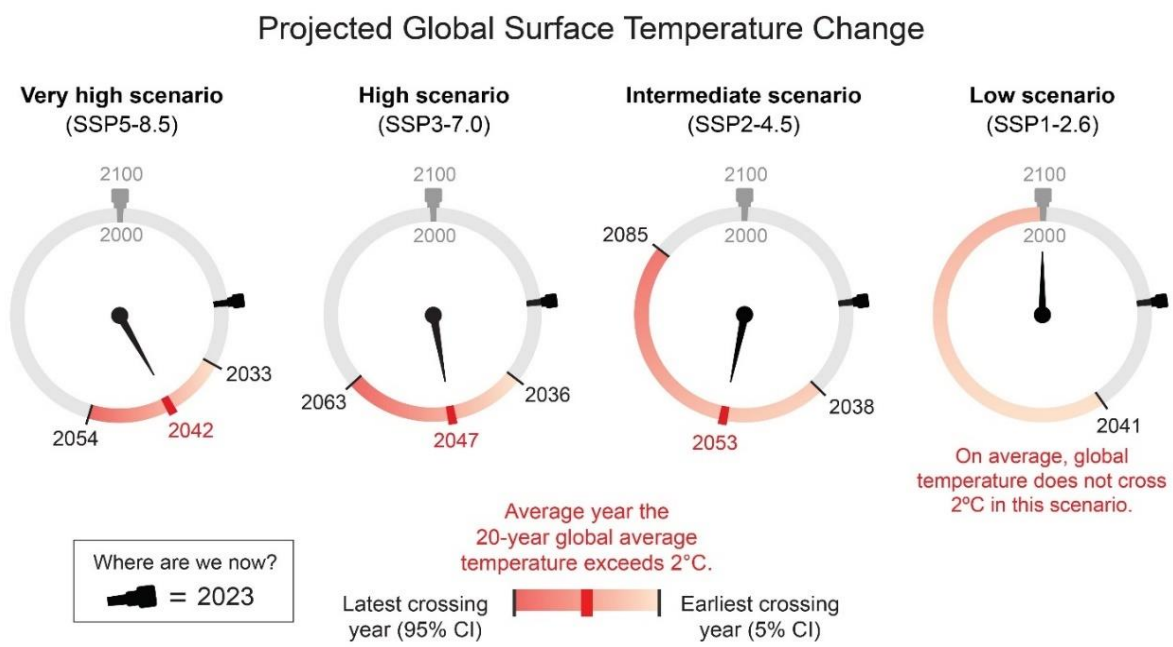


FIGURE 10-6: This figure represents an example of how various scenarios can be linked to specific GWLs and different timescales and is taken from the NCA5, Figure 2.14 (Marvel et al. 2023). In this example, the IPCC AR6 assessed warming projections for four future scenarios, with projected years at which the 2°C (3.6°F) global warming level would be reached. For example, under a very high scenario (SSP5-8.5), models project reaching 2°C between 2033 and 2054, with an average estimate of 2042. Under a low scenario (SSP1-2.6), the 5% CI (confidence interval) range begins in 2041, but the average projection shows that warming would actually stay below 2°C.

For example, in a very high scenario such as SSP5-8.5, the Earth is very likely to exceed a GWL of 2 (3.6 °F) between 2033 and 2054, depending on the climate sensitivity to greenhouse gas emissions from each global climate model (Marvel et al 2023; Figure 10-6). By contrast, in a low scenario such as SSP1-2.6, the Earth is very likely not to cross GWL 2 at all (Marvel et al. 2023; Figure 10-6). However, the rate of global warming varies across these scenarios as well, with high and very high scenarios assuming the Earth warms faster (Marvel et al. 2023). Since 1850, the Earth's temperature has risen by an average of 0.11° Fahrenheit per decade and, as of 2023, rising about 2 °F in total (Climate Change: Global Temperature | NOAA Climate.gov). However, since 1982, the rate of warming increased over 3 times as fast to about 0.36°F per decade. Currently, the planet is estimated to warm by nearly 5.4°F by the end of this century, meaning crossing a GWL 3 threshold, despite current global emission reduction pledges, according to the most recent United Nation's Annual 2023 Emissions Gap Report (Emissions Gap Report 2023 | UNEP - UN Environment Programme). Based on these trends, it is likely that the habitats, ecosystems, and conditions of South Carolina will also change as faster rates of climate change also increase the challenge of adaptation for natural systems and wildlife.

Climate projections use the best available physical science to predict how the climate system will respond to changes in human activities, but not all climate projections are developed in the same manner (IPCC 2023). Climate experts across the world have produced more than 50 global climate models under multiple greenhouse gas emissions and socioeconomic scenarios, each with unique variations and nuances. Some have undergone transformations like downscaling to improve spatial resolutions for smaller areas in order to make management decisions at a local scale. The most recent climate projections used in the Fifth NCA and associated climate parameters can be viewed on the National Climate Change Viewer. This tool, developed by the US Geological Survey, allows for visualizations of climate change impacts, such as days of extreme heat under projections of degree warming days, under SSP-based scenarios, and Global Warming Levels (Alder and Hostetler 2013). Additionally, these data are available as interactive maps and layers as part of the Fifth National Climate Assessment Interactive Atlas (National Climate Assessment Interactive Atlas (globalchange.gov)) and is where we have derived our spatial climate data for this report. Information pertaining to sea-level rise, as well as easy-to-understand state-level summaries on climate change impacts, are available from the National Oceanic and Atmospheric Administration (NOAA) website via their Sea-level Rise Technical Reports and Sea-level Rise Viewer Tool as well as their State Climate Summaries (Kunkel et al. 2022, Sweet et al. 2022).

In the Southeast, climate change will have pervasive impacts on natural habitats, ecological processes, and ecosystem services; regional efforts to mitigate or adapt to these impacts will be extremely important. According to NCA4 and NCA5, conditions in the Southeast may change dramatically (USGCRP 2018, 2023). Both Assessments indicate that current trends will continue such as increasing frequency, intensity, and duration of heatwaves, increasing wildfire risk, and rising sea levels. The most pertinent projected changes include extreme heat, extreme precipitation events, more intense drought, sea-level rise, and stronger tropical cyclones, as well as decreases in the intensity and frequency of cold-season events. Despite the significant threat climate change poses to the landscape, understanding the tools and resources available to address

climate change and develop effective strategies is difficult. As part of the survey administered to SWAP coordinators in 2021, the majority of SEAFWA states/territories reported integrating climate change as one of the most challenging aspects of upcoming SWAP revisions. Anecdotally, some SWAP coordinators noted that it is difficult to discern what tools are available, decide which tool is the right one to use, and choose the appropriate scale and timeframe when using tools. Some reported it is also challenging to determine what climate-change associated threats to include and how to spatially represent their impacts. As such, the Southeast Climate Adaptation Science Center (SECASC) has provided data and information for this chapter to help translate the actionable implications of future climate projections.

Precipitation Changes and Extreme Weather Events

Like the rest of the Southeast, South Carolina is predicted to experience a number of climate impacts, though the magnitude of change often varies by ecoregion, emissions scenario, and future timeframe. Generally, these impacts include hotter summers, warmer winters, more frequent extreme precipitation events, and rising sea levels (USGCRP 2018, 2023).

Generally, the number of extremely hot days (i.e. days with afternoon high temperatures of at least 95°F) are predicted to increase although there are differences in the degree of how many hotter days are expected across the State (Table 10-11). Under various global warming levels, summer nighttime minimum temperatures that exceed 70°F, and daytime maximum temperatures that exceed 95°F, become the norm in South Carolina (Alder and Hostetler 2013; USGCRP 2018; Hoffman 2023).

Lake Jocassee during the 2011 drought. Photo by Doug Young.

As nighttime temperatures rise, some species may also be impacted. Warmer nights can have a profound impact on animal and plant health because temperatures are generally lower at night, normally allowing the environment to cool down. Additionally, heatwaves in the U*S* have become hotter, more frequent, more widspread, and longer lasting in recent decades and are projected to continue, which has implications for drought in the region. The 5th NCA projects that the number of extremely hot days (days with maximum temperatures ≥95°F) may increase across South Carolina, with the most pronounced changes occurring in the central portions of the *S*tate (Table 10-11; Figure 10-7).

TABLE 10-11: Approximate observed historical and the future projected number of extremely hot days per year (i.e. days with afternoon high temperatures of at least 95°F) by EPA Level III ecoregions within South Carolina. The table summarizes projected future number of days for low, moderate, and high Shared Socioeconomic Pathway (SSP) emission scenarios using CMIP6-LOCA2 threshold and extreme event metric projections (Alder 2024) summarized at the ecoregion level by the Southeast and South Central Climate Adaptation Science Centers. For each future time period, numbers in parentheses represent the percent change between the models' future projections and the models' historical simulations. Observed historical summaries were generated with data from Pierce et al. (2021).

Historical & Future Projections: Number of Days with Maximum Temperatures ≥ 95°F			
SSP	**Observed Historical: 1950-2014**	**2025-2049 Projections** (percent change from historical simulation)	**2050-2074 Projections** (percent change from historical simulation)
Blue Ridge Ecoregion			
Low (SSP2-4.5)	3 days/year	10 days/year (430%↑)	17 days/year (775%↑)
Moderate (SSP3-7.0)		10 days/year (380%↑)	20 days/year (900%↑)
High (SSP5-8.5)		12 days/year (480%↑)	28 days/year (1290%↑)
Piedmont Ecoregion			
Low (SSP2-4.5)	14 days/year	35 days/year (170%↑)	47 days/year (260%↑)
Moderate (SSP3-7.0)		35 days/year (165%↑)	53 days/year (305%↑)
High (SSP5-8.5)		37 days/year (190%↑)	63 days/year (390%↑)
Southeastern Plains			
Low (SSP2-4.5)	17 days/year	42 days/year (165%↑)	55 days/year (240%↑)
Moderate (SSP3-7.0)		41 days/year (160%↑)	61 days/year (280%↑)
High (SSP5-8.5)		46 days/year (180%↑)	73 days/year (355%↑)
Middle Atlantic Coastal Plain Ecoregion			
Low (SSP2-4.5)	13 days/year	35 days/year (180%↑)	47 days/year (275%↑)
Moderate (SSP3-7.0)		34 days/year (170%↑)	51 days/year (310%↑)
High (SSP5-8.5)		38 days/year (210%↑)	65 days/year (425%↑)
Southern Coastal Plain Ecoregion			
Low (SSP2-4.5)	9 days/year	25 days/year (200%↑)	36 days/year (330%↑)
Moderate (SSP3-7.0)		25 days/year (190%↑)	39 days/year (365%↑)
High (SSP5-8.5)		28 days/year (240%↑)	53 days/year (535%↑)

Additionally, if the earth surpasses GWL 2°C above pre-industrial levels for a sustained period of time, the number of days where the temperature reaches 95°F or higher will increase across the State, compared to the past 30 years (1991-2020).

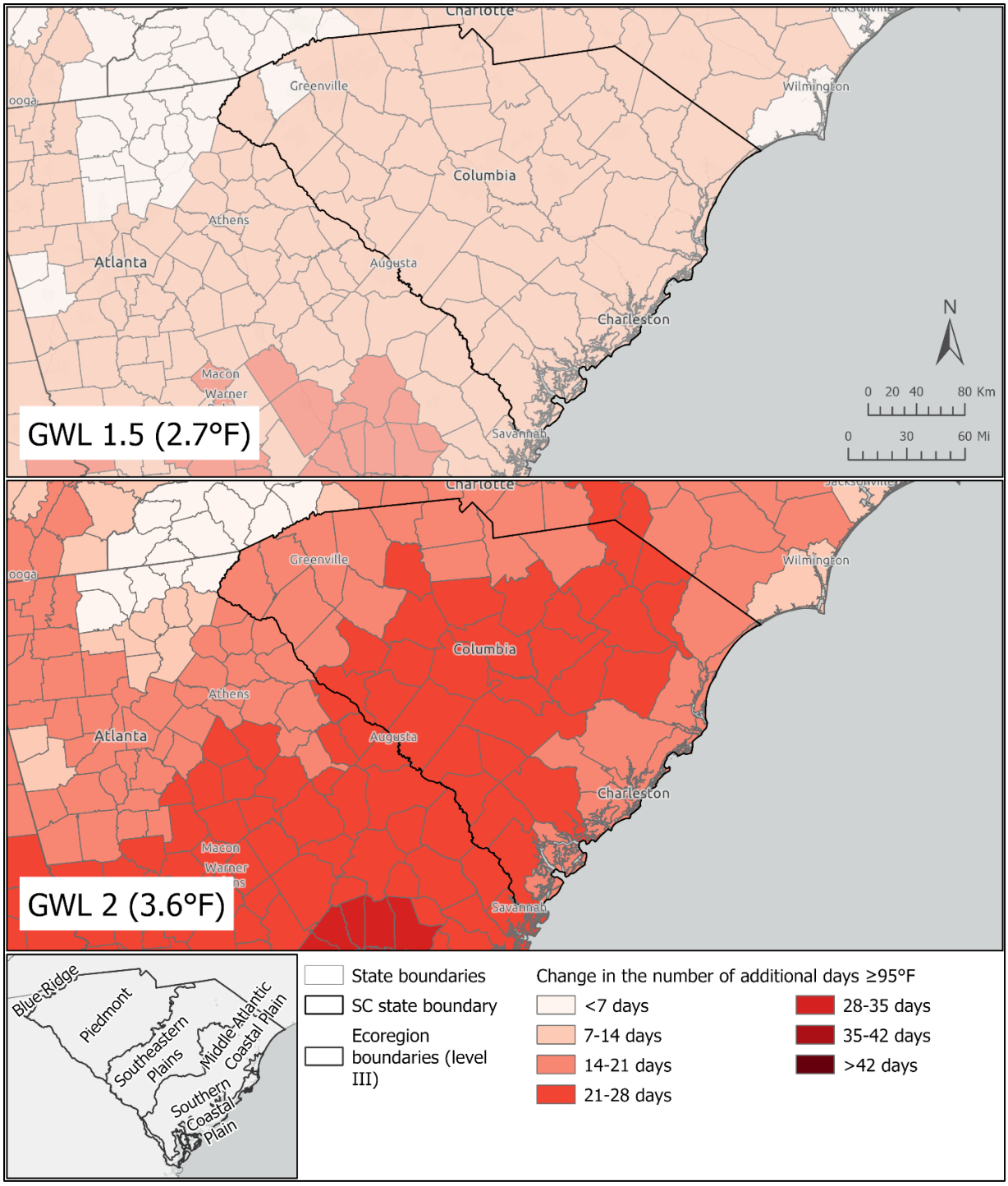


FIGURE 10-7: Projected future changes in the number of days of Extreme Maximum Temperatures (threshold temperature of 95°F) compared to preindustrial levels (1851-1900) based on GWL 1.5 (global temperature increase of 2.7°F) and GWL 2 (global temperature increase of 3.6°F). Note that this is not the *total number* of days, as presented in the table above, but the number of *additional* days where temperatures will reach ≥ 95°F. Figure created from data in the "Atlas of the 5th National Climate Assessment" web tool (National Climate Assessment Interactive Atlas (globalchange.gov; USGCRP et al. 2024) accessed on July 23, 2024.

Nine-banded Armadillos have experienced a range expansion, now making them a common site in South Carolina. Their rooting and diet can put them into direct conflict with native species. Photo by Anna Smith, SCDNR.

Winter temperatures are the fastest warming season in most of the US. In general, the number of extremely cold days (i.e. days with low temperatures of at least 32°F or lower) in South Carolina is predicted to decrease (Table 10-12). Winter conditions are key drivers of individual species performance and community composition in terrestrial habitats because species vary in susceptibility to these winter drivers (Williams et al. 2014). Shorter and warmer winters may cause species range shifts that would allow for warm-adapted species to dominate and shift distributions of cold-adapted species. For example, overwintering bird populations are responding to a warming climate (e.g. poleward shifts) by favoring the formation of winter bird communities dominated by warm-adapted species instead of cold-adapted species (Princé and Zuckerberg 2014, Osland et al. 2021). Range shifts that bring new species into a region or state leads to reconsiderations of what defines a "native species." Species that have moved into South Carolina in recent decades include the Coyote and Nine-Banded Armadillo. Rosette Spoonbills have now been documented nesting in the State.

Roseate Spoonbills have been documented nesting in SC. Photo by Norman Welsh, USFWS public domain

Additionally, winter conditions (e.g. snowfall, low temperatures) have a major effect on ecological processes such as litter decomposition, mineralization rates, nutrient leaching and gas fluxes in the soil, and hydrological processes. Winter soil freezing also affects insect and microbial communities for the subsequent warm season (Campbell et al. 2005). If the earth surpasses GWL 2°C above pre-industrial levels for a sustained period of time, the number of days where the temperature reaches 32°F or lower (freezing temperatures) will decrease across the State, compared to the past 30 years (1991-2020) (Figure 10-8).

TABLE 10-12: Approximate observed historical and future projected number of extremely cold days per year (days with minimum temperatures <32°F) for EPA Level III ecoregions within South Carolina. The table summarizes projected future number of days for low, moderate, and high SSP emission scenarios using CMIP6-LOCA2 threshold and extreme event metric projections (Alder 2024) summarized at the ecoregion level by the Southeast and South Central Climate Adaptation Science Centers. For each future time period, numbers in parentheses represent the percent change between the models' future projections and the models' historical simulations. Observed historical summaries were generated with data from Pierce et al. (2021).

Historical & Future Projections: Number of Extremely Cold Days (Min Temperatures ≤ 32°F)			
SSP	**Observed Historical: 1950-2014**	**2025-2049 Projections** (percent change from historical simulation)	**2050-2074 Projections** (percent change from historical simulation)
Blue Ridge Ecoregion			
Low (SSP2-4.5)	65 days/year	19 days/year (25%↓)	19 days/year (30%↓)
Moderate (SSP3-7.0)		19 days/year (25%↓)	20 days/year (35%↓)
Low (SSP5-8.5)		19 days/year (30%↓)	19 days/year (40%↓)
Piedmont Ecoregion			
Low (SSP2-4.5)	63 days/year	48 days/year (25%↓)	42 days/year (40%↓)
Moderate (SSP3-7.0)		48 days/year (25%↓)	40 days/year (45%↓)
High (SSP5-8.5)		46 days/year (30%↓)	35 days/year (50%↓)
Southeastern Plains Ecoregion			
Low (SSP2-4.5)	51 days/year	37 days/year (30%↓)	31 days/year (40%↓)
Moderate (SSP3-7.0)		37 days/year (30%↓)	29 days/year (45%↓)
Extreme (SSP5-8.5)		35 days/year (35%↓)	25 days/year (50%↓)
Middle Atlantic Coastal Plain Ecoregion			
Low (SSP2-4.5)	42 days/year	29 days/year (30%↓)	26 days/year (40%↓)
Moderate (SSP3-7.0)		31 days/year (30%↓)	25 days/year (45%↓)
High (SSP5-8.5)		29 days/year (35%↓)	21 days/year (50%↓)
Southern Coastal Plain Ecoregion			
Low (SSP2-4.5)	26 days/year	19 days/year (35%↓)	17 days/year (45%↓)
Moderate (SSP3-7.0)		20 days/year (30%↓)	16 days/year (45%↓)
Extreme (SSP5-8.5)		19 days/year (35%↓)	13 days/year (55%↓)

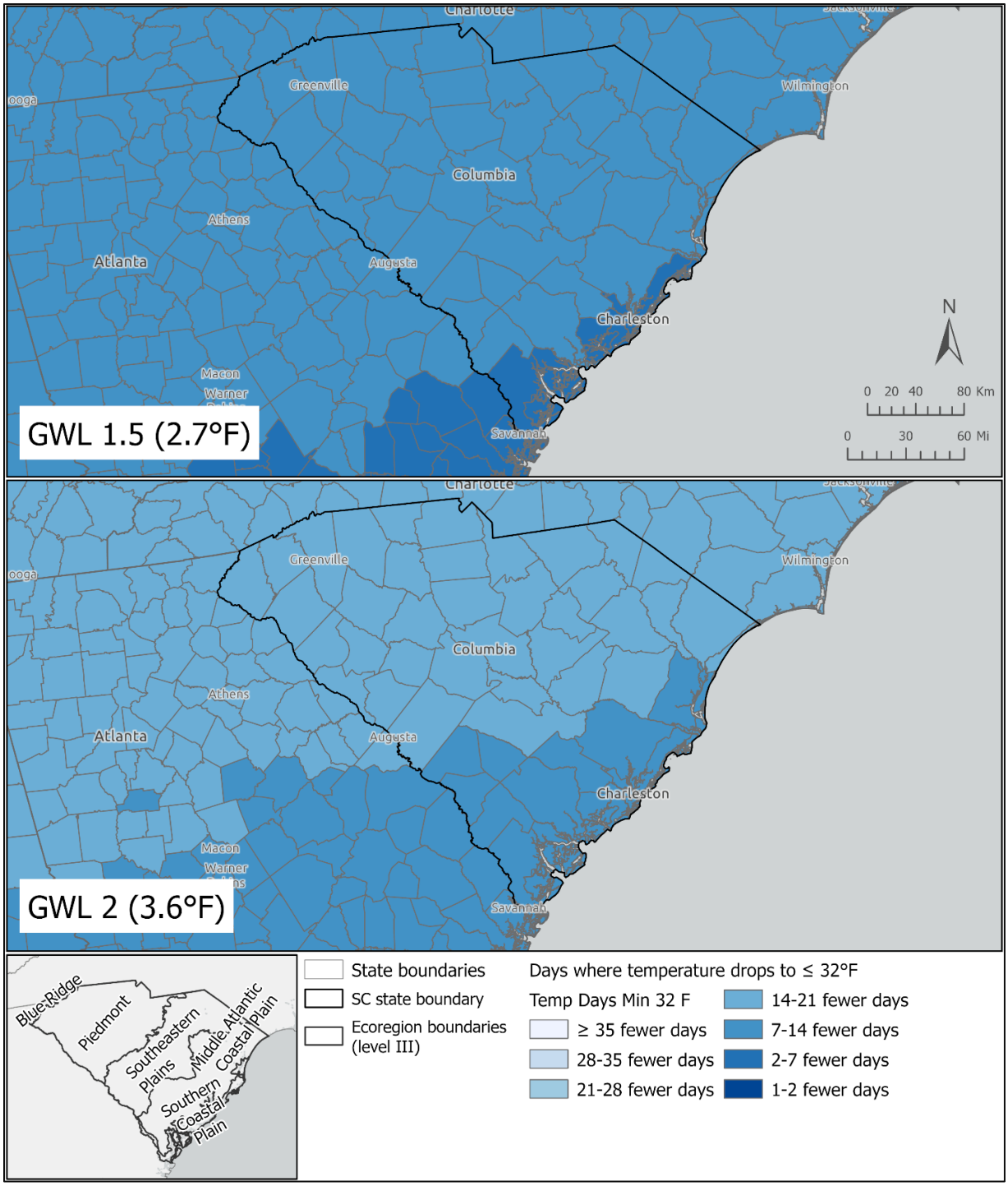


FIGURE 10-8: Change in days where minimum temperatures reach or drop below freezing (32°F) compared to preindustrial levels (1851-1900) based on GWL 1.5C (global temperature increase of 2.7°F) and GWL 3C (global temperature increase of 2.7°F). Figure created from data in the "Atlas of the 5th National Climate Assessment" web tool (National Climate Assessment Interactive Atlas (globalchange.gov); USGCRP et al. 2024).

In South Carolina, 15 out of the last 21 years have been characterized by warm-season drought conditions. However, little change in total annual precipitation is projected over this century, although the timing and intensity of precipitation events will change (Hoffman et al. 2023). Any increases in temperature will cause more rapid loss of soil moisture during consecutive dry days, increasing the intensity of naturally occurring droughts in the future. The Southeast has, in general, received more precipitation in the fall seasons but experienced drier conditions in spring and summer (Hoffman et al. 2023). Although hydrological droughts have become less frequent in eastern regions of the country since the 19th century, higher increases in evapotranspiration (the processes by which water is transferred to the atmosphere from Earth's surface) have generally made the Southeast more drought-prone than the Northeast (Hoffman 2023).

Other potential climate hazards may impact the state, such as extreme precipitation events, which are expected to increase in the future and often manifest as extreme weather and increased flooding (Wong et al. 2014). Total annual precipitation has been below average during most years since 2000 but was above average during the 2015–2020 period (Hoffman et al. 2023). There is no overall trend in annual precipitation since the beginning of the 20th century; however, a few recent years (notably 2015, 2018, and 2020) have been very wet. Between 2000 and 2015, the State experienced a below average number of 3-inch extreme precipitation events, but during the 2015–2020 period, the number was well above average (Hoffman et al. 2023).

The aftermath of Hurricane Florence on Longs, SC
Photo by Hope Mizzell, SCDNR.

In the Southeast region, extreme weather events are characterized by hurricanes and tropical storms that will likely increase in frequency and magnitude (USGCRP 2018). Tropical storms and hurricanes have been responsible for some of the Southeast's biggest and most damaging flooding events since 2018 (Hoffman 2023). The likelihood of hurricanes slowing down or stalling near the Southeast coastline has increased, which exacerbates the rainfall-related flooding threats from these storm systems (Hoffman 2023). Climate change is expected to strengthen North Atlantic hurricanes to at least Category 4 intensity and to undergo rapid intensification, as well as potentially increase the likelihood of storms making landfall (Hoffman 2023). More severe weather, and subsequent wave action, high winds, and storm surge, can severely erode beaches and dunes, eliminate sea turtle and shorebird nests, and degrade or erode maritime forests and salt marshes (USGCRP 2018).

Additionally, climate change projections suggest that the Southeast will get wetter, meaning some seasonal, annual average, and extreme precipitation amounts will increase across the region, driven mainly by more extreme events (e.g. precipitation of 3 or more inches in 24 hours) at higher levels of global warming (Hoffman 2023). Extreme rainfall that occurs while ocean water inundates and affects low-lying areas in the coastal plain (e.g. because of high tides or storm surges) creates compound flooding events (Hoffman 2023). Sea-level rise scenarios for the Southeast project a higher frequency of compound flooding by midcentury along the Atlantic coast (Hoffman 2023). Extreme rainfall events also contribute to increases in river and stream flooding across the landscape, which have different effects in different ecoregions and topography. For example, in the Appalachian Mountains where the susceptibility to landslides is already high, increases in extreme rainfall may lead to increases in landslides (Mirus et al. 2020). There is high spatial overlap between landslide susceptibility and biodiversity in the Appalachians which provides an opportunity to achieve co-benefits in both species conservation and development if these vulnerable sites are protected and restored (Li et al. 2022).

An October 2015 flood's impact on a Clarendon County road. Photo by SCDNR.

Table 10-13 summarizes approximate values for historically observed and future projections of extreme rainfall under different SSP scenarios for South Carolina ecoregions, while Figure 10-9 shows the projected future percent change in number of days per year with extreme precipitation (top 1% of rainfall) in South Carolina at GWL of 1.5 (2.7°F warmer than the last 30 years) and GWL 3 (2.7°F warmer than the last 30 years). While all ecoregions within South Carolina will experience days of extreme precipitation, the Blue Ridge and Piedmont ecoregions are projected to experience the greatest percent change in the number of days per year with extreme annual precipitation events across GWLs.

TABLE 10-13: Approximate observed historical and future projected number of days per year with extreme precipitation events (in the top 1% of historical rainfall events) for EPA Level III ecoregions within South Carolina. The table summarizes projected future number of days for low, moderate, and high SSP emission scenarios using CMIP6-LOCA2 threshold and extreme event metric projections (Alder 2024) summarized at the ecoregion level by the Southeast and South Central Climate Adaptation Science Centers. For each future time period, numbers represent the percent change between the models' future projections and the models' historical simulations. Observed historical summaries were generated with data from Pierce et al. (2021).

Historical & Future Projections: Number of Days with Extreme Rainfall (Days with Rainfall > 99th percentile)			
SSP	**Observed Historical: 1950-2014**	**2025-2049 Percent Change in Future Projections from Historical Simulation**	**2050-2074 Percent Change in Future Projections from Historical Simulation**
Blue Ridge Ecoregion			
Low (SSP2-4.5)	3 days/year	34%↑	50%↑
Moderate (SSP3-7.0)		34%↑	50%↑
Low (SSP5-8.5)		38%↑	58%↑
Piedmont Ecoregion			
Low (SSP2-4.5)	3 days/year	35%↑	52%↑
Moderate (SSP3-7.0)		35%↑	46%↑
High (SSP5-8.5)		37%↑	58%↑
Southeastern Plains Ecoregion			
Low (SSP2-4.5)	4 days/year	27%↑	44%↑
Moderate (SSP3-7.0)		27%↑	38%↑
High (SSP5-8.5)		28%↑	55%↑
Middle Atlantic Coastal Plain Ecoregion			
Low (SSP2-4.5)	4 days/year	22%↑	35%↑
Moderate (SSP3-7.0)		21%↑	31%↑
High (SSP5-8.5)		24%↑	48%↑
Southern Coastal Plain Ecoregion			
Low (SSP2-4.5)	3 days/year	17%↑	30%↑
Moderate (SSP3-7.0)		17%↑	23%↑
High (SSP5-8.5)		20%↑	43%↑

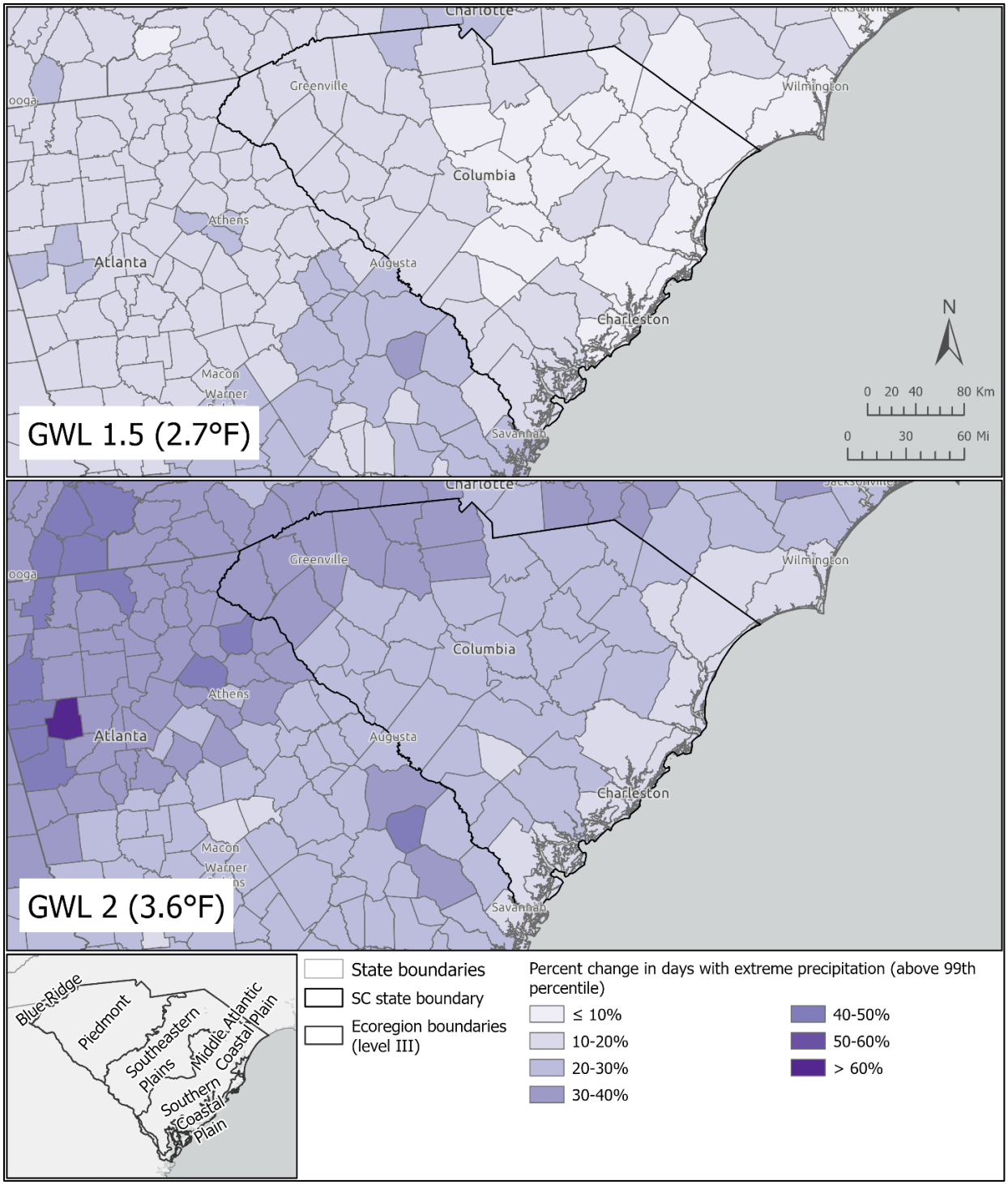


FIGURE 10-9: Future projected changes in the number of days per year of extreme precipitation (top 1% of rain events) compared to preindustrial levels (1851-1900) based on GWL 1.5C (global temperature increase of 2.7°F) and on GWL 2C (global temperature increase of 3.6°F). Figure created from data in the 'Atlas of the 5th National Climate Assessment" web tool (National Climate Assessment Interactive Atlas (globalchange.gov); USGCRP et al. 2024).

The Southeast has the highest aquatic diversity of any temperate system; however, the ecological relationships and life histories of many of the endemic species are not yet well understood within the constraints of climate change (Ingram et al. 2013). Freshwater ecosystems (e.g. streams, rivers, lakes, and wetlands) of the Southeast are highly vulnerable to warming. Impacts on rare species of fish and mussels are of particular concern in a changing climate. The combined effects of warming and changes in precipitation will likely alter overall hydrology including increased evapotranspiration and reduced stream base flow. Currently, many species declines are associated with widespread alteration of flow regimes and are expected to be exacerbated by climate change. Impacts of climate change on riverine and wetland ecosystems are predicted to also include increased water temperatures, which dictate many species' ranges and worsens low dissolved oxygen conditions (Ingram et al. 2013). In general, temperature regimes of freshwater ecosystems are projected to increase in parallel with shifts in air temperatures, which in turn may alter plant and animal communities including migratory birds (Princé and Zuckerberg 2015).

Sea Level Rise

Beyond the changes for temperature and precipitation, sea-level rise will also impact South Carolina. Sea level has risen and fallen over millions of years in South Carolina so that 80,000-100,000 years ago, it was where it is again today (Will Doer, SC Geological Survey – SCDNR, pers. comm.). Due to the magnitude of sea-level rise projected throughout the 21st century and beyond—coupled with subsidence—coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, flooding, and erosion (Wong et. al. 2014). Historically, coastal ecosystems in the region have adjusted to sea-level rise by vertical (accretion) and horizontal movement across the landscape. As sea levels continue to rise, some coastal ecosystems will be submerged and convert to open water, and saltwater intrusion will allow salt-tolerant coastal ecosystems to move inland at the expense of upslope and upriver ecosystems (e.g. salt marsh migration). Slope can affect marsh migration as can substrate such as clay (blocks movement) or sand (allows movement) (Will Doer, SC Geological Survey – SCDNR, pers. comm.).

The National Oceanic and Atmospheric Administration (NOAA) 2022 Sea Level Rise Technical Report, *Global and Regional Sea Level Rise Scenarios for the United States*, provides the most recent projections available to all US coastal areas out to the year 2150 (Sweet et. al 2022). The following tables show the predicted extent of flooding for coastal South Carolina at the average highest daily tide due to sea-level rise (Table 10-14) and the projected amount of sea-level rise by decade under various emissions scenarios (Table 10-15). Figure 10-10 also provides a statewide map of areas likely to experience flooding at high tide based on each foot of sea-level rise above current levels.

TABLE 10-14: Extent of flooding by projected average highest daily tide due to sea-level rise in South Carolina. Values from the NOAA sea-level rise inundation data.

Feet of sea-level rise	Acres	Percent of Area
0 feet	1,245,818	6.1%
1 foot	1,384,978	6.8%
2 feet	1,459,377	7.1%
3 feet	1,534,875	7.5%
4 feet	1,614,821	7.9%
5 feet	1,695,974	8.3%
6 feet	1,776,110	8.7%
7 feet	1,854,169	9.0%
8 feet	1,929,336	9.4%
9 feet	2,008,621	9.8%
10 feet	2,088,626	10.2%
Not projected to be inundated by up to 10 feet	*4,967,754*	*24.2%*
Sea-level rise unlikely to be a threat (inland counties)	*13,438,646*	*65.6%*
Total area	**20,495,027**	**100%**

TABLE 10-15: Projected sea-level rise by decade in South Carolina. Values are based on area-weighted averages of decadal projections for 1-degree grid cells that overlap this area based on NOAA's 2022 Sea Level Rise Report.

SLR Scenario	2020 (ft)	2030 (ft)	2040 (ft)	2050 (ft)	2060 (ft)	2070 (ft)	2080 (ft)	2090 (ft)	2100 (ft)
Low	0.36	0.56	0.77	0.97	1.1	1.3	1.4	1.5	1.6
Intermediate-low	0.38	0.61	0.86	1.1	1.3	1.6	1.8	2	2.3
Intermediate	0.39	0.64	0.91	1.2	1.6	2	2.5	3.1	3.8
Intermediate-high	0.39	0.68	1	1.4	2	2.6	3.4	4.2	5.2
High	0.4	0.69	1.1	1.6	2.3	3.3	4.4	5.5	6.8

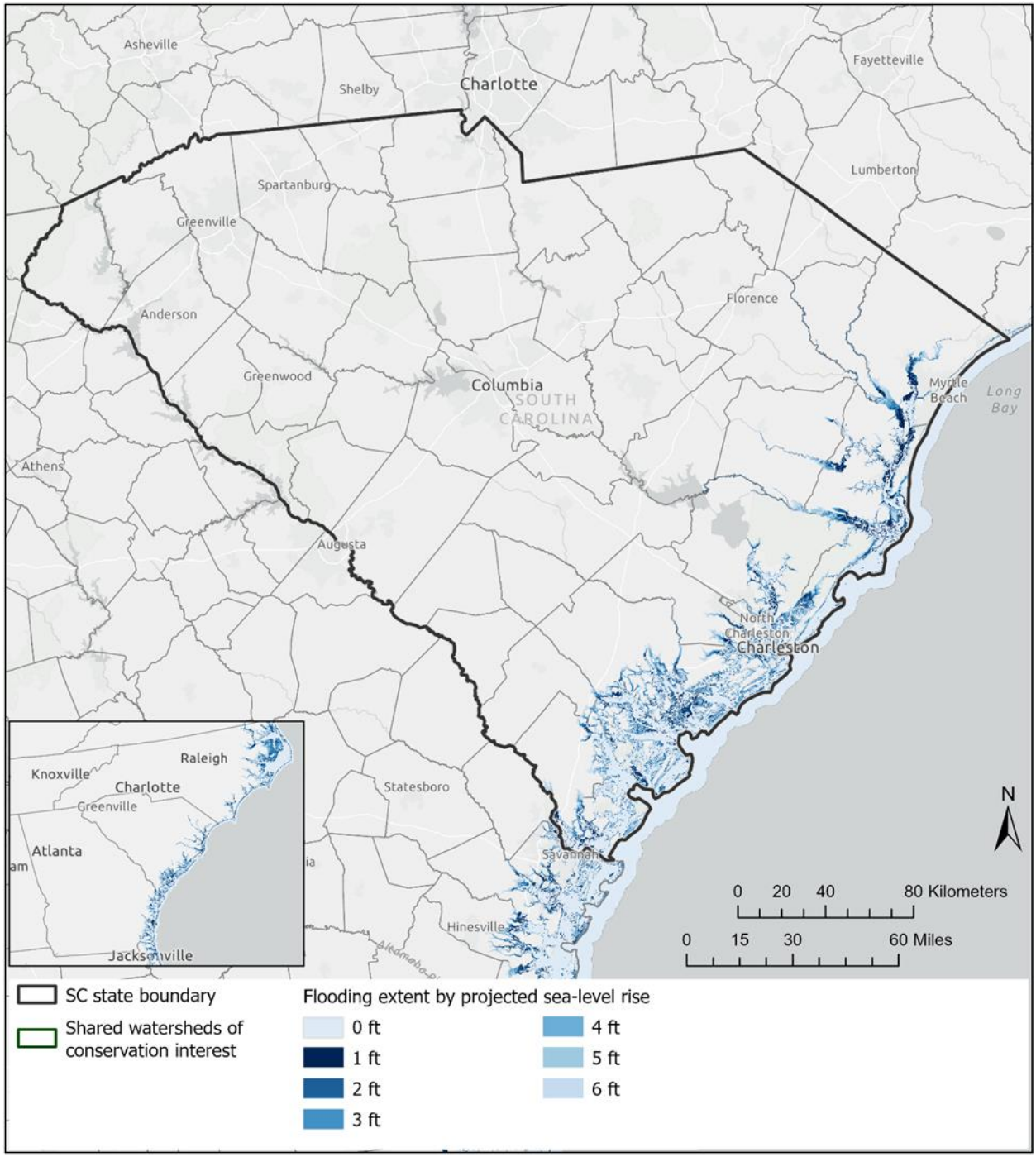


FIGURE 10-10: NOAA's sea-level rise (SLR) inundation models represent areas likely to experience flooding at high tide based on each foot of SLR above current levels. Darker blue areas will experience flooding first and at greater depth compared to lighter blue areas. These models are not linked to a future timeframe; see the projections in Tables 10-14 and 10-15. NOAA calculates the inundation footprint at "mean higher high water", or the average highest daily tide. The area covered in each SLR scenario includes areas projected to be inundated at lower levels. For example, the area inundated by 4 ft of SLR also includes areas inundated by 3 ft, 2 ft, 1 ft, and 0 ft of SLR (where 0 ft represents current levels).

Species' Responses to Changes in Climate: Vulnerability and Resiliency

As the climate, regional landscape, and weather patterns change, there is value in identifying regional strategies and conservation actions to support the SGCN and RSGCN that are most vulnerable to the impacts. A species is considered vulnerable to climate change if it is both sensitive and exposed to climate change impacts (Williams et al. 2008). For example, a species may be exposed to climate change because it experiences an impact like warmer stream temperatures, but if it is resilient to that change or able to disperse into new habitats, it may ultimately have low vulnerability. Conversely, a species that would be sensitive to climate change but is not exposed to any impacts may also not be considered vulnerable. Figure 10-11 visually represents these relationships. Understanding if a species is sensitive and will be exposed to climate change can help managers develop strategies to support the species most likely to be impacted.

Two common tools that have been used to determine climate vulnerability of species are 1) the Climate Change Vulnerability Index (CCVIs) (Young et al. 2016) developed by NatureServe and 2) environmental niche modeling-based vulnerability estimates produced by the academic research community. The CCVI is a worksheet-based tool where users apply readily available information about a species' natural history, distribution, landscape circumstances, and expert opinions to predict whether it will likely suffer a range contraction and/or population reduction due to climate change that results in a vulnerability score. By design, this score is distinct from NatureServe's national vulnerability ranking system that considers other threats. A species could score as not particularly vulnerable in terms of its Global or Subnational (State) rank (G-or S-rank), which is based on other factors, but could still rate as vulnerable to climate change. CCVI is based on an evaluation of the species' direct and indirect exposure to climate change and its sensitivity to climate change.

Ecological niche models (also called species distribution models) are a common approach for evaluating a species' vulnerability to climate change by the academic research community. These models start by identifying shared climate conditions at sites where a species is known to have occurred and then predict where similar climate conditions may be found on the landscape in the future. Some models also take into account the ability of a species to disperse to reach any new areas that may become climatically suitable. The resulting predictions from these models allow researchers to create spatially explicit estimates of whether suitable climate conditions for a species are likely to remain stable, become more widespread on the landscape (i.e. increase), or become more geographically rare in the future (i.e. decrease).

For example, if suitable climate conditions for a species were projected to decrease greatly in an area in the future, then the species would be considered more vulnerable to climate change than a species for which climate conditions were predicted to remain stable. It is important to note that raw data from niche models (e.g. spatial raster data) is not usually readily available to the public due to the large size of the files but instead is available in summary form in the research literature (i.e. academic journal articles). Therefore, more translational effort is needed with niche model results as the form of the data might not be readily interpretable by users. (Note: A collated and readily interpretable dataset of niche models conducted for Southeast RSGCN by researchers to date has been developed by the Armsworth lab at the University of Tennessee - Knoxville discussed in the next section of this chapter.)

Niche model results can be used in tandem with CCVI estimates to enhance the understanding of a given species' vulnerability, because CCVIs and niche models have complementary strengths that can help land managers make informed conservation decisions. Niche models offer more refined and spatially explicit predictions (i.e. changes in suitable habitat) about the direct exposure of a species to climate change but are only available for a limited set of species, in part because the models require extensive data on a species before they can be applied. CCVI estimates use an expert judgment-based approach that allows integration of different types of information about species and what might make them vulnerable to climate change (e.g. their natural history). It is important to compare CCVI estimates with available ecological niche model predictions for SGCN to fully understand a given species' vulnerability to climate change while keeping in mind the geographic (e.g. region or habitat evaluated) and biological contexts (e.g. estimated dispersal distance) of these assessments.

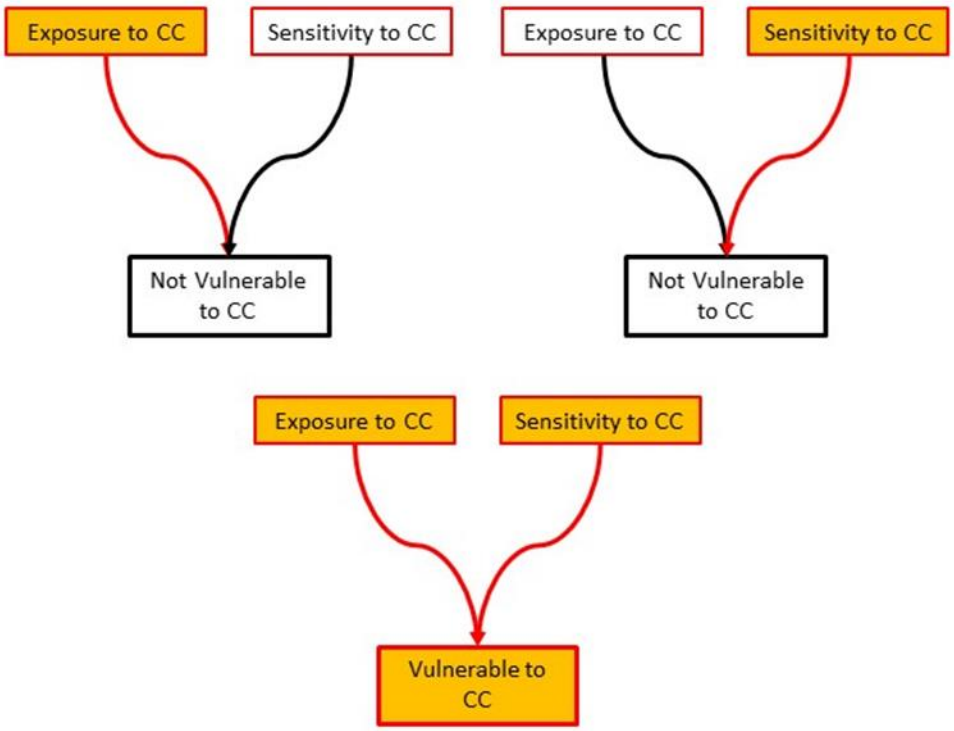


FIGURE 10-11: Climate change vulnerability is measured by both the exposure to and sensitivity to climate change. The figure is based on work by Williams et al. 2008.

Summary of Available Climate Change Vulnerability Indices

The USGS Southeast Climate Adaptation Science Center (SE CASC) and the University of Tennessee - Knoxville launched a research effort to support the SEAFWA states in integrating climate change considerations into their 2025 SWAP updates. This effort collated CCVI scores from 10 data sources within the eastern United States. It draws from CCVI assessments published in four SWAPs in the Southeast (West Virginia, Byers & Norris 2011; Tennessee, Glick et al. 2015; Florida, DuBois et al. 2011; and Louisiana, Holcomb et al. 2015) as well as the

Illinois SWAP (Walk et al. 2011), Natural Heritage Programs in the Northeast (Schlesinger et al. 2011, Furedi et al. 2011), the Appalachian and North Atlantic Landscape Conservation Cooperatives (Sneddon & Galbraith 2015, Sneddon & Hammerson 2014), and the National Park Service Cumberland Piedmont Network (Bruno et al. 2012), all of which were informed by state conservation practitioners. This work compiles 1,600 CCVI estimates for 795 species (Note: some species have multiple CCVI estimates coming from different states). Many of these are on the RSGCN list for the Southeast. For South Carolina, 150 SGCN have been scored using the CCVI estimates to date by other institutions. Figure 10-12 summarizes the combined results for these CCVI assessments.

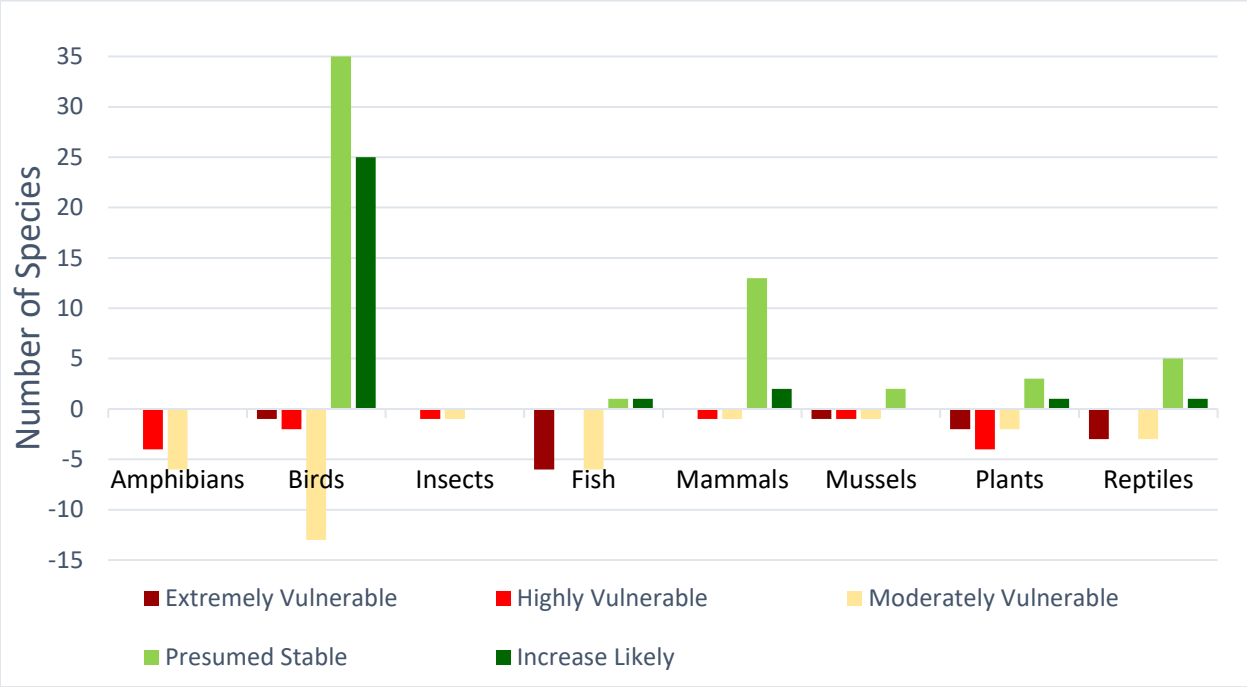


FIGURE 10-12: South Carolina SGCN estimated to be vulnerable, stable, or may increase in population based on available CCVI estimates from SEAFWA states (i.e. in their 2015 SWAPs) and other sources compiled by Armsworth et al. (*in progress*).

To date, most CCVI assessments for South Carolina's SGCN have focused on birds. Many of these CCVI assessments indicate that while some bird species may be vulnerable, a larger proportion may remain stable or increase under changing climatic conditions. Though more assessments are needed for other taxa, especially those that are not as well studied, these CCVI estimates suggest that amphibian and fish SGCN within South Carolina may be the most vulnerable to climate change.

Summary of Available Ecological Niche Models

In addition to the collation and summary of CCVI estimates, the SE CASC and the University of Tennessee have summarized complementary information on available ecological niche models.

For South Carolina, 148 SGCN have been evaluated to date, which consists of 430 vulnerability scores (note: some species have multiple scores for different future climate scenarios) across 12 academic research studies (Mckenny et al. 2007; Iverson et al. 2008; Matthews et al. 2011; Sutton et al. 2014; Bucklin et al. 2015; Struecker & Milanovich 2017; Pandey & Papeş 2018; Bateman et al. 2020; Lawler et al. 2020; Zellmer et al. 2020; Zhu et al. 2021; Lyon & Papeş 2022). Figure 10-13 summarizes the combined results for these ecological niche models.

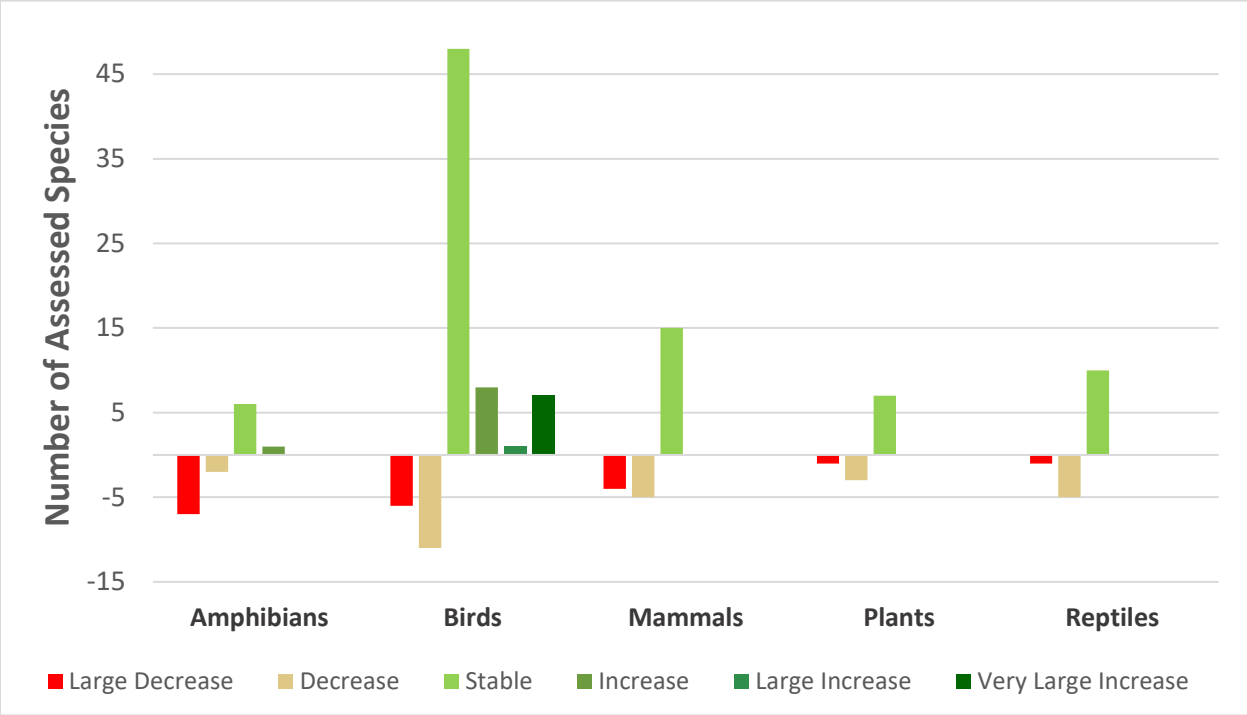


FIGURE 10-13: South Carolina Species of Greatest Conservation Need (SGCN) whose ranges may decrease, remain stable, or increase based on climate change vulnerability scores from available ecological niche models across 12 studies compiled by Armsworth et al. (*in progress*).

Like the CCVI assessments, most niche models to date focus on birds. Based on the assessments, many bird species may experience increases in their climatically suitable landscape within the Southeast Region. However, for the amphibians, plants and reptiles evaluated with niche models to date, there appears to be roughly equal proportions of climatically suitable areas for SGCN decreasing as increasing.

Comparing CCVI and Available Ecological Niche Models Results

Comparing the results of the ecological niche models to the CCVI estimates for SGCNs within South Carolina reveals similar trends for taxa that were evaluated using both methods. All taxa within the Southeast (including plants) will experience some vulnerability (i.e. moderately, highly, extremely vulnerable) and some decreases (i.e. decrease or large decrease). But looking beyond birds, results suggest that amphibians and reptiles are projected to have large proportions of their populations vulnerable to climate change. Amphibians have the fewest species with predicted stable populations across both methods, and no species within this assessment are

presumed stable or increasing in the CCVI estimates. Birds have the most species identified as vulnerable to climate change, but also the most species with predicted stable or increasing populations across both approaches, partially due to how many more bird SGCN have been evaluated compared to other taxa.

Currently, few species overlap between both the CCVI and ecological niche model datasets, which limits the scope of comparisons. In particular, niche model estimates are not yet available for many aquatic species such as fishes and mussels, which the scientific literature suggests may be some of the most vulnerable to climate change in South Carolina and the Southeast Region (Halpern and Kappel 2012; Poff et al. 2012; Ingram et al. 2013). However, the available CCVI for these aquatic taxa suggests that fish have the greatest number of South Carolina SGCN predicted to be extremely vulnerable to climate change.

Yet, by comparing these two methods, there is support for focusing climate adaptation strategies on the conservation of amphibians and aquatic species. SARP already considers identification and remediation of anthropogenic barriers to aquatic organism passage a priority conservation action, and this can also be an important climate adaptation strategy to support the resilience of fish and other species that rely on aquatic connectivity.

Comparing CCVIs and Ecological Niche Models: Appalachia as a Refuge for Salamanders and Other Threatened Amphibians

The Southeastern US is recognized as a global biodiversity hotspot for amphibians with nearly 200 unique species, more than 50 of which are endemic to the region (Duellman 1999). The potential impacts of climate change on amphibians in the Southeast is of great concern given the strong relationship between climate and the distribution and patterns of amphibian diversity (Milanovich et al. 2010, Barrett et al. 2014). Table 10-16 summarizes the available CCVI and ecological niche model data for a selection of amphibian SGCN in South Carolina.

There is some alignment between CCVI estimates and vulnerability scores from ecological niche models. For example, CCVI assessments indicate that both the Green and Seepage Salamanders are considered “moderately vulnerable” to climate change. Similarly, the ecological niche models suggest both species are projected to experience “large decreases” in climatically suitable areas across their ranges within the Southeast.

When there is disagreement across the tools, it is important to consider how the analyses were conducted. CCVI estimates do not include spatially explicit data, and in many cases, the ecological niche model results suggest a species may be more vulnerable to climate change than estimated by the CCVIs due to changes in suitable habitat. However, there are other species like the Tiger and Four-toed Salamander, where the assessments differ due to disparities in the scale of analysis between the various methods (i.e. CCVI estimates conducted for individual states and niche models conducted at the region or ecoregion level). For the disagreement between the vulnerability estimates for the Tiger and Four-toed Salamander, it is recommended to examine the spatial extent and biological assumptions (e.g. assumed dispersal capacity of the species) of the niche models and the parameters used for the CCVI assessments, as they could be driving the discrepancies in vulnerability estimates. In some cases, where large discrepancies exist between the two methods, further vulnerability assessments may be needed.

TABLE 10-16: Assessment of climate vulnerability for amphibian SGCN based on available CCVI estimates and ecological niche model vulnerability scores from recent studies geographically close to or within SC. CCVI estimates taken from Bruno et al. (2012), Sneddon & Galbraith (2015), and NatureServe (2023). Niche model vulnerability scores calculated by Armsworth et al. (*in progress*), Sutton et al. (2014), Zellmer et al. (2020), and Zhu et al. 2021.

	Species	SC SCGN	Southeast RGSCN	CCVI	Niche models
Salamanders					
Frosted Flatwoods Salamander	*Ambystoma cingulatum*	X	X	Not assessed	Large Decrease
Tiger Salamander	*Ambystoma tigrinum*	X		Extremely vulnerable	Stable
Green Salamander	*Aneides aeneus*	X	X	Moderately Vulnerable	Large Decrease
Hellbender	*Cryptobranchus alleganiensis*			Highly - Moderately Vulnerable	Large Decrease
Seepage Salamander	*Desmognathus aeneus*	X	X	Moderately Vulnerable	Large Decrease
Southern Dusky Salamander	*Desmognathus auriculatus*			Not assessed	Stable
Four-toed Salamander	*Hemidactylium scutatum*	X		Moderately Vulnerable	Stable
Webster's Salamander	*Plethodon websteri*	X	X	Not assessed	Large Decrease
Other Amphibians					
Pine Barrens Tree Frog	*Hyla andersonii*	X	X	Not assessed	Large Decrease
Gopher Frog	*Lithobates capito*	X	X	Highly Vulnerable	Large Decrease
Wood Frog	*Lithobates sylvaticus*	X		Moderately Vulnerable	Decrease

However, across the assessment methods, almost all South Carolina salamander SGCN, as well as many other amphibian SGCN, are estimated to be at least moderately vulnerable to climate change and projected to experience decreases in suitable land area (i.e. habitat). Given that the Blue Ridge and Piedmont Ecoregions of South Carolina, which are crucial habitat for many amphibian SGCN, are expected to experience the greatest increase in maximum temperatures and greatest increase in precipitation (see A Changing Climate section), conservation action and management for amphibians in these parts of the State is of greatest priority.

Adaptation Strategies

Identifying adaptation strategies to address impacts and vulnerability is a step towards climate resiliency. Climate adaptation and mitigation comes in various forms, and multiple frameworks have been built to support planning for and implementing climate adaptation. Most climate adaptation frameworks generally include:

1. Recognizing limitations to adaptation, such as the degree of natural resource management, availability of funding, or staffing capacity; and
2. Deciding which type(s) of adaptation approach(es) meet specific conservation goals.

Two well-known examples of frameworks include the Resist-Accept-Direct (RAD) Framework developed by the US National Park Service (see also Chapter 9 where it is discussed) and the Climate Adaptation in Practice: Resistance, Resilience and Transition (RRT) Framework developed by Colorado State University. There are also multiple sources for adaptation and mitigation strategies. The Adaptation Workbook, a compilation of resources developed by the Northern Institute of Applied Climate Science and its partners, provides an excellent overview of strategies.

The Adaptation Workbook is broken down into sections, one of which is Adaptation Strategies and Approaches. In this section, climate adaptation strategies are listed in what are known as "menus"—categorized by focus areas—with the goal of providing conservationists with specific, actionable adaptation options from which to select. The menus are not all-encompassing, nor are they intended to serve as guidance for management decisions. They simply serve as a starting point for those interested in climate adaptation so that they do not have to start from scratch.

Climate adaptation menus that apply to the Southeast United States include:

Agriculture
Fire-Adapted Ecosystems
Forests
Forest Carbon Management
Forested Watersheds
Grasslands
Non-Forested Wetlands
Recreation
Saltwater Coastal Ecosystems*
Tribal Perspectives
Urban Forests
Wildlife Management

**in development*

Working in Resilient Landscapes

Regardless of the projected impacts of climate hazards, some portions of the State are predicted to be more resilient than others. Focusing conservation actions within resilient places is a climate-smart investment.

Terrestrial Resilience

Much of South Carolina's natural landscape is considered a resilient terrestrial site. The Nature Conservancy (TNC) developed a data set called Resilient Land Data and identifies areas with different landscape characteristics that influence an area's capacity to maintain species diversity

and ecosystem function in the face of climate change. It measures two factors that influence resilience. The first, landscape diversity, reflects the number of microhabitats and climatic gradients created by topography, elevation, and hydrology. The second, local connectedness, reflects the degree of habitat fragmentation and strength of barriers to species movement. Highly resilient sites contain many different habitat niches that support biodiversity and allow species to move freely through the landscape to find suitable microclimates as the climate changes. Resilience emphasizes diverse landscapes where species are likely to be able to move and adjust to changing conditions. While the species themselves may change, these areas are likely to be able to host a continued diversity of species into the future.

Coastal Resilience

South Carolina's coastal and estuarine environments are key areas to build and sustain resiliency in the face of climate change. In particular, tidal marshes and habitats provide vital ecosystem services like shoreline stabilization, water filtration, food production, and recreational opportunities. Identifying places where tidal marshes and habitat provide resiliency to climate hazards currently and in the future is a key strategy in mitigating climate change impacts.

SCDNR biologist, Grace Lewis, measures changes in wetland elevation using the Surface Elevation Tool. Photo by SCDNR.

The US Geological Survey (USGS) used remote sensing to calculate the unvegetated-vegetated ratio of tidal wetlands, which compares how much of a wetland is not covered by plants (e.g. sediment, rocks, open water) to how much is covered by plants. Marshes that maintain a higher proportion of vegetation tend to be more stable and resilient to threats like sea-level rise, erosion, and coastal development. This data offers a lens to identify marshes that may be good candidates for restoration to help them persist in the face of changing conditions (USGS 2017). Recent research shows that a high unvegetated-vegetated ratio correlates with elevation measurements that detect vertical changes due to accretion, subsidence, or compaction—meaning that stable marshes with high vegetative cover tend to better keep pace with sea-level rise.

In addition to resilient terrestrial sites, TNC also developed Resilient Coastal Sites, which provides a way to map and visualize coastal habitats with the capacity to migrate to adjacent

lowlands in order to sustain biodiversity and natural services under increasing inundation from sea-level rise. Scientists from TNC evaluated more than 1,200 coastal sites in the South Atlantic region that contained tidal marsh and tidal habitats to identify places more likely to continue to support biological diversity and ecological functions under rising sea levels (Anderson and Barnett 2019). It is based on the physical and condition characteristics of current tidal complexes, their predicted migration space, and surrounding buffer areas. These characteristics include marsh complex size, shared edge with migration space, sediment balance, water quality, natural landcover, landform diversity, and many others.

Case Study: Adapting to Changing Weather Patterns and Effects on Prescribed Burning

Wildland fire has shaped much of the biodiversity across the Southeast. Not only do many SGCN rely on habitats maintained by fire, but so do several game species like Eastern Wild Turkey and Northern Bobwhite quail. Prescribed fire, also called prescribed burning or controlled burning, is a critical tool for managing habitat for wildlife, reducing wildfire risk, and meeting ecological objectives like suppressing invasive species and maintaining disturbance-dependent habitat like grasslands (i.e. Piedmont prairies) and longleaf pine savannas. Historically, wildland fire occurred at large landscape-level scales with much of the Coastal Plain, Sandhills and Piedmont Ecoregions likely adapted to fire return intervals of 4-6 years with longer fire return intervals closer to the Blue Ridge Ecosystem (Figure 10-14) (Guyette et al. 2012).

A prescribed fire in a grassland returns nutrients to the soil.
Photo by Anna Smith, SCDNR.

In the Southeast Region, it is likely that a changing climate will impact fire regimes (defined by factors including frequency, intensity, size, pattern, season, and severity of fire), which may have a large impact on natural habitats and systems. In order to conduct prescribed burns safely, land managers must burn during times where specific meteorological criteria (suitable weather conditions within which burning may occur based on maximum daily temperature, daily average relative humidity, and daily average wind speed) are met, as well as within the social criteria of municipalities (Kupfer et al. 2022). Based on available research for historical and future prescribed burn windows, changes in climate are projected to shift the available time windows

where these conditions are available (Kupfer et al. 2022). Moreover, rapid urban expansion near managed forests may reduce opportunities to use prescribed fire, which could lead to declines in native species, increases in nonnative species, increases in wildfire occurrence, and negative impacts to economic and human health.

Wildfires reach the crown of trees, destroying even hardy species like pines. Photo of the Gaston Fire of 1966 by SCW.

Given that the Southeast is a historically fire-adapted landscape (see Chapter 2), this has significant implications for overall ecosystem health in the region. Many animal and plant SGCN and RSGCN are fire-dependent, like Red-cockaded Woodpeckers, Indigo Snakes, pitcher plant species, and Smooth Purple Coneflower. According to the 2023 Southeast Blueprint fire frequency indicator, an estimated 687,527 acres were burned from 2013-2021 in South Carolina with only slightly more than 40,000 acres burned three times or more (Southeast Conservation Adaptation Strategy 2023). While across the Southeast, prescribed fire is increasing in some ecosystems like longleaf pine, this trend needs to continue to increase in order to meet the regional SECAS goal as well as to support SGCN and other statewide objectives.

A prescribed burn under loblolly pines helps control competing vegetation and reduce the risk of wildfire. Photo by Anna Smith, SCDNR.

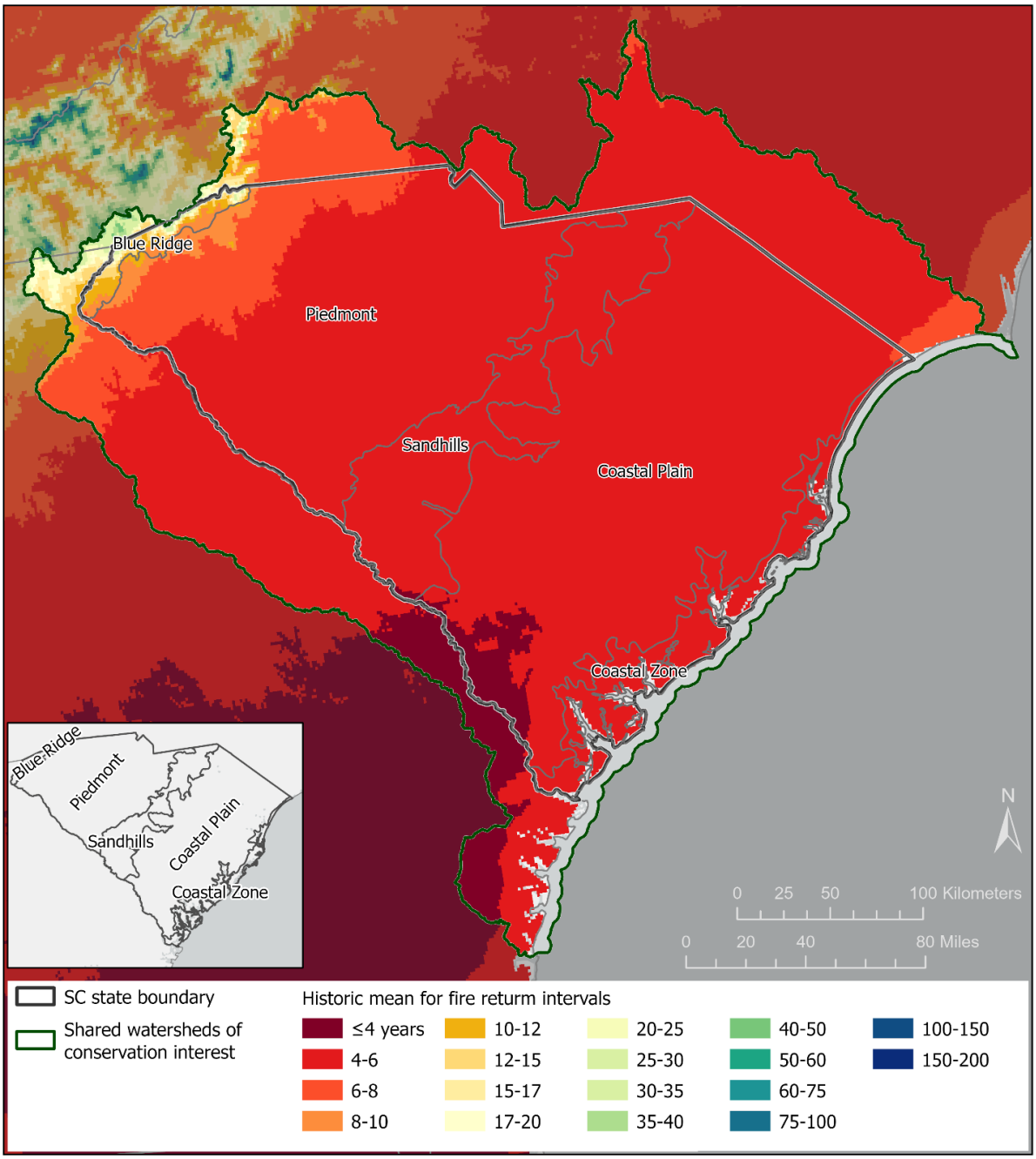


FIGURE 10-14: This map depicts likely historic fire return intervals as predicted by the Physical Chemistry Fire Frequency Model (PC2FM) developed by Guyette et al. (2012). This equation relies on theories and data in physical chemistry, ecosystem ecology, and climatology to predict likely historic fire return intervals.

Researchers working with the SE CASC conducted a study aimed at evaluating the potential impacts of projected climatic change on prescribed burning opportunities in the Southeast (Kufer 2020). Understanding how burn windows, or when there are suitable weather conditions to conduct a prescribed burn, will shift is important for land managers not only for managing habitats but also for securing the resources required to conduct the burns; these include fire

specialists, burn crews, equipment, and securing permits. The study, which included much of the Southeast, considered how many days per season met the conditions to conduct prescribed burns under two RCP scenarios: RCP 4.5 representing an intermediate scenario and RCP 8.5 representing a very high scenario.

The study also provided a baseline for comparison by projecting conditions from 2010 to 2017. The seasonal trends from this time window show that South Carolina has experienced year-round opportunities to conduct prescribed burns, especially during the spring (March to May). While conditions were less favorable during the summer months (June to August), especially in the Piedmont Ecoregion (Figure 10-15), there were still opportunities to conduct burns in this growing season. Conducting prescribed burns in the summer growing season can help control invasive plants and improve habitat quality.

The study found that under both scenarios, the percentage of suitable days for conducting prescribed burning significantly decreased by 2100, especially during summer months (Kupfer et al. 2022). Although historically, almost 65% of summertime days met the burn window criteria, under the intermediate scenario 40.6% of days in the summer were suitable and under the very high scenario only 21.9% of the days in summer were suitable for conducting prescribed burns (Jewell 2020, Kupfer et al. 2022). These results also vary across the region with much less opportunities to conduct summer burns in some states, like Louisiana, compared with South Carolina. These changes are even more significant for land management given that summers may start earlier, be hotter, last longer, and have more periods of drought.

Examining future conditions from 2040-2049 under the intermediate-emissions RCP4.5 and higher-emissions RCP 8.5 scenarios suggests that there will be less suitable conditions to conduct prescribed burning during the summer growing season in South Carolina, especially in the Piedmont Ecoregion. Overall South Carolina will likely continue to experience favorable conditions to conduct prescribed burns during the fall, spring, and winter seasons. In addition, other states with shared RSGCN stewardship responsibility with South Carolina—like Georgia and Louisiana—are projected to experience much more dramatic declines in the percentage of suitable days to conduct prescribed burns. Therefore, South Carolina might be in a better position than other Southeastern states to conduct prescribed burning to maintain important fire-dependent habitats, as well as contribute to local and regional goals for prescribed burning.

FIGURE 10-15: Average percentage of days each season with suitable prescribed burning conditions under different future time periods and emissions scenarios. Projected conditions from 2010-2017 under RCP4.5 was used as a baseline because it most closely aligned with the climate scenario that South Carolina is currently experiencing. This is compared to the forecasted percentage of suitable prescribed burning conditions for 2040-2049 under the RCP4.5 and RCP8.5 emissions scenario.

With shifting seasonal windows and conditions that will be conducive to conduct prescribed burns, it will also be important to consider how to best distribute resources across the State to adapt to these changing conditions along with airsheds and air quality. With a constricted window to be able to conduct prescribed burns, it is likely that more practitioners will burn in concentrated timeframes where conditions are suitable (S. Cammack, GADNR, pers. comm). This may lead to concerns with overwhelming airsheds as they can only hold so much smoke, and if transport winds or dispersion are low, smoke will remain in the airshed over longer times (S. Cammack, GADNR, pers. comm). This may impact the size or duration of burns through the burn permit system, especially with recent changes in the National Ambient Air Quality Standards (S. Cammack, GADNR, pers. comm). It may be important to balance what are currently considered as marginal or poor days for burning with future opportunities while also considering information on fine particle matter (PM2.5).

A prescribed burn reduces fuel loads on the forest floor. Photo by Anna Smith, SCDNR.

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CHAPTER 11: INTERNATIONAL CONSERVATION

Many species of marine fish and mammals, birds, bats, and insects are migratory and travel outside of state geopolitical boundaries or even the region at different times of the year. This can make conservation hard for a state that has identified them as Species of Greatest Conservation Need (SGCN) in their State Wildlife Action Plan (SWAP). Some of South Carolina's SGCN do not have full life cycles within the State, the Southeast Region, or even the United States. They may travel to higher latitudes in North America for breeding, to Central and South American wintering grounds, or travel south to South Carolina for the winter.

Silver-haired Bat. Photo by SCDNR staff.

Of all the bat species in the United States, 24% have transnational ranges (Adams et al. 2024). The only "true" migratory bat species South Carolina has is the Silver-haired Bat, migrating into the State in the winter but rarely remaining into the summer. Red and Hoary Bats are present year-round, but the State's winter populations are presumed to increase due to an influx of migrants coming in from other areas. All three of these bat species are in the South Carolina SWAP. Tracking research is needed to determine if any of South Carolina's bats cross international borders into Canda or Mexico during some part of their migration cycle.

Dragonflies and butterflies can be migratory as well. Common Green Darners (*Anax junius*) are multi-generational migrants that move south from Canada in the fall (Hallworth et al. 2018), and Wandering Gliders (*Pantala flavescens*) have a global population and thus are undoubtedly long-distance migrants (Wade Worthen, Furman University, pers. comm.). Neither of these species are SGCN in the South Carolina SWAP but do reside in the State during some phase of their life cycle. The Monarch Butterfly (*Danaus Plexippus*; SGCN), is the most well-known of the migratory insects. They are famous for their multi-generational migrations to and from the oyamel fir forests in Mexico to the United States and southern Canada. However, in a five-year mark-recapture study conducted by researchers at the South Carolina Department of Natural Resources (SCDNR), Monarch Butterflies were found to live year-round in South Carolina, obviously overwintering in the State instead of migrating to Mexico (Kendrick and McCord 2023). These insects were cuing in on aquatic milkweed in coastal plain maritime environments as well as inland swamp habitats, both of which are priority habitats for

A tagged Monarch Butterfly, part of a multi-year capture-recapture project through SCDNR. Photo by Erin Weeks, SCDNR.

conservation in South Carolina by SCDNR and a multitude of conservation partners (Kendrick and McCord 2023).

Perhaps the best-known international species are Neotropical migratory birds and those that nest near the Arctic Circle. These species traverse both North and South American continents, using South Carolina as a migratory stopover for resting and feeding, refueling for the long journey. Sometimes they only stay for the winter months or only the summer breeding season. The State's role in these species' continued existence may only be seasonal or migratory, but developing cooperative conservation partnerships and research and survey projects across multiple countries would benefit these species more than just a single-season approach (Rich et al. 2013). This is especially important if knowledge of population limiting factors is unknown (Rich et al. 2013). Sources of information on distribution of migratory species, habitat use, and abundance as well as partnership potentials include: NatureServe, Eco Index, Western Hemisphere Migratory Species Initiative, Partners in Flight, the American Bird Conservancy, BirdLife International, Cornell Lab eBird, Audubon Bird Migration Explorer, Southern Wings, Bat Conservation International, The Xerces Society for Invertebrate Conservation, Rainforest Alliance, The Nature Conservancy, the Butterfly Conservation Initiative, Joint Ventures (e.g. Atlantic Coast Joint Venture), various conservation plans (see Appendix 1), and the primary literature. Federal agencies in the United States with international programs include the United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), and the National Park Service (NPS). Network partnerships are already well-developed for some bird species, but this network could be expanded to other taxa (Rich et al. 2013).

FIGURE 11-1: This image, a collaborative effort between SCDNR biologists, the United States Fish and Wildlife Service, and Ron Porter, shows the one-year migration path of a Red Knot.

Tracking studies using Motus Wildlife Tracking Systems, geolocators, and satellite technology are helping researchers learn where South Carolina's migratory species go, critical data to have for conservation planning with other states, regions, and countries. An example is an ongoing program tracking Red Knots with geolocators, adding fine scale location data for understanding this threatened species. For example, Figure 11-1 shows the full life cycle travels of a Red Knot tagged in South Carolina. This bird was captured in South Carolina in 2016 on Deveaux Bank and a geolocator was affixed to its leg band. During the life of the tag, the bird traveled twice to its nesting grounds above the Arctic Circle and to its wintering grounds in Tierra Del Fuego and Bahia Lomas at the southern

tip of South America. The bird was captured again in January 2018, and the geolocator was retrieved. Archived locations from other satellite tagged Red Knots are at Movebank.

The South Carolina Department of Natural Resources (SCDNR) participates in international species working groups and cooperative programs that are advancing studies of bird life cycles and promoting data sharing. Examples include: Shorebird Science and Conservation Collective, Smithsonian Atlas of Migratory Connectivity, Movebank, and Motus Wildlife Tracking System, BandedBirds.org. Clemson University is engaged in nesting and tagging research on Black-capped Storm Petrels in the Dominican Republic. University researchers collaborate closely with the other non-governmental organizations (NGOs) working on the species including the American Bird Conservancy, Environmental Protection in the Caribbean, and Grupo Jaragua.

Willet captured as part of a geolocator study by SCDNR. Photo provided by SCDNR-MRD.

Funding opportunities for cross-national collaborations include the Neotropical Migratory Bird Conservation Act's (NMBACA) grant program. In April 2024, the "Migratory Birds of the Americas Conservation Enhancements Act of 2023," (H.R. 4389), reauthorized and amended the NMBCA. According to the USFWS (2024), who has administered the program since 2002, the NMBCA has provided more than $94.2 million in grants to support 747 projects in 43 countries. Additionally, the Association of Fish and Wildlife Agencies (AFWA) created Southern Wings in 2009 to facilitate state fish and wildlife agency participation in the conservation of priority migratory birds across their full life cycle. Since its inception, 41 states have contributed over $4.2 million to conservation efforts on stop-over and wintering grounds in Mexico, Central America, South America, and the Caribbean. Southern Wings has launched an online guide for full annual cycle conservation planning resources. Southern Wings Guide for South Carolina provides information on migratory bird species with international ranges that include South Carolina.

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APPENDIX 1: EXISTING CONSERVATION PLANS AND RESOURCES

- A Blueprint for the Future of Migratory Landbirds (Migratory Bird Program Strategic Plan 2004-2014) – USFWS
- A Field Guide to Southeast Bird Monitoring Protocols and Programs (2012) – Partners In Flight Southeast Working Group
- American Woodcock Conservation Plan (2008) – Wildlife Management Institute
- American Shad Sustainable Fishing Plan Update for South Carolina (2020) – SCDNR
- Aquatic Connectivity Program - SARP
- Atlantic Coast Joint Venture (ACJV) Plans, Reports, and Publications
- Atlantic Coast Joint Venture Waterfowl Implementation Plan (2005)
- Atlantic & Mississippi Flyways Double-crested Cormorant Management Plan (2010)
- Atlantic States Marine Fisheries Commission Fishery Management Plans (links to various plans and data)
- Atlantic States Marine Fisheries Commission Habitat Program (links to various reports and data)
- Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs (2009) – ASMFC
- Avian Knowledge Network's list of bird conservation plans
- Basic Smoke Management Practices (BSMPs) and Tools (Southern Fire Exchange)
- Bat Conservation International Strategic Plan 2020-2025
- Best Management Practices for Wildlife in Maritime Forest Developments – J. D. Whitaker et al. / SCDNR-MRD
- Best Management Practices for Work in or Around Aquatic Environments (2022) – USFWS
- Blueback Herring Sustainable Fishing Plan Update for South Carolina (2020) – SCDNR
- City of Folly Beach Marshfront Management Plan
- Classification of the Natural Communities of North Carolina - 4th Approximation (2024)
- Climate Change Impacts to Natural Resources in South Carolina (2013) – SCDNR
- Conservation Strategy for the Robust Redhorse (2003)
- Eastern Brook Trout Joint Venture Agency Management Plans and Maps
- Eastern Ruffed Grouse Conservation Plan (2025-2034)
- Forest Management and Bats (2020) – White-nose Syndrome Response Team
- Francis Marion National Forest Revised Land and Resource Management Plan (2017) – USFS *[available as PDF]*
- Gopher Tortoise Conservation Plan for South Carolina (2009; *update in progress*)
- Habitat Management Guidelines for Amphibians and Reptiles of the Southeastern United States (2013) – PARC
- Halting the Invasion: State Tools for Invasive Species Management (2002) – Environmental Law Institute
- Integrating Land Use Planning and Biodiversity (2003) – Defenders of Wildlife
- Local Comprehensive Beach Management Plans – DHEC
- National Aquatic Barrier Inventory & Prioritization Tool (by SARP)
- National Bobwhite and Grassland Initiative publications
- National Fish, Wildlife, and Plants Climate Adaptation Strategy | U.S. Climate Resilience Toolkit (2012; 2021 update)

- National Oceanic and Atmospheric Administration (NOAA) Fisheries Management Plans
- National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (2022)
- NOAA Fisheries Atlantic Highly Migratory Species Best Scientific Information Available Regional Framework
- NOAA Fisheries Biological Opinions
- NOAA Fisheries Climate Vulnerability Assessment for Fish and Invertebrates in the United States South Atlantic Large Marine Ecosystem
- NOAA Fisheries Ecosystem-Based Fisheries Management Road Map
- NOAA Fisheries Endangered Species Acts 5-Year Reviews
- NOAA Fisheries Endangered Species Act Status Reviews
- NOAA Fisheries Gulf of Mexico Climate Vulnerability Analysis for Fishes and Invertebrates
- NOAA Fisheries Species Recovery Plans
- NOAA Fisheries Strategic Plans
- The Natural Communities of South Carolina (1986) – J. B. Nelson / SCDNR
- North American Bird Conservation Initiative (NABCI) State of the Birds Reports by year
    - 2025 Report
- North American Waterfowl Management Plan (2018 update) – Ducks Unlimited et al. (*Note: A 2024 update is in progress.*)
- Partners in Amphibian and Reptile Conservation (PARC) Strategic Plan and Conservation Action Plans (various species)
- Performance Measures for Ecosystem Management and Ecological Sustainability – TWS Technical Review 02-1 (2002) – The Wildlife Society (TWS)
- PIF Bird Conservation Plan for the South Atlantic Coastal Plain (Physiographic Area 03) (2003) – American Bird Conservancy
- PIF Bird Conservation Plan for the Southern Blue Ridge (Physiographic Area 23) (1999) – American Bird Conservancy
- PIF Bird Conservation Plan for the Southern Piedmont (Physiographic Area 11) (2014) – Southern Appalachian Bird Conservancy
- PIF Landbird Conservation Plan (2019)
- Pollinator Action Plan (2025) – USFWS Center for Pollinator Conservation
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- Range-wide Conservation Plan for Longleaf Pine (2025-2040) – America's Longleaf Restoration Initiative
- River Herring Alternative Management Plan for South Carolina (2020) – SCDNR
- Ruffed Grouse Conservation Plan. Association of Fish and Wildlife Agencies Resident Gamebird Working Group (2006)
- Santee Basin Diadromous Fish Restoration Plan (2017; amended 2019) – NOAA, NCWRC, SCDNR, and USFWS
- Shortleaf Pine Initiative's Shortleaf Pine Restoration Plan (2016)
- Smoke Management Guide for Prescribed Fire (2020)
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- South Atlantic Migratory Bird Initiative Implementation Plan (v 3.3, 2008) – USFWS, ACJV
- South Atlantic Salt Marsh Initiative (SASMI) Plan (2023)
- South Carolina Aquatic Invasive Species Management Plan (2008)
- South Carolina Aquatic Plant Management Plan (2024) – SCDNR
- South Carolina Breeding Bird Atlas 1988-1995 – J. Cely / SCDNR
- South Carolina Coastal and Estuarine Land Conservation Plan (2012)
- South Carolina Comprehensive Climate Action Plan (CCAP) (2024) – Palmetto Air Quality Collaborative (PAQC)
- South Carolina Department of Natural Resources State Listed Species Protection Guidance (2024)
- South Carolina Forest Action Plan – SCFC
- South Carolina's Green Infrastructure Plan (with regional sub-plans listed) – SCFC & GIC
- South Carolina State Comprehensive Outdoor Recreation Plan (SCORP) – SC Parks, Recreation and Tourism
- South Carolina Strategic Statewide Resilience and Risk Reduction Plan (2023), 2024 Annual Update, and Resilience Atlas – SCOR
- Southeast Aquatic Habitat Plan (2008) - SARP
- Southeast Conservation Blueprint (2023) – Southeast Conservation Adaption Strategy
- Southeast Region Coastal Species of Concern Predation Management Plan and Programmatic Environmental Assessment -DRAFT – National Park Service
- Southeastern Plants Regional Species of Greatest Conservation Need (2023) – SEPCA et al.
- Southeastern United States Regional Waterbird Conservation Plan. Section of Waterbird Conservation for the Americas (2006) – USFWS et al.
- Southern Appalachian Climate Change Vulnerability Assessment (USFS, *in progress*)
- Status of Aquatic Mollusks in the Southeastern United States: A Downward Spiral of Diversity (from Aquatic Fauna in Peril: The Southeastern Perspective; Southeast Aquatic Research Institute Special Publication, 1; 1999)
- Sumter National Forest Revised Land and Resource Management Plan (2004) – USFS
- Sustain SC Roadmap to Sustain SC (and see Sustain SC 2024 Annual Report)
- Town of Kiawah Island Marsh Management Plan (2023)
- United States Shorebird Conservation Plan – Southeastern Coastal Plain/Caribbean (2002 update) – C. Hunter / USFWS
- United States Fish and Wildlife Service Species Recovery Plans
- Waterbird Conservation for the Americas (North American Waterbird Conservation Plan, Version 1) – NAWCP
- Watershed Approach Handbook: Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects (2014) – Environmental Law Institute and The Nature Conservancy
- Western Hemisphere Shorebird Reserve Network, Species Conservation Plans
- Workbook and Key to the Freshwater Bivalves of South Carolina by Bogan and Alderman – NC State Museum, USFWS, et al. (2004)

APPENDIX 2: NON-EXHAUSTIVE LIST OF SCDNR PARTNERSHIPS

- ACE Basin Task Force
- A.C. Moore Herbarium, University of South Carolina
- American Bird Conservancy
- American Rivers
- Amphibian and Reptile Conservancy (ARC)
- Association of Fish and Wildlife Agencies
  - Southeastern Association of Fish and Wildlife Agencies
- Atlanta Botanical Garden
- Atlantic Large Whale Take Reduction Team
- Atlantic Coast Joint Venture (ACJV)
- Atlantic States Marine Fisheries Commission
- Audubon Society
- Avian Conservation Center / Center for Birds of Prey
- Avian Research and Conservation Institute (ARCI)
- Bartlett Tree Research Laboratories
- Bat Conservation International (BCI)
- Baruch Institute for Marine & Coastal Sciences
- Black River Cypress Preserve
- Bog Learning Network
- Bottlenose Dolphin Take Reduction Team
- Brays Island Nature Center
- Center for Coastal Environmental Health and Biomolecular Research
- Center for Heirs Property Preservation
- Central Carolina Community Foundation (CCCF)
- City of Columbia Parks
- Clemson University Cooperative Extension
- Clemson University Herbarium
- Coalition of Prescribed Fire Councils
- Coastal Carolina University Herbarium
- Collaborative to Combat the Illegal Trade in Turtles (CCITT)
- Cornell Lab of Ornithology
- **Department of Defense (DOD) / Military Installations**
  - Fort Jackson US Army Training Center
  - Joint Base Charleston (Air Force and Navy) / & North Auxiliary Airfield, Orangeburg
  - McEntire Joint National Guard Base
  - Marine Corps Air Station Beaufort
  - Marine Corps Recruit Depot Paris Island
  - Poinsett Bombing Range
  - Shaw Air Force Base
- Ducks Unlimited (DU)
- Environmental Action Volunteers of Bluffton, SC

- Environmental Protection Agency (EPA)
- Esri
- Fire Learning Network
- Florida Fish and Wildlife Commission
- Foothills Trail Conservancy
- Friends of the Edisto
- Friends of the Revolutionary Rivers
- Furman University Herbarium
- Georgia Aquarium
- Georgia Department of Natural Resources
- Gibbons, Parker (Private Researcher)
- Greenville Zoo
- Gulf and South Atlantic Regional Panel on Aquatic Invasive Species
- Gullah-Geechee Nation
- Harry Hampton Memorial Wildlife Fund, Inc.
- Hitchcock Woods Foundation
- Hollings Marine Laboratory
- Indian Creek Wildlife Habitat Restoration Initiative Partnership
- Irmo-Chapin Recreation Commission
- **Land Trusts and the Land Trust Network**
    - Aiken Land Conservancy
    - Beaufort County Open Land Trust
    - Central Savannah River Land Trust
    - Congaree Land Trust
    - Edisto Island Open Land Trust
    - Katawba Valley Land Trust
    - Kiawah Island Natural Habitat Conservancy
    - Lord Berkeley Conservation Trust
    - Lowcountry Land Trust
    - Nation Ford Land Trust
    - Naturaland Trust
    - Pee Dee Land Trust
    - Spartanburg Area Conservancy
    - The Trust for Public Land
    - Upper Savannah Land Trust
    - Upstate Forever
    - Wetlands America Trust
- Longleaf Alliance
- Lowcountry Sentinel Landscape
- Manomet - Conservation Sciences
- Master Naturalist Program (through Clemson Extension)
- National Deer Association (formerly Quality Deer Management Association)
- National Bobwhite and Grassland Initiative
- National Estuarine Research Reserve (NERR)

- National Fish and Wildlife Foundation
- National Institute of Standards and Technology
- National Oceanic and Atmospheric Administration (NOAA)
- National Parks Service
- National Wild Turkey Federation (NWTF)
- **Native American Tribes (Indigenous Peoples of South Carolina)**
  - Catawba Indian Nation
- Natural Resource Conservation Service (NRCS)
- NatureServe
- Nemours Wildlife Foundation
- Newberry College Herbarium
- North American Bird Conservation Initiative (NABCI)
- North Carolina Division of Marine Fishes
- North Carolina Museum of Natural Sciences
- NOAA Fisheries
- NOAA Marine Debris Program
- NOAA National Ocean Service
- Open Space Institute (OSI)
- Orangeburg National Fish Hatchery
- Palis, John (Private Researcher)
- Palmetto Agrobusiness Council
- Palmetto Bluff Conservancy
- Palmetto Conservation
- Partners in Flight (PIF Joint Ventures and Bird Conservation Regions)
- PEW Charitable Trusts
- Pheasants / Quail Forever
- Pollinator Partnership
- **Power Companies**
  - Dominion Energy (with SCANA Corporation)
  - Duke Energy
  - Lockhart Energy
  - Santee Cooper
- Riverbanks Zoo and Gardens
- Riverkeepers
  - Black-Sampit
  - Catawba
  - Charleston
  - Congaree
  - Edisto
  - Lumber
  - Savannah
  - Waccamaw
- Robust Redhorse Conservation Committee
- Sea Turtle Nest Protection Network

- Sea Turtle Stranding and Salvage Network
- Shortleaf Pine Initiative
- Smithsonian Institute and National Zoo
- SOLO Task Force
- South Carolina Air National Guard
- South Carolina Aquarium
- South Carolina Botanical Garden
- South Carolina Coastal Conservation League
- South Carolina Conservation Bank
- South Carolina Department of Archives and History
- South Carolina Department of Commerce
- South Carolina Department of Education
- South Carolina Department of Environmental Services (formerly SCDHEC)
- South Carolina Department of Transportation (SCDOT)
- South Carolina Department of Parks, Recreation and Tourism (SCPRT)
- South Carolina Educational Television (SCETV)
- South Carolina Environmental Law Project
- South Carolina Farm Bureau
- South Carolina Forestry Association (SCFA)
- South Carolina Forestry Commission (SCFC)
- South Carolina Invasive Pest Council
- South Carolina Master Naturalist Program (Clemson Extension)
- South Carolina Native Plant Society
- South Carolina Office of Resilience
- South Carolina Partners in Amphibian and Reptile Conservation (SCPARC)
- South Carolina Prescribed Fire Council
- South Carolina Public Radio
- South Carolina Sea Grant Consortium
- South Carolina Tourism Council
- South Carolina Wildlife Federation (SCWF)
- South Atlantic Fishery Management Council
- South Atlantic Migratory Bird Initiative (SAMBI)
- Southeast Aquatic Resources Partnership (SARP)
- Southeast Climate Adaptation Science Center (SE CASC)
- Southeast Conservation Adaptation Strategy (SECAS)
- Southeast Regional Partnership for Planning and Sustainability (SERPPAS)
- Southeastern Fisheries Science Center
- Southeastern Plant Conservation Alliance (SEPCA)
- Southeastern Right Whale Recovery Plan Implementation Team
- Southern Environmental Law Institute
- Southern Fire Exchange
- Spring Island Nature Center
- Stevenson, Dirk (Private Researcher)
- Sustain SC

- Swallow-tailed Kite Conservation Alliance
- Tall Timbers Research Station
- Tangled Bank Conservation
- Terwilliger Consulting, Inc. (TCI)
- The Amphibian Foundation
- The Conservation Fund (TCF)
- The Gopher Tortoise Council
- The Nature Conservancy
- The Orianne Society
- The Sustainability Institute
- The Wilds
- The Wildlife Society (TWS)
    - South Carolina Chapter of TWS
- Trout Unlimited
- Turtle Survival Alliance
- Turtle Survival Center
- United States Army Corps of Engineers (USACE)
- United States Coast Guard (USCG)
- United States Forest Service (USFS)
- United States Geological Survey (USGS)
- United States Fish and Wildlife Service (USFWS)
- **Universities**
    - Appalachian State University
    - Charleston Southern University (CSU)
    - Coastal Carolina University (CCU)
    - College of William and Mary
    - Cornell University
    - Clemson University and Clemson Extension Service
    - College of Charleston (CoC)
    - College of Charleston Grice Marine Laboratory
    - Delaware State University (DSU)
    - East Carolina University (ECU)
    - Florida State University (FSU)
    - Francis Marion University
    - Georgia Southern University
    - George Washington University
    - Kennesaw State University
    - Louisiana State University (LSU)
    - Marshall University
    - Medical University of South Carolina (MUSC)
    - North Carolina State University
    - Plymouth State University
    - Sacred Heart University
    - Sewanee: The University of the South
    - Texas A&M University, Corpus Christi

  - The Citadel
  - University of California-Berkeley's Center for Stable Isotope Biogeochemistry
  - University of Georgia (UGA) and Southeastern Cooperative Wildlife Disease Study (SCWDS)
  - University of Georgia (UGA) & Savannah River Ecology Lab (SREL)
  - University of Florida
  - University of Massachusetts, Amherst
  - University of North Carolina – Chapel Hill
  - University of North Carolina, Wilmington
  - University of North Florida
  - University of South Carolina (USC) – *various campuses*
  - University of Tennessee
  - Virginia Institute of Marine Science
  - Virginia Commonwealth University (VCU)
  - West Liberty University
- University of North Carolina Herbarium – Chapel Hill
- Wildlife Management Institute (WMI)
- Winyah Rivers Alliance
- Xerces Society for Invertebrate Conservation
- Zoo Knoxville
- ***Other states' wildlife agencies***

SCIPC Invasive Exotic Plant List Updated July/2024	This list of invasive-exotic plants in South Carolina was developed by the SC-Invasive Pest Council (SC-IPC), formerly known as the SC EPPC (SC Exotic Pest Plant Council), in collaboration with natural resource professionals working in the fields of biology, forestry, botany, wildlife/ habitats, and land management in South Carolina. Definitions, distribution map, and resources follow the list.	Category	Please report observations of invasive exotic plant species to EDDMapS at https://www.eddmaps.org/ so that more complete occurrence information is documented and available.	SOUTH CAROLINA SC-IPC INVASIVE PEST COUNCIL
Growth Form	**Common Name**		**Scientific Name 2024**	**Distribution 2024**
Category I	Invasive-exotic plants that are known to cause significant threat to native plant communities by displacing native species and impacting plant communities negatively through changes to composition, structure or ecological function, or hybridizing with natives. This list also includes those species considered difficult to manage by professionals.			
Aquatic	Alligator-weed	I	*Alternanthera philoxeroides*	CZ, CP, S
Aquatic	Brazilian Waterweed	I	*Egeria densa*	CZ, CP, S, P
Aquatic	Hydrilla	I	*Hydrilla verticillata ssp. verticillata*	ALL
Aquatic	Wandering Hydrilla	I	*Hydrilla verticillata ssp. peregrina*	P, M
Aquatic	Dotted Duckmeat	I	*Landoltia punctata*	CZ, CP, S, P
Aquatic	Showy Water-primrose	I	*Ludwigia grandiflora*	CZ, CP, S, P
Aquatic	Water primrose	I	*Ludwigia hexapetala*	ALL
Aquatic	Floating Primrose-willow	I	*Ludwigia peploides var. glabrescens*	ALL
Aquatic	Parrot-feather	I	*Myriophyllum aquaticum*	ALL
Aquatic	Eurasian watermilfoil	I	*Myriophyllum spicatum*	S, P
Aquatic	Crested floating heart	I	*Nymphoides cristata*	CP, P
Aquatic	Water hyacinth	I	*Oshuna crassipes*	CZ, CP, S
Aquatic	Water Lettuce	I	*Pistia stratiotes*	CZ, CP
Aquatic	Curly-leaf pondweed	I	*Potamogeton crispus*	CP, P
Aquatic	Water Spangles, Floating Fern	I	*Salvinia minima*	CZ, CP
Aquatic	Giant salvinia	I	*Salvinia molesta*	CP
Ferns	Japanese false spleenwort/Japanese lady fern	I	*Deparia petersenii*	ALL
Ferns	Autumn fern, Japanese red shield-fern, Japanese shield-fern	I	*Dryopteris erythrosora*	ALL
Ferns	Swordfern/ Mariana Maiden Fern/Torres's Fern	I	*Macrothelypteris torresiana*	ALL
Grass, sedge	Basket Grass, Small Carpetgrass, Joint-headed Grass	I	*Arthraxon hispidus var. hispidus*	ALL
Grass, sedge	Giant reed	I	*Arundo donax*	CZ, CP, S, P
Grass, sedge	Cuban bulrush	I	*Cyperus blepharoleptos*	CZ, CP
Grass, sedge	Pond Lovegrass	I	*Eragrostis japonica*	CP, S
Grass, sedge	Cogongrass	I	*Imperata cylindrica*	ALL
Grass, sedge	Nepalese browntop, Japanese stilt grass	I	*Microstegium vimineum*	ALL
Grass, sedge	Chinese silvergrass	I	*Miscanthus sinensis*	ALL
Grass, sedge	Torpedo grass, Creeping panic, Couch panicum	I	*Panicum repens*	CZ, CP, S
Grass, sedge	Bahia grass	I	*Paspalum notatum*	ALL
Grass, sedge	Common reed, Phragmites	I	*Phragmites australis*	CZ, CP, S

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Growth Form	**Common Name**		**Scientific Name 2024**	**Distribution 2024**
Grass, sedge	Johnson grass	I	*Sorghum halepense*	ALL
Herb	Coco yam, Taro	I	*Colocasia esculenta*	CZ, CP, S, P
Herb	Fig buttercup, Lesser clenandine	I	*Ficaria verna*	P
Herb	Sericea, Chinese bush clover	I	*Lespedeza cuneata*	ALL
Herb	Wart removing herb, Marsh dewflower, Aneilema, Asian spiderwort	I	*Murdannia keisak*	ALL
Herb	Perilla, Beefsteak plant	I	*Perilla frutescens*	ALL
Shrub	Trifoliate Orange, Hardy Orange	I	*Citrus trifoliata*	ALL
Shrub	Thorny-olive	I	*Elaeagnus pungens*	ALL
Shrub	Autumn-olive	I	*Elaeagnus umbellata*	ALL
Shrub	Winged Euonymus, (Winged) Burning Bush	I	*Euonymus alatus*	P, M
Shrub	Two Color Bush Clover, Shrub Lespedeza	I	*Lespedeza bicolor*	ALL
Shrub	Glossy, Tall Glossy Privet	I	*Ligustrum lucidum*	ALL
Shrub	Chinese Privet	I	*Ligustrum sinense*	ALL
Shrub	Leatherleaf Mahonia	I	*Mahonia bealei*	ALL
Shrub	Nandina, Sacred Bamboo	I	*Nandina domestica*	ALL
Shrub	Taiwanese Photinia	I	*Photinia serratifolia*	CZ, CP, S, P
Shrub	Japanese Knotweed, Fleeceflower, Mexican Bamboo	I	*Reynoutria japonica*	ALL
Shrub	Cherokee Rose	I	*Rosa laevigata*	CZ, CP, S, P
Shrub	Multiflora Rose	I	*Rosa multiflora*	ALL
Shrub	Rattlebox, Scarlet wisteria tree, Spanish Gold, Purple or Red sesbania	I	*Sesbania punicea*	ALL
Shrub	Beach Vitex, Chasteberry, Roundleaf Chastetree	I	*Vitex rotundifolia*	CZ
Tree	Tree of heaven	I	*Ailanthus altissima*	ALL
Tree	Mimosa, Silktree	I	*Albizia julibrissin*	ALL
Tree	Paper Mulberry	I	*Broussonetia papyrifera*	CZ, CP, S, P
Tree	Chinese Parasol Tree	I	*Firmiana simplex*	ALL
Tree	Chinese Holly, Burford Holly	I	*Ilex cornuta*	ALL
Tree	Chinaberry	I	*Melia azedarach*	ALL
Tree	Princess Tree/Royal Paulownia	I	*Paulownia tomentosa*	ALL
Tree	White Poplar	I	*Populus alba*	ALL
Tree	Callery Pear (Bradford Pear)	I	*Pyrus calleryana*	ALL
Tree	Canary Island Tamarisk	I	*Tamarix canariensis*	CZ
Tree	Chinese Tamarisk	I	*Tamarix chinensis*	CZ

SCIPC Invasive Exotic Plant List Updated July/2024	This list of invasive-exotic plants in South Carolina was developed by the SC-Invasive Pest Council (SC-IPC), formerly known as the SC EPPC (SC Exotic Pest Plant Council), in collaboration with natural resource professionals working in the fields of biology, forestry, botany, wildlife/ habitats, and land management in South Carolina. Definitions, distribution map, and resources follow the list.	Category	Please report observations of invasive exotic plant species to EDDMapS at https://www.eddmaps.org/ so that more complete occurrence information is documented and available.	SOUTH CAROLINA SC-IPC INVASIVE PEST COUNCIL
Growth Form	**Common Name**		**Scientific Name 2024**	**Distribution 2024**
Tree	French Tamarisk	I	*Tamarix gallica*	CZ
Tree	Smallflower Tamarisk	I	*Tamarix parviflora*	CZ
Tree	Chinese Tallow Tree	I	*Triadica sebifera*	CZ, CP, S, P
Tree	Tung oil tree	I	*Vernicia fordii*	CZ, CP, S, P
Vine	Hybrid Asian Wisteria	I	*Wisteria ×formosa*	ALL
Vine	Asian/Oriental Bittersweet	I	*Celastrus orbiculatus*	ALL
Vine	Sweet Autumn Virgin's Bower, Yam-leaved clematis	I	*Clematis terniflora*	ALL
Vine	Chinese yam	I	*Dioscorea polystachya*	ALL
Vine	English Ivy	I	*Hedera helix var. helix*	ALL
Vine	Japanese Hop	I	*Humulus scandens*	P
Vine	Japanese Honeysuckle	I	*Lonicera japonica*	ALL
Vine	Japanese Climbing Fern	I	*Lygodium japonicum*	ALL
Vine	Kudzu	I	*Pueraria montana var. lobata*	ALL
Vine	Asian/Japanese Wisteria	I	*Wisteria floribunda*	ALL
Vine	Chinese Wisteria	I	*Wisteria sinensis*	ALL
Category II	Invasive exotics that have increased in abundance or frequency but have not yet altered South Carolina plant communities to the extent shown by Category I species. These species may become Category I if ecological damage is demonstrated.			
Aquatic	Yellow Floating Heart	II	*Nymphoides peltata*	CZ, CP, S, P
Fern	Simpler East Indian Holly Fern	II	*Arachniodes simplicior*	S, P
Fern	Downy Maiden Fern, Soft Fern	II	*Christella dentata*	CZ, CP, S, P
Fern	Asian Net-veined Holly Fern	II	*Cyrtomium falcatum*	CZ, CP, S, P
Grass, sedge	False beardgrass	II	*Chrysopogon pauciflorus*	CP
Grass, sedge	Uruguayan pampas grass, pampas Grass, Silver pampas Grass	II	*Cortaderia selloana*	CZ
Grass, sedge	Weeping love grass	II	*Eragrostis curvula*	CZ, CP, P
Grass, sedge	Blackseed or Japanese Panic Grass	II	*Panicum bisulcatum*	CZ, CP, S
Grass, sedge	Golden bamboo, Fishpole bamboo	II	*Phyllostachys aurea*	ALL
Grass, sedge	Mediterranean Beardgrass	II	*Polypogon maritimus var. maritimus*	CZ
Grass, sedge	Annual Rabbitfoot Grass	II	*Polypogon monspeliensis*	CZ
Herb	Slender wild basil	II	*Clinopodium gracile*	ALL
Herb	Tropical spiderwort, Bengal dayflower	II	*Commelina benghalensis*	CZ, CP, S
Herb	Showy rattlebox	II	*Crotalaria spectabilis*	ALL
Herb	Chameleon Plant, Rainbow Plant	II	*Houttuynia cordata*	CP, S

SCIPC Invasive Exotic Plant List Updated July/2024	This list of invasive-exotic plants in South Carolina was developed by the SC-Invasive Pest Council (SC-IPC), formerly known as the SC EPPC (SC Exotic Pest Plant Council), in collaboration with natural resource professionals working in the fields of biology, forestry, botany, wildlife/ habitats, and land management in South Carolina. Definitions, distribution map, and resources follow the list.	Category	Please report observations of invasive exotic plant species to EDDMapS at https://www.eddmaps.org/ so that more complete occurrence information is documented and available.	SOUTH CAROLINA SC-IPC INVASIVE PEST COUNCIL
Growth Form	**Common Name**		**Scientific Name 2024**	**Distribution 2024**
Herb	Liriope, Monkey grass, Big blue lilyturf	II	*Liriope muscari*	ALL
Herb	Creeping Lilyturf	II	*Liriope spicata*	CZ, CP, S, P
Herb	Creeping Charlie, Creeping Jenny, Moneywort	II	*Lysimachia nummularia*	ALL
Herb	Purple loosestrife, Rainbow weed, Spiked loosestrife	II	*Lythrum salicaria*	CP, P
Herb	Mosla, Miniature Beefsteakplant	II	*Mosla dianthera*	CP, P, M
Herb	Dwarf Lilyturf	II	*Ophiopogon japonicus*	S
Herb	Stringy Stonecrop	II	*Sedum sarmentosum*	P, M
Herb	Rattlebox, Poison-bean	II	*Sesbania drummondii*	CZ
Herb	Asiatic Hawksbeard	II	*Youngia japonica*	ALL
Shrub	Coral Ardisia, Coralberry, Spiceberry, Hen's Eyes, Marlberry	II	*Ardisia crenata*	CZ, CP
Shrub	Evergreen Barberry	II	*Berberis julianae*	P
Shrub	Summer-lilac, Orange-eye Butterfly-bush	II	*Buddleja davidii*	ALL
Shrub	Harlequin Glory-bower	II	*Clerodendrum trichotomum var. ferrugineum*	S
Shrub	Japanese Holly	II	*Ilex crenata*	ALL
Shrub	Japanese Privet, Waxy-leaf Privet	II	*Ligustrum japonicum*	ALL
Shrub	European Privet	II	*Ligustrum vulgare*	P
Shrub	Sweet Breath of Spring, January Jasmine	II	*Lonicera fragrantissima*	ALL
Shrub	Amur Honeysuckle	II	*Lonicera maackii*	P
Shrub	Macartney Rose	II	*Rosa bracteata*	CZ, CP, S, P
Shrub	Wineberry, Wine Raspberry	II	*Rubus phoenicolasius*	P, M
Shrub	Jerusalem Cherry	II	*Solanum pseudocapsicum*	CP, S, P
Shrub	Meadowsweet	II	*Spiraea japonica*	P, M
Shrub	Cleome, Spiderflower, Pinkqueen	II	*Tarenaya hassleriana*	CZ, CP, S, P
Tree	Camphortree	II	*Camphora officinarum*	CZ, CP, P
Tree	Loquat	II	*Eriobotrya japonica*	CZ, CP, S, P
Tree	Honey Locust (native to the U.S. but not native to S.C.)	II	*Gleditsia triacanthos*	ALL
Tree	Golden Raintree	II	*Koelreuteria paniculata*	CZ, CP, S, P
Tree	White Mulberry	II	*Morus alba*	ALL
Tree	Sawtooth Oak	II	*Quercus acutissima*	CP, S
Tree	Japanese evergreen oak	II	*Quercus glauca*	CP
Tree	Cleyera, False Japanese Cleyera, Japanese Ternstroemia	II	*Ternstroemia gymnanthera*	CP
Tree	Chinese Elm	II	*Ulmus parvifolia*	CZ, CP, S, P

APPENDIX 3A: NON-NATIVE INVASIVE PLANTS

SCIPC Invasive Exotic Plant List

Updated July/2024

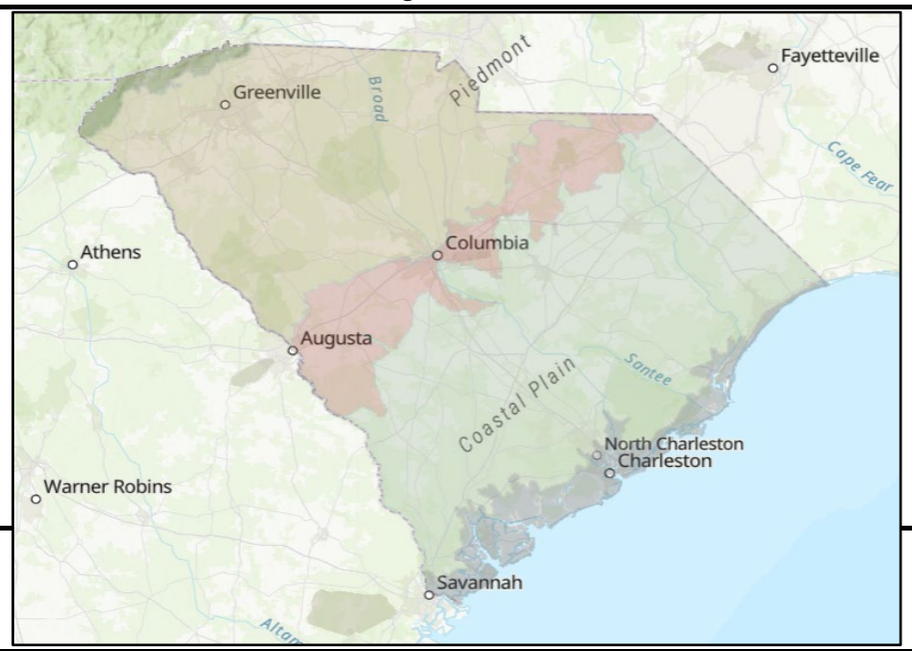
This list of invasive-exotic plants in South Carolina was developed by the SC-Invasive Pest Council (SC-IPC), formerly known as the SC EPPC (SC Exotic Pest Plant Council), in collaboration with natural resource professionals working in the fields of biology, forestry, botany, wildlife/ habitats, and land management in South Carolina. Definitions, distribution map, and resources follow the list.

Please report observations of invasive exotic plant species to EDDMapS at https://www.eddmaps.org/ so that more complete occurrence information is documented and available.

Growth Form	Common Name	Category	Scientific Name 2024	Distribution 2024
Tree	Siberian Elm, Dwarf Elm	II	*Ulmus pumila*	CZ, CP, S, P
Vine	Green kiwi-fruit, Chinese gooseberry	II	*Actinidia chinensis var. deliciosa*	M
Vine	Fiveleaf akebia, Chocolate Vine	II	*Akebia quinata*	P, M
Vine	Porcelain berry	II	*Ampelopsis glandulosa*	P, M
Vine	Climbing Euonymus, Winter Creeper	II	*Euonymus fortunei*	ALL
Vine	Bigleaf Periwinkle	II	*Vinca major*	ALL
Vine	Common Periwinkle	II	*Vinca minor*	ALL

SC-IPC Definitions of Terms	
Exotic	a species introduced into South Carolina, either by intentional or unintentional means, that belongs to a natural range outside of South Carolina.
Native	a species whose natural range includes South Carolina
Naturalized	an exotic plant species that is able to establish and sustain itself outside of cultivation
Invasive Exotic	an exotic plant species that has naturalized in an area and is expanding on its own in South Carolina native plant communities
Region	refers to the general area in South Carolina each species is distributed or has been recorded as established. Does not indicate range within the state of SC

Regions (SC Ecoregions/SC Wildlife Action Plan)	
CZ=	Coastal Zone
CP=	Coastal Plain
S=	Sandhills
P=	Piedmont
M=	Mountains/Blue Ridge
ALL=	occurs in all SC regions



Resources

SC Native Plant Society: Issues and alternatives - https://scnps.org/invasive-plant-species/	
SCDNR:	management - https://www.dnr.sc.gov/invasiveweeds/program.html
SCDNR:	SC illegal aquatic plants - https://www.dnr.sc.gov/invasiveweeds/illegal1.html
SC Department of Plant Industry: illegal plants - https://www.clemson.edu/public/regulatory/plant-industry/plant-pest-regulations/state-plant-pest-information/pests_list.html	
USDA Federal Noxious Weed list: https://www.ams.usda.gov/sites/default/files/media/StateNoxiousWeedsSeedList.pdf	

APPENDIX 3B: AQUATIC PLANT SPECIES ILLEGAL TO POSSESS, IMPORT, OR DISTRIBUTE IN SOUTH CAROLINA

While there is a crossover with the aquatic plant list in Appendix 3A, the list of aquatic plants here versus those listed in legislation are different. Therefore, both the South Carolina Invasive Pest Council (SCIPC) list and the South Carolina Department of Environmental Services (SCDES) list are provided in this SWAP for reference. The list below resides on the SCDES Illegal Aquatic Plants webpage. An asterisk (*) denotes species that are also on the Federal Noxious Weed List.

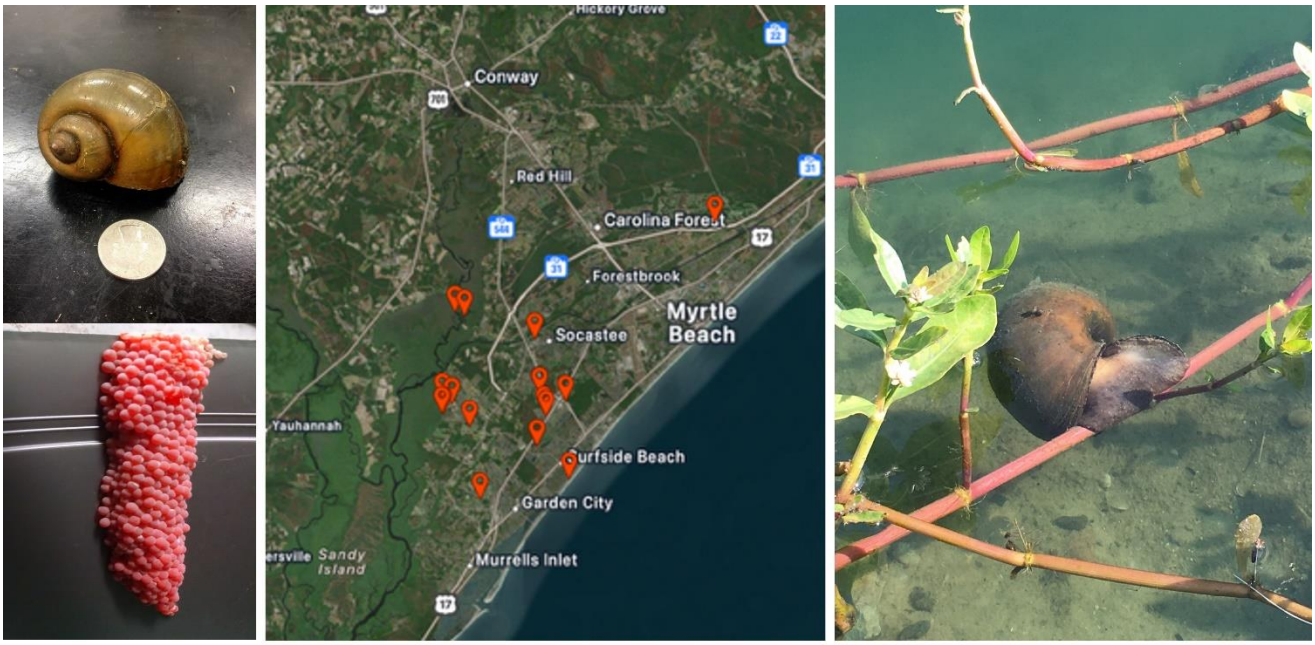
COMMON NAME	SCIENTIFIC NAME
African Oxygen Weed*	*Lagarosiphon major*
Alligatorweed	*Alternanthera philoxeroides*
Ambulia*	*Limnophila sessiliflora*
Arrowhead*	*Sagittaria sagittifolia*
Arrow-leaved Monochoria*	*Monochoria hastata*
Brazilian Elodea	*Egeria densa*
Caulerpa*	*Caulerpa taxifolia*
Common Reed	*Phragmites australis*
Crested Floating Heart	*Nymphoides cristata*
Duck-lettuce*	*Ottelia alismoides*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Exotic Bur Reed*	*Sparganium erectum*
Giant Salvinia*	*Salvinia molesta, S. biloba, S. herzogii, S. auriculata*
Hydrilla*	*Hydrilla verticallata*
Melaleuca*	*Melaleuca guinguenervia*
Miramar Weed*	*Hydrophila polysperma*
Monochoria*	*Monochoria vaginalis*
Mosquito Fern*	*Azolla pinnata*
Purple Loosestrife	*Lythrum salicaria*
Rooted Water Hyacinth*	*Eichhornia azurea*
Slender Naiad	*Najas minor*
Water Chestnut	*Trapa natans*
Water Hyacinth	*Eichhornia crassipes*
Water Lettuce	*Pistia stratiotes*
Water Primrose	*Ludwigia hexapetala*
Water Spinach*	*Ipomoea aquatica*
Wetland Nightshade*	*Solanum tampicense*
Yellow Floating Heart	*Nymphoides peltata*

APPENDIX 4: NON-NATIVE INVASIVE ANIMAL SPECIES WATCHLIST

ANIMAL	THREAT
aquarium/ornamental fish, in general	competes with native species for resources
Argentine Black-and-White Tegu (*Salvator merianae*)	outcompetes and predates native species, increased predation on ground nesting bird nests, potential parasite and disease vector
Asian Citrus Psyllid (*Diaphorina citri*)	damages citrus plants and serves as a vector for Citrus Greening Disease
Asian Clam (*Corbicula fluminea*)	competes with native mussels for habitat and food
Asian Jumping Worm (*Amynthas agrestis*)	changes soil structure and nutrient composition thus impacting communities; outcompete other earthworm species
Asian Long-horned Beetle (*Anoplophora glabripennis*)	damages native hardwood trees
Asian Needle Ant (*Brachyponera chinensis*)	causes native ant displacement leading to plant diversity changes in the environment
Asian Tiger Mosquito (*Aedes albopictus*)	transmits viruses
Asian Tiger Shrimp (*Penaeus monodon*)	out-competes native species
Basket Clams (*Corbicula* sp.)	out-competes native species
Black Rat (*Rattus rattus*)	damages structures; disease vector
Blue Catfish (*Ictalurus furcatus*)	preys on native fishes and mussels
Blue Land Crab (*Cardisoma guanhumi*)	may degrade habitat and infrastructure
Bocourt Swimming Crab (*Callinectes bocourti*)	out-competes native species; potentially impacts commercially important species such as blue crab and oysters
Brown Anole (*Anolis sagrei*)	out-competes native species
Brown Marmorated Stink Bug (*Halyomorpha halys*)	damages agricultural crops
Charrua Mussel (*Mytella charruana*)	creates dense fouling communities which may displace native species
Chinese Mystery Snail (*Cipangopaludina chinensis*)	competes for resources with native gastropods
Common Carp (*Cyprinus carpio*)	omnivorous and can disturb substrates with their activities
Cuban Treefrog (*Osteopilus septentrionalis*)	out-competes native species; preys upon native frogs
Elm Zigzag Sawfly (*Aproceros leucopoda*)	damages elm trees which also impacts native elm insect communities
Emerald Ash Borer (*Agrilus planipennis*)	detructive to native ash trees
European green crab (*Carcinus maenas*)	(not yet found in SC) out-competes native species; potential impacts to commercially important species such as blue crab and oysters
European Starling (*Sturnus vulgaris*)	damages human structures and agriculture; disease vector
feral cats and cat colonies	prey on native species; disease vector; degrades habitat
feral dogs	prey on native species
feral goats	degrade habitat
feral swine (*Sus scrofa*)	prey on native species; degrade habitat
Flathead Catfish (*Pylodictis olivaris*)	preys on native species of fishes and mussels

Forest Tent Caterpillar (*Malacosoma disstria*)	defoliates native trees
Formosan Subterranean Termite (*Coptotermes formosanus*)	damages human dwellings
German Cockroach (*Blattella germanica*)	disease vector; allergen
German Yellowjacket (*Vespula germanica*)	damages structures
Giant Resin Bee (*Megachile sculpturalis*)	out-compete and outright kill native carpenter bees
Greenhouse Frog (*Eleutherodactylus planirostris*)	unknown; possibly competes with native frogs for resources
Green Mussel (*Perna viridis*)	create fouling communities; can generate economic costs by impacting systems reliant on water exchange (e.g., clogging pipes, filters, operational shutdowns).
Green Sunfish (*Lepomis cyanellus*)	competes with and prey on native fish species
Spongy Moth (*Lymantria dispar dispar*) --formerly European Gypsy Moth	damages native trees and shrubs (no established populations in SC)
Greater Wax Moth (*Galleria mellonella*)	damages honeybee colonies by feeding on combs and larvae
Green Porcelain Crab (*Petrolisthes armatus*)	affects oyster growth rates and recruitment through combined filter-feeding activities of dense, intertidal aggregations
Hemlock Wooly Adelgid (*Adelges tsugae*)	causes loss of native hemlock species which changes forest composition
Honey Bee (Apis mellifera)	out-competse native species
European House Sparrow / English Sparrow (*Passer domesticus*)	damage to human structures and agriculture; disease vector; direct competition with native species
Indo-Pacific Lionfish (*Pterois volitans* / *miles*)	outcompetes and predates native species
Indo-Pacific Swimming Crab (*Charybdis hellerii*)	out-compete native species; potential impacts to commercially important species such as blue crab
Island Apple Snail (*Pomacea maculata*)	may outcompete native species; disease vector
Japanese Beetle (*Popillia japonica*)	damages turf and ornamental and native plants
Joro Spider (*Nephila clavata*)	unknown; possibly competes with native spiders for resources
Kudzu Bug (*Megacopta cribraria*)	damages legume crops
Lumholtz Waterflea (*Daphnia lumholtzi*)	out-compete native zooplankton; disrupt food web
Marbled Crayfish (*Procambarus virginalis*)	(not yet found in SC) disease vector; outcompetes native species; has parthenogenic reproduction
Mediterranean House Gecko (*Hemidactylus turcicus*)	unknown
Multicolored Asian Lady Beetle (*Harmonia axyridis*)	outcompetes and displaces certain native lady beetles
Mystery Snail species (*Cipangopaludina* sp.)	competes for resources with native gastropods
Northern Snakehead (*Channa argus*)	preys on native fish and may spread parasites
Norway Rat / Brown Rat (*Channa argus*)	disease vector; damages structures
Red Bay Ambrosia Beetle (*Xyleborus glabratus*)	causes Laurel Wilt Disease in native species
Red-eared Slider (*Trachemys scripta elegans*)	hybirdizes with native slider species; outcompetes native specie;, potential vector of disease or parasites from captive collections
Red Imported Fire Ant (*Solenopsis invicta*)	preys on native species
Red Swamp Crayfish (*Procambarus clarkii*)	outcompetes native species; disease vector; preys on native mussels; degrades habitat/infrastructure

Rock Dove / Pigeon (*Columba livia*)	damages human structures and agriculture; disease vector
Small Hive Beetle (*Aethina tumida*)	damages honey colonies by feeding on pollen and honey
Spotted Lanternfly (*Lycorma delicatula*)	damages native plants and agricultural crops
South American Cactus Moth (*Cactoblastis cactorum*)	damages native cactus species
Tracheal Mite (*Acarapis woodi*)	infects honeybees causing colony collapse
Varroa Mite (*Varroa destructor*)	infects honeybees causing colony collapse
Veined Rapa Whelk (*Rapana venosa*)	(not currently present in SC); in Chesapeake Bay prey on ecologically- and commercially important bivalve species; as adults, lack native predators
Virile Crayfish (*Faxonius virilis*)	outcompetes native species; disease vector; degrades habitat
Yellow Fever Mosquito (*Aedes aegypti*)	disease vector
Yellow Legged Hornet	predates honeybees
Zebra Mussel	clogs water intakes; outcompetes native mussels for habitat and food resources



Invasive Apple Snails have been found in retention ponds in coastal South Carolina. They get quite large and produce pink eggs that contain neurotoxin. These herbivorous snails can over-browse native aquatic vegetation and outcompete native snails.
Photos provided by Peter Kingsley-Smith, SCDNR

APPENDIX 5: FRESHWATER FISHES SPECIES SELECTION PROCESS

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To provide a preliminary ranking of conservation need among South Carolina's freshwater fishes, we incorporated four key species attributes that have been used for various taxa and spatial scales to quantify the likelihood of a species becoming imperiled due to anthropogenic alteration of natural ecosystems (Rabinowitz 1981; Freitag and Van Jaarsveld 1997; Mace et al. 2006; Pritt and Frimpong 2010; Master et al. 2012; Faber-Langendoen et al. 2012; Flather and Sieg 2013; Birdsong et al. 2021): (1) frequency of occurrence (i.e. commonness), (2) abundance, (3) range size / endemism and (4) existing range-wide conservation concern (i.e. recognized risk or decline). The index was designed under the rationale that conservation need should be greatest for species that occur infrequently, are less abundant at a given scale, have a narrower overall distribution, and/or have been designated as species of concern in previous assessments. Species exhibiting these characteristics, especially in combination, would be most likely to decline with increasing anthropogenic alteration of aquatic ecosystems.

We assembled data from multiple statewide stream and river assessment studies spanning 19 years and following standardized sampling protocols aimed at providing directly comparable data on fish assemblage composition and species occurrence and abundance. The dataset included 858 samples from streams and rivers representing a watershed size range of 0.2 – 1,911 km² (Table 1).

TABLE 1: Data included in the conservation prioritization of South Carolina freshwater fishes.

Study	Years of Data Collection	Number of Samples	Range of Sample Site Watershed Area
Reedy River Watershed Study	2005	20	7 – 41 km²
South Carolina Stream Assessment	2006 – 2011	604	0.2 – 150 km²
Small River Assessment	2016 – 2020	100	150 – 1,911 km²
Stream Quantification Tool Development Study	2020 – 2021	100	0.2 – 245 km²
South Carolina Stream Assessment	2022 – 2023	34	4 – 184 km²
Total	2005 - 2023	858	0.2 – 1,911 km²

The dataset included samples representing predominantly (90%) randomly selected sites and a wide range of stream and river integrity (Table 2); the statewide species frequency and

abundance measures therefore characterize species across the full spectrum of conditions.

TABLE 2: Mean and [range] percent coverage of primary land cover types at the total watershed scale by datasets used in the statewide conservation prioritization of South Carolina freshwater fishes.

Study	Years of Data Collection	Natural	Ag	Developed	NLCD
Reedy River Watershed Study	2005	50.3 [8.5-81.5]	18.6 [1.0-50.9]	30.5 [4.2-90.4]	2004
South Carolina Stream Assessment	2006 – 2011	65.6 [10.9-98.6]	20.0 [0-66.3]	13.8 [1.3-88.8]	2011
Small River Assessment	2016 – 2020	66.9 [31.9-96.5]	19.6 [0.2-60.5]	12.6 [3.3-58.4]	2019
Stream Quantification Tool Development Study	2020 – 2021	71.7 [12.9-98.6]	15.2 [0-60.3]	12.4 [1.4-84.3]	2019
South Carolina Stream Assessment	2022 – 2023	66.7 [13.4-96.0]	14.6 [0.3-43.3]	18.1 [3.2-85.0]	2019
Total	2005 - 2023	66.2 [8.5-98.6]	19.0 [0-66.3]	14.1 [1.3-90.4]	Various

At the statewide scale, we then computed the frequency of occurrence, mean relative abundance, and standard deviation of relative abundance (i.e. spatial variation in relative abundance) for each species. Because certain sites were sampled for as many as six consecutive years in the first statewide iteration of the SCSA (2006-2011), we combined these into a single composite sample in each case to reduce the influence of functionally repeated samples on species frequency and relative abundance statistics. After repeat samples were collapsed into composites, the statewide total was 719 samples.

As a measure of species presence (commonness) across the state, we computed frequency of occurrence. Frequency of occurrence was defined as the percent of samples (out of 719 possible) in which the species was collected. Frequency of occurrence ranged from 0% to 69% (Table 3).

TABLE 3: Mean and range of frequency of occurrence, relative abundance, and range size among 131 species evaluated for conservation need.

Measure	Frequency of Occurrence (as proportion)	Mean Relative Abundance (as proportion)	Range Size (number of 8-digit HUCs)
Mean	0.10	0.008	243
Range	0 – 0.69	0 – 0.13	2 – 1112

Normalized (Index) Mean	0.10	0.06	0.40
Normalized (Index) Range	0 – 0.69	0 – 1.0	0.003 – 1.85

To assess abundance on a statewide scale, we first relativized the total catch of each species within each sample to produce relative abundance, then computed the mean relative abundance for each species across all samples in the dataset. Mean relative abundance ranged from 0% to 13.1% (Table 3).

Range size was quantified as the number of drainages (8-digit HUC; hereafter HUC8) in which each species is known to have occurred in its native range. We used two data sources in order to account for possible differences based on taxonomic recognition and therefore increase accuracy in range size quantification. HUC8 distributions were obtained from the NatureServe Digital Distribution Maps of the Freshwater Fishes in the Conterminous United States (NatureServe 2010). In addition, we obtained the HUC8-scale distribution data as used in Elkins et al. (2019; see section 2.1 therein for description of data curation) in a study of imperilment among southeastern aquatic taxa, which were filtered for taxa occurring in South Carolina by E. Walther, University of Georgia (pers. comm.). Since the HUC8 distributions in Elkins et al. (2019) were limited to the spatial scope of that study (a portion of the southeastern U.S.) and the distributions of many of South Carolina's fish species extend outside of this region, the full range HUC8 counts from NatureServe were used in these cases. For species restricted to within the extent of Elkins et al. (2019), HUC8 distribution counts for each species from the two datasets (Elkins et al. 2019 and NatureServe) were compared and any differences were inspected carefully to determine the appropriate distribution based on the most recent available taxonomic information. Within South Carolina, we also included any potential HUC8 distributional data from recent SCDNR surveys that may not yet have been integrated with NatureServe or the databases used in Elkins et al. (2019). Because proactive conservation is a primary objective of the SWAP and taxonomic revision of many fish species occurring in South Carolina is ongoing, we investigated and used the most recent proposed or published information to represent the greatest degree of taxonomic distinctiveness, typically using the taxonomic remarks in each species account of Rohde et al. (2009) as a starting point since many of the impending revisions were recognized by that time.

Regardless of status at the statewide scale, species known to be declining or at high risk of decline in other portions of their ranges warranted concern. To account for existing recognition of conservation concern, we used the list produced by the 2019 Southeast Regional Species of Greatest Conservation Need (RSGCN) effort organized by the Wildlife Diversity Committee of the Southeastern Association of Fish and Wildlife Agencies (SEAFWA; Rice et al. 2019). This effort evaluated all the SEAFWA member state SGCN fish species using criteria including the degree of southeastern regional endemism (i.e. regional stewardship responsibility), conservation concern and status, and biological/ecological significance. Taxonomic experts from the SEAFWA states reviewed and proposed a conservation priority level for each species, which were then aggregated using a formula to compute a final regional priority level (very high, high, or moderate). The final RSGCN list included 36 species of freshwater fish (not including diadromous species) occurring in South Carolina.

We developed a formula following a point-scoring method (Mace et al. 2006; e.g. Birdsong et al. 2021) to incorporate these four attributes and produce a score indicative of conservation need for each species. Frequency of occurrence was maintained as a raw proportion with possible values ranging from 0 (0.0% of sites occupied) to 1 (100%). Mean relative abundance was normalized by dividing the value for each species by the maximum value exhibited (13.1%; Eastern Mosquitofish *Gambusia holbrooki*), thus producing a proportion ranging from 0 to 1. Range size was also normalized by dividing the number of HUC8 drainages for each species by 601, which represents the total number of HUC8 drainages encompassing the southeastern U.S. at the scope employed by Warren et al. (2000); this measure therefore ranged from 0.003 to 1.85 (since the distributions of some species exceeded the extent of the entire southeastern U.S.). The values for frequency, normalized abundance and normalized range size were summed to produce a subtotal score (i.e. a lower score was indicative of lower frequency, lower mean relative abundance and/or smaller range size and therefore higher risk and greater conservation need; Table 4). Finally, the subtotal score was reduced by a factor incorporating the level of 2019 RSGCN priority: -75% for very high conservation need; -50% for high conservation need; -25% for moderate conservation need; and no reduction for species that did not receive RSGCN priority. Resulting values represented the final scores used to provide a preliminary ranking of conservation need (Table 4).

TABLE 4: Example of conservation need scoring system showing values for a relatively high priority species, *Semotilus lumbee* (Sandhills Chub), and a low priority species, *Lepomis auritus* (Redbreast Sunfish).

Measure	*Semotilus lumbee*	*Lepomis auritus*	**Definition**
Frequency of occurrence	0.01	0.69	Proportion of sites occupied statewide
Mean relative abundance (normalized)	0.01	0.52	Mean relative abundance as proportion of maximum (*Gambusia holbrooki*)
Range size (normalized)	0.01	0.42	Number of HUC8 drainages in range as proportion of 601 (entire southeast)
Subtotal Score	0.03	1.63	Sum of values above
Existing concern	-50%	None	*S. lumbee* listed as High Concern in the 2019 RSGCN effort
Final Priority Score	**0.02**	**1.63**	**Lower score = Higher priority**

The list of species ranked by preliminary conservation need score (including their component values for frequency, abundance, range size and regional concern) was distributed to the technical team to serve as a reference framework for subsequent review and input. Because standardized data from certain habitat types (e.g. large rivers) were not available for assessing relative status of certain species as explained above, this step allowed representation of conservation concern for such species as provided by personnel with experience surveying these habitats. Each technical team member was instructed to assign a proposed subnational

conservation status rank (S-rank) for each species (for which he or she felt qualified to do so) following the NatureServe S-rank definitions as a guideline. The existing species S-ranks (as of February 2024) were provided for reference. Proposed S-ranks were submitted to the technical team co-chairs for compilation.

Proposed S-ranks were provided by 16 technical team members, with a mean of 77 species ranked per technical team member (range: 3-118). The mean number of technical team responses per species was 10 and ranged from 7 to 14. A mean quantitative S-rank was computed for each species across all the responses to summarize technical team recommended conservation need by species. These mean S-ranks were then used along with the SGCN rubric and data-based index ranking to guide the assignment of SGCN status. Species representing potential SWAP additions or removals were subsequently reviewed by the technical team.

Four species not previously considered SGCN—Shorthead Redhorse (*Moxostoma macrolepidotum*), Brassy Jumprock (*Moxostoma* sp.), Lined Topminnow (*Fundulus lineolatus*) and Least Killifish (*Heterandria formosa*)—showed data-based rankings within the range suggesting SGCN. However, three of these species were determined based on technical team experience and S-ranks to be secure in habitats that were not sufficiently represented in the dataset and were therefore excluded from the SWAP: Shorthead Redhorse (secure in large rivers of the Santee and Pee Dee Bsins), Lined Topminnow and Least Killifish (both abundant in swamps, sloughs and ponds in the coastal plain). Brassy Jumprock, which was considered for inclusion in 2015 but ultimately left out due to apparent security in riverine habitats, was added for 2025 due to continuing data-indicated need as well as its status as a SEAFWA RSGCN species (Rice et al. 2019).

Twelve SWAP species from 2015 ranked outside of the data-indicated SWAP inclusion range but were reviewed for other potential risks and technical team concern. Ironcolor Shiner (*Alburnops chalybaeus*), Swallowtail Shiner (*Miniellus procne*) and Rosyface Chub (*Hybopsis rubrifrons*) were all on the RSGCN list due to regional concern and responsibility and were therefore retained as SWAP species. Three ictalurids—Snail Bullhead (*Ameiurus brunneus*), Flat Bullhead (*Ameiurus platycephalus*), and White Catfish (*Ameiurus catus*)—are threatened by the ongoing expansion of the introduced Flathead Catfish (*Pylodictis olivaris*) among other factors and were retained as SWAP species. Banded Killifish (*Fundulus diaphanus*) was also included as a SWAP species due to very few recent collections (apparently low abundance) in its limited range within the State (Waccamaw River) and recent research indicating the form of this species occurring in South Carolina may be genetically and morphologically distinct from those of other river basins (F. Rohde, personal communication). Similarly, evidence of increased taxonomic distinctiveness of the Rosyside Dace (*Clinostomus funduloides*) form occurring in South Carolina (Weyand and Piller 2019; Tracy et al. 2024) and its relatively narrow habitat requirements led to its retainment as an SGCN. Four former SGCN were relatively widespread and secure as reflected by the data and technical team corroboration and were therefore removed from the SGCN list: Notchlip Redhorse (*Moxostoma collapsum*), Greenfin Shiner (*Cyprinella chloristia*), Sandbar Shiner (*Notropis scepticus*) and Lowland Shiner (*Pteronotropis stonei*). Finally, due to overarching agreement in the Comely Shiner (*Notropis amoenus*) being nonindigenous in the Pee Dee basin (Hocutt et al. 1986; Jenkins and Burkhead 1994; Tracy 2018; Tracy et al. 2024), its only known locality in South Carolina, it was removed from the

SGCN list.

Altogether, this revision represents the addition of one species to the SWAP (Brassy Jumprock) and the removal of five (Notchlip Redhorse, Greenfin Shiner, Sandbar Shiner, Comely Shiner and Lowland Shiner).

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