North Carolina Wildlife Action Plan

North Carolina Wildlife Resources Commission
www.ncwildlife.org

Recommended citation:

North Carolina Wildlife Resources Commission. 2005. *North Carolina Wildlife Action Plan*. Raleigh, NC.

This program receives Federal financial assistance from the U.S. Fish and Wildlife Service. Under Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, Title IX of the Education Amendments of 1972, the U.S. Department of the Interior and its bureaus prohibit discrimination on the bases of race, color, national origin, age, disability, age or sex (in educational programs). If you believe that you have been discriminated against in any program, activity, or facility, or if you desire further information please write to: Equal Employment Officer, 1703 Mail Service Center, Raleigh, NC 27699-1703, Tel. (919) 707-0101.

xxxx Copies of this public document were printed at a cost of $xxxx or $xx per copy, FIXDATE.

Design and layout by Vickie Cribb, Absolute Typography

Cover photo of Croatan National Forest
by Nate Bacheler

FOREWORD

Since the North Carolina Wildlife Resources Commission was created more than a half century ago, our state has seen its wild turkey populations restored, anadromous striped bass populations stabilized, the return of bald eagles to the skies, more than two million acres of wildlife habitat conserved, and opportunities for fishing, hunting and wildlife-watching expanded to include North Carolinians of all abilities.

Tasked with creating more sporting opportunities for more people as rapid human population growth has changed the face of the state, the Commission has met this challenge in both rural and urban settings, and even expanded its work from a traditional game animal focus to embrace conservation of all species.

New research, new technology, and new management principles and philosophies have provided the basis for a growing emphasis on the sustainability of all of our state's wildlife resources.

But conservation challenges remain, and so I am honored to introduce the Commission's latest and most innovative effort to serve as responsible stewards of our state's wildlife resources: the North Carolina Wildlife Action Plan.

Developed in compliance with a Congressional mandate, the Plan is the Commission's blueprint for fish and wildlife conservation statewide for the next half century, providing guidance and assistance to other conservation-minded agencies, organizations, industries, academics and individuals.

The Plan builds on all of the conservation efforts that have come before, and it is strengthened by concurrent conservation strategies being implemented by other states across the nation. The Plan proposes a cost-effective, proactive approach to the conservation of entire communities, including those often overlooked fish and wildlife species for which management opportunities were traditionally under-funded.

It is an ambitious Plan, calling for the conservation of a wide array of aquatic and terrestrial species and their associated habitats.

It is a forward-looking Plan, anticipating new management strategies yet to be developed to meet the conservation challenges created by continued growth and diversity in the state's human population.

It is a comprehensive Plan for fish and wildlife, whose success will not be measured by population estimates or growth rates, but by the cultivation of lasting conservation partnerships and by the promise of fish and wildlife resources for future North Carolinians.

John E. Pechmann
Chairman
North Carolina Wildlife Resources Commission

EXECUTIVE SUMMARY

For more than fifty years, state fish and wildlife agencies have benefited from funds accumulated through the Federal Aid in Wildlife Restoration Act (Pittman-Robertson), the Federal Aid in Sport Fisheries Restoration Act (Dingell-Johnson), and the Aquatic Resources Trust Fund (Wallop-Breaux), to support the conservation and management of game fish and wildlife species. These funds have been critical to the establishment of long-term state agency planning related to game species. Yet conservation efforts for the majority of fish and wildlife species, those that are not hunted or fished, have in large part been opportunistic and crisis-driven, limited by the availability of funding, and by a lack of strategic approaches to species and habitat conservation. With more than 1,000 species now listed on the Federal Endangered and Threatened species list, the need has never been greater for funding and planning to support the conservation, protection, and restoration of the full array of wildlife species, especially those not covered under traditional funding sources.

In 2001 Congress, recognizing this need, began providing annual funding allocations to supplement existing state fish and wildlife conservation programs. Along with this new funding came the responsibility of each state and territory to develop a Wildlife Action Plan. This North Carolina Wildlife Action Plan is being submitted to meet that obligation, and in the process, provide a conservation blueprint for agencies, organizations, industries, and academics across the state to advance the sound management of our fish and wildlife resources into the future. Within the document, we identify critical fish and wildlife resources and priority conservation needs associated with those resources. Our Plan is strengthened by all of the local, state, and regional conservation planning efforts that have preceded it; these efforts provided us a foundation upon which to build. Our Plan promotes proactive conservation measures to ensure cost-effective solutions (“keeping common species common”) instead of reactive measures enacted in the face of imminent losses.

Five goals form the core of the Plan: 1) to improve understanding of the species diversity in North Carolina and enhance our ability to make conservation or management decisions for all species, 2) to conserve and enhance habitats and the communities they support, 3) to foster partnerships and cooperative efforts among natural resource agencies, organizations, academia and private industry, 4) to support educational efforts to improve understanding of wildlife resources among the general public and conservation stakeholders, and 5) to support and improve existing regulations and programs aimed at conserving habitats and communities.

In order to meet these goals, we engaged hundreds of people across a broad spectrum of agencies and organizations. We continue to seek the feedback and input of conservation stakeholders.

Key themes that are perpetuated through the document include:

- The need to strengthen partnerships among natural resource agencies, organizations, academics, and individuals in order to meet shared goals and visions,
- The need to impact the landscape in a large-scale fashion, and to consider all components of a sustainable community of plants and animals,
- The need to gather additional information and fill knowledge gaps in order to advance our understanding of species and their habitats,
- The need to work cooperatively with private landowners to influence the conservation of natural resources across the majority of the state, and
- The need to educate and engage local governments, planning commissions, and urban publics about the importance of fish and wildlife conservation as a key component of successful land use planning.

The sections of the Plan build on one another in similar fashion to its development. Within the **Approach** section are summaries of key processes and exercises that were carried out in order to develop the Plan, including organizational frameworks, partnerships and stakeholder involvement, and the species prioritization process. Next, in **The State of the State** we provide an overview of the condition of the state's natural resources, threats affecting species and habitats in the state, key conservation partners, and challenges faced in program administration and efficacy. In **Statewide Conservation Strategies** we address four broad-scale conservation issues, including strategies on urban wildlife issues, private lands wildlife management, land conservation priorities, and education and outreach. Following is the most detailed chapter of the report, entitled **Species and Habitat Assessments & Conservation Strategies**. In this chapter, we feature the conservation needs of terrestrial resources within habitats across the three ecoregions of the state (the Southern Blue Ridge, Piedmont, and Mid-Atlantic Coastal Plain), aquatic resources within the 17 river basins in the state, and marine resources at our coast (this section is largely based on the North Carolina Division of Marine Fisheries Coastal Habitat Protection Plan). Next, we address cross-cutting conservation needs among habitats and basins within **Synthesis of Conservation Priorities**. In **Status and Trends Monitoring** we discuss species and habitat monitoring needs. We outline ways to monitor the implementation of conservation activities, adapt to new information, and revise future iterations of the Plan in our final chapter, **Implementation Monitoring, Adaptive Management, & Review and Revision Procedures**. Last, we present **Acknowledgements**, a comprehensive **Glossary**, a **Key to Abbreviations and Acronyms**, and multiple **Appendices**.

This document was developed at the strategic level, meaning that the implementation of activities identified in the Plan must go one step farther to consider the operational details of involving partners, setting explicit objectives and targets, detailing monitoring protocols, etc. We have organized the format and content of the Plan to provide maximum utility as a resource to set conservation priorities. The Plan is designed to flow from beginning to end, but individual chapters and sections can also be used independently, as stand-alone documents. For example, users may turn to a particular habitat or basin section to review priority needs and recommendations pertaining specifically to their region or expertise area (e.g., the Catawba River basin, maritime forest habitat). We hope that the information provided within each chapter and section translates into clear and objective conservation planning at that level.

Our Plan has been nearly three years in development. The development process was strengthened by the input, feedback, and participation of hundreds of stakeholders across the state (stakeholder representation extended across more than 15 state and federal agencies, 12 non-governmental organizations, five universities, and four private companies). But the completion of this first edition is just the beginning. The Plan is a work in progress, and will continue to evolve during implementation and through future revisions. Though the funding that initiated development of the state Plan continues to be allocated on an annual basis (making long-term planning difficult), there is hope across the nation that our state Strategies will clearly demonstrate to Congress the need for increased and permanent Federal fish and wildlife conservation funding in the future. Regardless of funding sources, the partnerships and collaborative efforts that this Plan fosters should lead to significant accomplishments in the conservation of North Carolina's wildlife resources.

TABLE OF CONTENTS

CHAPTER 1.
INTRODUCTION

Problem and Need

For more than fifty years, state fish and wildlife agencies have benefited from funds provided by the Federal Aid in Wildlife Restoration Act (Pittman-Robertson), the Federal Aid in Sport Fisheries Restoration Act (Dingell-Johnson), and the Wallop-Breaux Act, to support the conservation and management of game fish and wildlife species. These funds, collected through federal excise taxes at the manufacturers' level, have been critical to the establishment of long-term agency conservation planning related to game species.

Yet conservation efforts for the majority of fish and wildlife species, those that are not hunted or fished, have in large part been opportunistic and crisis-driven, limited by a lack of funding, and by a lack of strategic approaches to species and habitat conservation. Today, with more than 1,000 species listed on the Federal Endangered and Threatened species list, and many more species in decline, the need has never been greater for a complimentary source of funding to support the conservation, protection, and restoration of the full array of wildlife species, especially those not covered under traditional funding strategies.

Legislative Mandate and Guidance

As a compromise following failed efforts to pass the Conservation and Reinvestment Act, in 2001 Congress developed new conservation funding legislation, the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program. These programs were designed to assist states by providing annual allocations for the development and implementation of programs to benefit wildlife and their habitats. The funding was intended to supplement, not duplicate, existing fish and wildlife programs, and to target species in greatest need of conservation, species indicative of the diversity and health of the states' wildlife, and species with low and declining populations, as deemed appropriate by the states' fish and wildlife agencies.

Under these new funding measures, states were required to develop a Wildlife Action Plan by October 2005, integrating information across eight required elements :

1. Information on the distribution and abundance of species of wildlife, including low and declining populations as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state's wildlife;
2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1);
3. Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats;
4. Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions;
5. Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions;
6. Descriptions of procedures to review the 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 Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats;
8. Documentation of broad public participation during development and implementation of the Plan.

The International Association of Fish and Wildlife Agencies and the US Fish & Wildlife Service established guidelines to supplement the eight required elements (Appendix A). These guidelines provided recommendations across four topics related to the development process: Planning Processes and Partnerships; Focus and Scope; Format and Content; and Completion, Outcomes, and Availability. States were encouraged to use these guidelines, both in the initial development process, and during future revisions, to improve and strengthen their Comprehensive Wildlife Conservation Strategies.

State Overview

In North Carolina, a huge diversity of fish and wildlife habitats exist across the three distinctive regions of the state: the Coastal Plain, the Piedmont, and the Mountains. These regions fall within larger ecoregions that span state borders and link North Carolina to neighboring states (Figure 1.1). Elevations ranging from sea level to over 6,000 feet provide habitat for over 1,000 species of birds, mammals, fish, reptiles, amphibians, mollusks, and crustaceans, in addition to thousands of other invertebrate species.

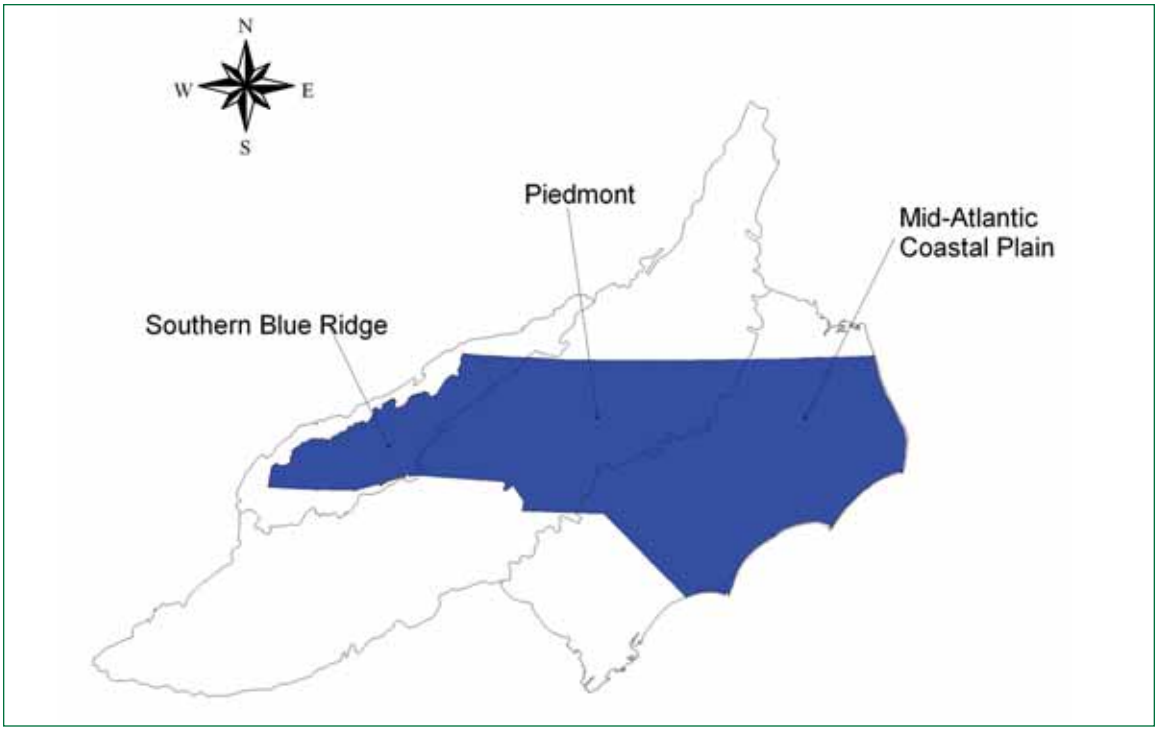


Figure 1.1. Ecoregional delineations in North Carolina (data source: NC GAP; ecoregions as defined by Bailey 1995).

The Coastal Plain region is characterized by flat lands extending from the coast inland an average of 125 miles. Elevations in the region increase inlandat approximately one foot per mile. The region covers almost two-fifths of the area of the state. The central Piedmont begins west of the coastal plain, separated by the "fall line" (a distinctive landscape change thought to have been the location of the shoreline thousands of years ago). The Piedmont is characterized by rolling hills ranging from 150–1,000 feet in elevation; the region covers another two-fifths of the state. The Mountain region, covering one-fifth of the state, is marked by numerous mountain ranges within the Southern Appalachians (principally the Blue Ridge and the Great Smoky Mountains). Forty-three peaks exceed 6,000 feet in elevation; 80 peaks exceed 5,000 feet.

The state of North Carolina is approximately 84% privately owned; this figure emphasizes the key role that private landowners play in determining the fate of the state's natural resources (NRCS 1997). Habitat degradation and loss due to development associated with human population growth are among the most threatening impacts to fish and wildlife species across the state. According to

the US Census Bureau, North Carolina experienced a 15% increase in population from 1990 to 1999, and growth continues unabated (2000). The Natural Resources Conservation Service reports that the state ranked sixth in the country for total acres of land developed between 1992 and 1997 (1997). As land development and population growth rates have increased, fish and wildlife habitats have been altered, fragmented and destroyed.

Today, more than 40 federally-listed endangered or threatened animal species and more than 60 state endangered or threatened animal species occur in the state. There are 115 state Species of Special Concern, and many more are at risk of being added to that list. North Carolina contains eight of the top 21 most endangered ecosystems in the country, based on extent of decline, present area (rarity), imminence of threat, and number of federally-listed threatened and endangered species associated with each type, including Southern Appalachian spruce-fir forest, longleaf pine forest and savanna, ancient Eastern deciduous forest, and southern forested wetlands (Noss et al., 1995). The state also contains many watersheds critical to the preservation of aquatic biodiversity in the southeast (Master et al., 1998). Clearly, the need is great for proactive conservation planning to address these concerns, in particular, and the full array of fish and wildlife species and habitat concerns in general.

Value and Goals

North Carolina's Wildlife Action Plan (hereafter Plan) is a guide to the North Carolina Wildlife Resources Commission (hereafter Commission) and to our partners in conservation for sound management of North Carolina's fish and wildlife resources into the future. Unlike many planning documents in the past, this Plan provides critical direction and serves as a blueprint for fish and wildlife conservation activities in the state. Within, we have identified significant wildlife resource and critical habitats across the state, as well as priorities for conserving those resources. We have addressed local, regional, and state-wide concerns across key terrestrial and aquatic habitats, using the best information currently available. In addition, we have identified critical knowledge gaps and future data needs. We have outlined a methodology for prioritizing activities that allows for allocation and reallocation of available manpower, funds, and material resources to meet changing conservation needs. And we have established a framework to measure the effectiveness of proposed strategies and monitor the results. Our Plan not only fulfills the requirements set forth by Congress; it also serves as a practical and essential resource for future fish and wildlife conservation planning in North Carolina.

The goals of our Plan are to:

- Improve our understanding of the species diversity in our state and enhance our ability to make conservation or management decisions for all species.
- Conserve and enhance habitats and the communities they support.
- Foster partnerships and cooperative efforts among natural resource agencies, organizations, academia and private industry.
- Support educational efforts to improve understanding of our wildlife resources among the general public and conservation stakeholders.
- Support and improve existing regulations and programs aimed at conserving habitats and communities.

The implementation of activities set forth in the Plan will result in maintaining our diverse fish and wildlife resources well into the future. Not only will North Carolina agencies and organizations dedicated to natural resource management and conservation benefit from the planning resource, but the citizens of the state will also benefit by the efforts put forth to maintain an environment favorable to wildlife. The continued availability of natural lands and wildlife populations will allow those engaged in wildlife-oriented recreation, be it consumptive or non-consumptive, to continue to enjoy their pursuits and will enhance those opportunities. More importantly, intact habitats and functioning ecosystems play a critical role in supporting all life on this planet, including our own.

Report Organization and Format

The following chapters build on one another in similar fashion as our Plan was developed. Within the **Approach** section are summaries of key processes and exercises that we carried out in order to develop the Plan, including our organizational framework, partnerships and stakeholder involvement, and our species prioritization process. Next, in the section entitled **The State of the State**, we review the condition of the state's natural resources, identify threats affecting species and habitats in the state, key conservation partners, and challenges faced in program administration and efficacy. In **Statewide Conservation Strategies** we address four broad scale conservation issues, including strategies on urban wildlife issues, private lands wildlife management, land conservation, and education and outreach. Following is the **Species and Habitat Assessments & Conservation Strategies** section, in which we detail the conservation needs of terrestrial and aquatic systems within the habitats, river basins and coastal waters of the state. Next we address cross-cutting strategies among habitats and basins within **Synthesis of Conservation Priorities**. In **Status and Trends Monitoring**, we discuss species and habitat monitoring needs. We outline ways to monitor and measure the implementation of conservation activities, adapt to new information, and review and revise future iterations of the Plan **in Implementation Monitoring, Adaptive Management, & Review and Revision Procedures**. Last, we present **Acknowledgements**, a comprehensive **Glossary**, a **Key to Abbreviations and Acronyms**, and multiple **Appendices**.

References

Bailey, R. G. 1995. Descriptions of the ecoregions of the United States. Report #1391. U.S. Department of Agriculture, Forest Service.

Master, L. L., S. R. Flack, and B. A. Stein, editors. 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, VA.

Natural Resources Conservation Service (NRCS). 1997. 1997 Natural Resources Inventory, revised December 2000. Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Noss, R. F., E. T. LaRoe, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. National Biological Service, U.S. Department of the Interior, Washington, D.C.

U.S. Census Bureau. 2000. 1990 to 1999 total population estimates. U.S. Census Bureau, Population Distribution Branch. http://www.census.gov/population.html.

CHAPTER 2.
APPROACH

Planning for and protecting North Carolina's fish and wildlife diversity is a multifaceted task that can only be accomplished through coordinated efforts by representatives of natural resource agencies, organizations, corporations, and private citizens. While staff within the Commission's Division of Wildlife Management (DWM) and Division of Inland Fisheries (DIF) oversaw the development of the Plan, we sought out the expertise and feedback of many other agencies, organizations, and individuals. The successful implementation of the Plan depends on their input and support.

General Process Timeline

The timeline below (Figure 2.1) identifies the three major phases of the Plan development process. We spent the first year and a half (Aug 2002 – Dec 2003) scoping and planning the process. This included the development of committees and a staff organizational structure, the review of conservation planning literature and guidelines, the design of processes necessary to fulfill the eight required elements, and the development of a format outline. The majority of 2004 was spent developing and expanding text, identifying supporting materials (i.e., maps, figures, tables), and assimilating existing conservation planning resources. This involved extensive assistance from biologists and staff among many organizations and agencies across the state. The final six months (Jan – July 2005) were spent finalizing edits, and preparing the Plan for completion.

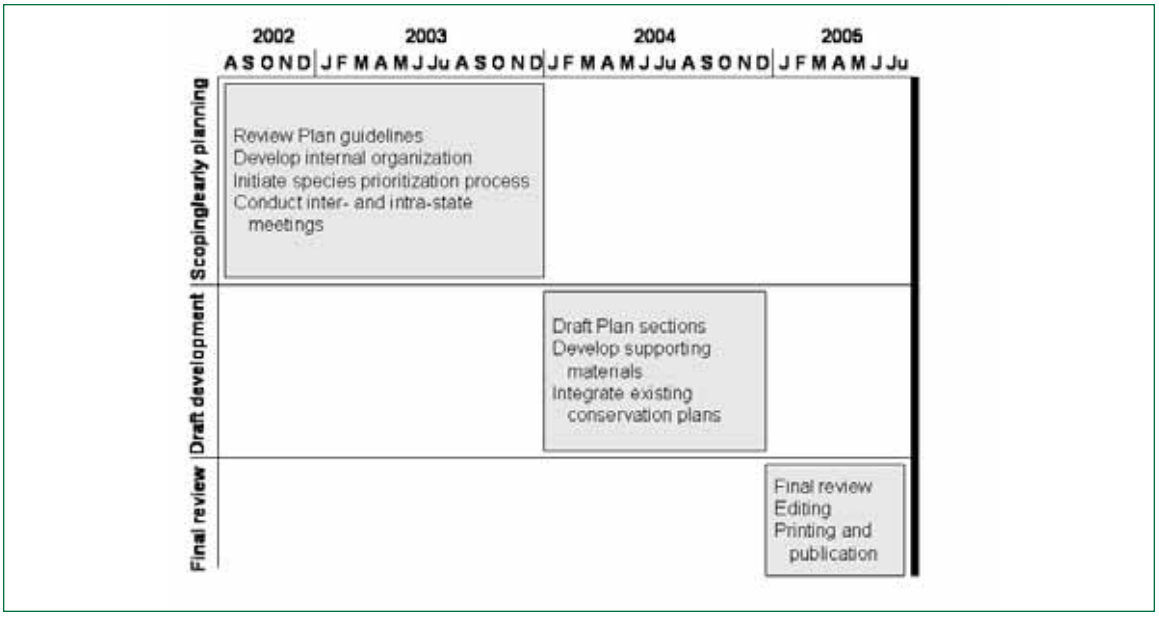


Figure 2.1. Generalized timeline for Plan development; key events/processes identified within each phase.

Organizational Structure

Wildlife Action Plan Coordinator (Salinda Daley)

Role: Coordinate the Plan development process; act as project manager; be a liaison to, and communicate the activities of, each internal committee; ensure involvement of all interested parties; help assemble final products and publications.

The following internal committees (made up of Commission staff) were developed to serve as resources for the Coordinator on particular aspects of the Plan development process:

Steering Committee

Role: Oversee the Plan development process; provide guidance related to administrative and policy issues; give final approval of products and processes developed.

Members: Fred Harris (Assistant Deputy Director), David Cobb (Chief, DWM), Bob Curry (Chief, DIF), Shannon Deaton (Section Manager, DIF), Brad Gunn (Section Manager, DWM), Wib Owen (Section Manager, DWM), Ken Bridle (Nongame Wildlife Advisory Committee Representative), Tom Henson (Faunal Diversity Coordinator, DWM), and Scott Van Horn (Research and Surveys Coordinator, DIF)

Meeting frequency: The Coordinator met with the Steering Committee approximately every six weeks throughout the entire Plan development process.

Technical Committee

Role: Provide guidance and support related to Plan details and content; assist in developing text and coordinating with external contacts and resources; assist in identifying supporting materials pertinent to the Plan; ensure the utility of the Plan as an on-the-ground planning and implementation resource.

Members: Scott Van Horn (Research and Surveys Coordinator, DIF), Tom Henson (Faunal Diversity Coordinator, DWM), Steve Fraley (Mountain Region Aquatic Nongame Biologist, DIF), Jeff Simmons (Mountain Region Aquatic Nongame Biologist, DIF), Ryan Heise (Central Region Aquatic Nongame Biologist, DIF), Rob Nichols (Central Region Aquatic Nongame Biologist, DIF), Angie Rodgers (Eastern Region Aquatic Nongame Biologist, DIF), Nolan Banish (Eastern Region Aquatic Nongame Biologist, DIF), Chris McGrath (Mountain Faunal Diversity Supervisor, DWM), Jeff Marcus (Piedmont Faunal Diversity Biologist, DWM), David Allen (Coastal Faunal Diversity Supervisor, DWM), Mark Johns (NC Partners in Flight Biologist, DWM), Sarah Cross (Herpetologist, DWM), Scott Anderson (Faunal Diversity Research Biologist, DWM & DIF)

Meeting frequency: The Coordinator met with the Technical Committee approximately every six weeks during the draft development phase of the process (as need be with the entire group, but more often as separate groups, aquatic and terrestrial).

Outreach Committee

Role: Provide guidance related to public outreach opportunities, media publications, web site development, and final production and publication of the Plan.

Members: Kate Pipkin (Outreach Biologist, Division of Conservation Education- DCE), Jodie Best (Outreach Specialist, DCE), Russell Wong (Outreach Supervisor, DCE), Mark Dubowski (Special Publications Editor, DCE)

Meeting frequency: The Coordinator met with the Outreach Committee members as the need for their guidance was warranted (approximately once every three months).

Partnerships and Public Involvement

External stakeholders were engaged in many ways throughout the Plan development process. Stakeholder involvement varied in nature, depending on the audience and their interests (Table 2.1). Early in our planning efforts, we identified four broad groups of stakeholders that we engaged, or will engage in the future, in different ways throughout the development, implementation, and review process:

Partners

This group of stakeholders includes other agencies and organizations who have a direct stake in Plan development and implementation, and with whom we directly collaborate and share data and resources (e.g., North Carolina Audubon, North Carolina Natural Heritage Program, The Nature Conservancy, university researchers). The standing Nongame Wildlife Advisory Committee to the Commission is a key representative group who will continue to play a vital feedback and coordination role in Plan implementation and review *(see more about the committee below)*.

User Groups

This group of stakeholders includes organizations that represent specific natural resource advocacy, education, and/or recreation groups. These groups, with whom we primarily consult and share information, are key to maintaining support for fish and wildlife conservation and funding, and to disseminating information to wider audiences across the state (e.g., North Carolina Wildlife Federation, North Carolina Herpetological Society).

General Public

The general public was engaged in a number of different ways during development of the Plan. Primarily, our efforts were focused on enhancing education and understanding about the importance of conservation funding and the work that it makes possible, with the purpose of gaining and maintaining public support for continued conservation funding into the future. Through the general news media, the Commission magazine, the Plan web site, and the Commission Wildlife Advisory Hotline *(see below for more details on these tools)*, the public was educated about the State Wildlife Grants program and about projects made possible through State Wildlife Grant funding, and was invited to participate in the Plan development process.

Private Landowners

Private landowners are an integral part of fish and wildlife conservation in the state, a vital subset of the general public, and a key audience to target, especially during implementation activities. Within Chapter 4B we highlight opportunities to further engage private landowners in land and watershed conservation projects, with the purpose of strengthening and expanding conservation on private lands in the state. We support the recommendations generated through two stakeholder-driven private lands initiatives already underway in the state, the Working Lands Summit and the North Carolina Forestry Summits (sponsored through the One North Carolina *Naturally* Program, NC Department of Environment and Natural Resources).

Table 2.1. Stakeholder involvement activities and primary audience targets.

		Primary audience target			
Level of involvement	**Type of activities**	**Partners**	**User Groups**	**General Public**	**Private Landowners**
Inform	• Meetings/presentations • Web site • Media • Email updates	X	X	X	X
Consult	• Meetings/presentations • Committees work groups • Web site • **Future human dimensions surveys*	X	X	*X	*X
Involve	• Committees/work groups • Review/feedback on draft text	X	X	X	
Collaborate	• Partnerships • Project coordination • Data sharing	X	X		

Key Stakeholder Involvement Activities

The following section highlights some of the most important stakeholder involvement activities carried out during the Plan development process. Beyond these specific activities initiated to engage and involve external stakeholders, it is also important to note that, at the field level, coordination among agencies and organizations in North Carolina has been ongoing for many years. Commission biologists regularly coordinate with their counterparts in agencies such as the US Forest Service, National Park Service, US Fish & Wildlife Service, and the Natural Resources Conservation Service, among others. Implementation partnerships are growing out of these ongoing coordination efforts.

Individual Meetings

Throughout the entire Plan development process, the Coordinator met with individual stakeholder groups. Early on, these meetings were primarily to inform groups about the Plan requirements and engage them in the development process. As the project grew, some meetings became more specialized in nature as more specific technical expertise or assistance was sought. During the Plan development process, the Coordinator held over 40 meetings with individual groups.

Small-scale Group Meetings

Stakeholders were also engaged through small group meetings (<20 individuals) in order to facilitate dialogue and cooperation among groups with common interests. This included both intra- and inter-state efforts.

- 'Neighbor States' meeting: In July 2003, we held a meeting of our neighboring states (Virginia, Tennessee, Georgia, South Carolina, Alabama) and our regional Federal Assistance coordinators, to discuss common issues and develop guidelines that would allow our individual Strategies to link across state boundaries. A key product of that meeting was the drafting of a format outline endorsed by all six states and the Federal Aid representatives. The outline was eventually combined with examples from two other states to become one of two Plan formatting examples endorsed by the US Fish & Wildlife Service and the International Association of Fish and Wildlife Agencies, and offered as a model to states nationwide.
- 'Partners' meeting: In October 2003, the Coordinator organized a meeting of five key partners in North Carolina, each of whom were involved in specific conservation planning efforts in the state (Table 2.2). The purpose of the meeting was to share information about the objectives of each effort in order to identify common goals and strategies to highlight in the Plan. The information shared by attendees at that meeting ultimately resulted in better representation and synthesis of the strengths of each individual conservation effort within the Plan.

Table 2.2. Groups invited to participate in a small scale conservation planning meeting and their respective conservation planning efforts, October 2003.

Agency/Organization	Conservation planning effort
NC Natural Heritage Program	Ongoing species and habitat data collection, *'One NC Naturally'* Program
NC Gap Analysis Program	Statewide land cover, species distribution modeling, and stewardship data; NC GAP report
NC Division of Water Quality	Basinwide Plans for the 17 river basins in North Carolina
NC Division of Marine Fisheries *(unable to attend meeting)*	Coastal Habitat Protection Plan
The Nature Conservancy	Ecoregional Plans, Site Conservation Plans

As the text and format of the Plan developed, other small-scale meetings were organized on a variety of topics in order to initiate dialogue and brainstorming. Different stakeholders and partners were called to the table, depending on their interest and expertise. For example, discussions about land conservation strategies involved representatives from The Nature Conservancy and the NC Natural Heritage Program; private lands management meetings involved representatives from the US Fish & Wildlife Service, Natural Resources Conservation Service, the NC Division of Forest Resources, timber industry representatives, and the Southern Environmental Law Center.

Though considered, we opted not to hold a series of public meetings because of first-hand experience and concern expressed among Steering Committee members about the effectiveness of such meetings at actually engaging the public. Instead, we focused our attention on engaging and empowering stakeholder groups to spread the word to their constituencies and on partnering with other conservation initiatives in the state to reach as many people as possible. We recognize a need to do more to engage developer/homebuilder associations and local zoning and planning commissions; we hope that by partnering with other conservation efforts (e.g., the One North

Carolina *Naturally* Initiative, NC Department of Environment and Natural Resources; the Coastal Habitat Protection Plan, NC Division of Marine Fisheries) we will be more effective in our communications with these groups in the future.

Taxa Committees

We used feedback from expert species authorities in the state to assist in prioritizing our species conservation targets *(this process is detailed in the next section, Species Prioritization Process)*. Taxa group committees were initially convened during the spring and summer of 2003 to discuss the results of the species prioritization process. Members of the committees were subsequently involved (to varying degrees depending on their interest) in identifying species and habitat threats, survey, research and monitoring needs, and conservation recommendations. Throughout the Plan development process, we expanded our list of species and habitat authorities such that in the future, formal committee membership will likely grow in size and scope.

Nongame Wildlife Advisory Committee

The Nongame Wildlife Advisory Committee (NWAC) is a standing committee of the Commission that provides guidance on matters of nongame fish and wildlife species and conservation issues. The NWAC is made up of 19 individuals representing state and federal agencies, universities, private industry, and land conservancies. A member of the NWAC served on the Steering Committee during the Plan development process. The Coordinator attended the quarterly meetings of the NWAC to keep them up to date on progress, and individuals on the committee were involved in specific aspects of Plan development as their technical expertise warranted. And as of November 2004, four additional NWAC members were on-hand to provide direct feedback on draft Plan text and were invited to subsequent Steering Committee meetings. The NWAC will continue to be a vital connection to external stakeholders across the state and their role in future revisions and editions of the Plan is expected to become more formalized and substantial.

Media

A variety of media products were developed throughout the Plan development process to highlight the work that the State Wildlife Grants program makes possible and the importance of the Plan in implementing future work. Key examples are listed below (also see Appendix B for copies of select media examples):

- *FIRST AMONG equals* – article in *Wildlife in North Carolina* magazine, February 2004
- 'Back Porch' note in *Wildlife in North Carolina* magazine, August 2004
- 12 + articles in the news media across North Carolina, developed from Commission press releases
- Write-ups in the following newsletters/publications: NC Partners in Flight, NC Chapter of the American Fisheries Society, NC Chapter of The Wildlife Society, NC Conservation Network, NC Sea Grant *Coastwatch* magazine.
- Commission Wildlife Advisory Hotline announcements – the Commission sponsors an e-mail hotline that releases information on various topics to citizens who have signed up to receive such updates. Public comment and review of draft Plan text were solicited in this way, in addition to quarterly email updates.

Stakeholder Input Meeting

On March 2, 2004 the Commission hosted a large-scale meeting in Raleigh to solicit stakeholder input from groups statewide. The meeting was attended by 53 individuals representing 48 different groups, including State and Federal agencies, conservation organizations, private industry, and academia. Our objectives were to: 1) educate stakeholders about the State Wildlife Grants Program and the Wildlife Action Plan, 2) gain a better understanding of the conservation concerns of stakeholders, and 3) learn how stakeholders would like to be involved in the Plan development and implementation process. Stakeholder feedback was solicited through breakout group discussions facilitated by staff of the Watershed Education for Communities and Local Officials office

(Cooperative Extension, NC State University). Stakeholder feedback helped us to verify the importance of issues we were pursuing in the Plan, generated additional issues and topics to consider, and even gave us the ability to identify issues that are important to conservation stakeholders in North Carolina but need to be addressed through avenues beyond the scope of the Plan. One of the most important findings of the meeting was the indication that stakeholders preferred to continue their involvement through smaller, more directed meetings and communications. This, in large part, directed our future approaches to stakeholder involvement. An Executive Summary of the feedback (including a list of attendees) can be found in Appendix C.

Stakeholder Communication and Updates

As a result of our Stakeholder input meeting, we began regular communications and updates with stakeholder groups and partners through quarterly email updates, newsletter announcements, and participation in meetings and conferences. Invited presentations were given at the following meetings: US Fish & Wildlife Service Ecosystem Team meeting, Onslow Bight Conservation Initiative, joint meeting of the NC Chapter of The Wildlife Society and the NC Chapter of the American Fisheries Society. Other meetings the Coordinator participated in included annual meetings of NC Partners in Flight, the inaugural meeting of NC Partners in Amphibian and Reptile Conservation, One North Carolina Naturally initiative regional meetings, and the One North Carolina Naturally 2005 statewide conference.

Web Site

In April 2004, we completed the design and development of a web site dedicated to providing visitors with up-to-date information about the Plan development process (to visit, go to *http://www.ncwildlife.org/fs_index_07_conservation.htm*, or look under the 'Wildlife Species and Conservation' topic from the Commission homepage, *www.ncwildlife.org*). We also used the web site as a clearinghouse for information exchange by:

- Offering visitors the opportunity to sign up as expert resources related to specific species, habitats, or river basins
- Posting chapters of the Plan as they were drafted and soliciting interim external review and comment
- Posting the final draft document and soliciting final external review and comment

Species Prioritization Process

The State Wildlife Grants program established funding for species not traditionally covered under most previous federal funding programs. To qualify for these funds, each state was mandated to develop a Plan with a focus on "species of greatest conservation concern" and "species with greatest conservation need." It was left to the states' discretion as to how they identified these species. Criteria to consider included species that are currently rare or designated as at-risk, those for which we have knowledge deficiencies and those that have not received adequate conservation attention in the past. To identify these priority species in North Carolina, in the fall of 2002 the Commission began developing an iterative prioritization process.

First, a number of different planning/prioritization efforts were reviewed in order to weigh the utility of using a pre-existing database/prioritization effort versus developing a new process. An independent review and prioritization process was developed based on the following requirements: a) we wanted to consider all species within a taxa (regardless of status or threat) at the start of the process, b) we wanted to collect information not previously measured in existing prioritization efforts (e.g., degree of knowledge about a species), and c) we wanted to develop a process that reflected the Commission's mission and goals.

Our goal was to develop a Species Review process that would serve as a tool to set conservation priorities across eight taxonomic groups in North Carolina: amphibians, birds, crayfish, freshwater fish, freshwater snails, freshwater mussels, mammals, and reptiles. The Commission focused the reviews on these eight groups based on jurisdictional and traditional programmatic boundaries, and

the need to initiate the process, recognizing that it could be expanded in the future. This focus does not mean that groups excluded from this process are not addressed within the Plan (see *Note*). Conservation plans, prioritization methodologies and species groups that were not considered for this first edition will be evaluated for inclusion in the Plan during future updates and revisions.

> *Note:* Recognizing that the following groups fall outside the bounds of the aforementioned prioritization process, we have done our best, using existing information, to identify conservation priorities for each of these groups: marine mammals and fish; pelagic birds; insects; arachnids; terrestrial gastropods. We have incorporated species and habitat priorities and conservation recommendations for these groups into the Plan where possible. Marine species (including pelagic birds) are addressed in the Marine Systems section (Chapter 5C). Invertebrates are discussed in Appendix D.

First, we developed complete and accurate lists of species found in North Carolina for each group. Next, through recommendations of the Steering Committee, we developed committees of taxonomic authorities from which to solicit information on each of the eight animal groups (Table 2.3). Generally, the larger the taxa group, the larger the committee. For some groups (e.g., snails and crayfish) we found only one or two individuals who had the knowledge and expertise to conduct a review. It should be noted that our list of expert contacts has grown considerably since we first initiated the Species Review process. Though our initial committees were quite small in size, we would like to recognize all of the individuals who have since contributed their time and expertise to the development of our Plan (see Acknowledgements).

Next, we developed a list of criteria for which we sought information. We collected ideas from a variety of sources to arrive at our final list of criteria: protection status, Natural Heritage ranks, staff feedback, and other prioritization efforts (e.g., Hunter et al., 1993, Millsap et al., 1990). We strove for practicality, simplicity, and utility. We came up with 10 criteria we initially wished to consider (all criteria are defined in detail in Appendix E):

1. State protection status
2. NC Natural Heritage Program state rank (S1-S5)
3. Degree of exploitation/harvest
4. Past or current Commission funding
5. Past or current external funding
6. Feasibility measure
7. Knowledge of the species' population status
8. Population status (trend)
9. Knowledge of species' distribution in the state
10. Knowledge of limiting factors affecting the species

Table 2.3. Taxa committee members, 2002 - 2003.

Species group	Member	Affiliation
Amphibians and Reptiles	Chris McGrath	NC Wildlife Resources Commission
	Alvin Braswell[1]	NC Museum of Natural Sciences
	Jeff Beane	NC Museum of Natural Sciences
	John Sealy	Appalachian State University[2]
Birds	Mark Johns	NC Wildlife Resources Commission
	David Allen	NC Wildlife Resources Commission
	John Gerwin	NC Museum of Natural Sciences
	David Lee[1]	NC Museum of Natural Sciences
	Harry LeGrand	NC Natural Heritage Program
Crayfish	John Cooper	NC Wildlife Resources Commission
	Aimee Fullerton	past employee, NC Wildlife Resources Commission
Freshwater Fish	Scott Van Horn[1]	NC Wildlife Resources Commission
	Steve Fraley	NC Wildlife Resources Commission
	David Yow	NC Wildlife Resources Commission
	Wayne Starnes	NC Museum of Natural Sciences
	Bryn Tracy	NC Division of Water Quality
	Fritz Rohde	NC Division of Marine Fisheries
Freshwater Mussels	Judy Ratcliffe	NC Wildlife Resources Commission
	John Alderman	Private consultant
	Art Bogan[1]	NC Museum of Natural Sciences
Freshwater Snails	Brian Watson	VA Department of Game and Inland Fish
	Art Bogan[1]	NC Museum of Natural Sciences
Mammals	Chris McGrath	NC Wildlife Resources Commission
	Mary Kay Clark	NC Museum of Natural Sciences
	David Webster	University of North Carolina at Wilmington

In December 2002, we initiated the reviews with the taxa committee members, sending each a Word document with directions for completing the reviews and an Excel spreadsheet with the species list and criteria. We supplied the information for criteria 1 and 2; the reviewers were asked to fill in scores for the remaining eight criteria based on their professional expertise, and only for those species they felt qualified to comment on. As review data were received (over approximately 2 months, Jan – Feb 2003), they were compiled in Excel spreadsheets.

Scoring the Reviews

It took considerable time to develop a scoring system appropriate to the criteria. We tested a number of different systems before arriving at one that seemed to work the best across all taxa, that gave appropriate weight to criteria, and that made best use of the information collected in the reviews. We grouped these criteria into two categories: "Concern" group data included those that gave some indication of the species' current status/population concern; "Knowledge" group data included the three metrics of knowledge about a species (Table 2.4).

[1]Member did not provide initial data, but was involved in subsequent discussions.

[2]John Sealy is now with the Rockingham County Department of Public Health.

Table 2.4. Criteria and scores for prioritizing species, 2003.

	Criteria	Measure	Score	Range
'Concern' Group	Protection Status*	Endangered or Threatened	3	1 (lowest concern) – 6 (highest concern) *Keep in mind, a species may not have a Protection status score
		Special Concern	2	
		Significantly Rare	1	
	Population Trend	Decreasing	3	
		Stable	2	
		Increasing	1	
'Knowledge' Group	Knowledge of Population Status	High	3	3 (low knowledge levels, i.e., knowledge deficiencies) – 9 (high knowledge levels)
		Medium	2	
		Low	1	
	Knowledge of Distribution	High	3	
		Medium	2	
		Low	1	
	Knowledge of Factors Affecting the Species	High	3	
		Medium	2	
		Low	1	

Next, we scheduled meetings with each group of reviewers to examine the data and work towards identifying our priority species and conservation goals. At each meeting, we reviewed the lists to discuss priority species and actions that are critical to their conservation. Each list identified a different sort of need—species scoring high on the 'Concern' list likely had immediate population concerns, and may be associated with imperiled habitats in need of protection, restoration, and/or management. Species scoring low on the 'Knowledge' list indicated a need for survey, monitoring, and or research attention in order to improve our overall understanding of them, or to fill a particular knowledge gap.

Each committee reviewed the scored data and generally considered species that fell within the following ranges as priority species:

- Those with a 'Concern' score ≥ 3 (indicating that, at the very least, the species was considered declining, and at most, Endangered), **and/or**
- Those with a 'Knowledge' score of ≤ 5 (indicating low knowledge levels, or knowledge deficiencies, as summed across the three knowledge metrics).

> *Note:* Critical review of the scored data by knowledgeable authorities was essential to this process. This being our first attempt, it would have been rash to assume that scoring process alone could provide the most accurate assessment of prioritization status for each and every species. We anticipate many improvements to the process during future iterations.

The following changes were made as a result of discussions during taxa committee meetings:

- **Birds** – when reviewing the scored data, species at the extreme periphery of their range in the state, accidentals, and/or sporadic migrants were not considered priority species.
- **Freshwater fish** – when reviewing the scored data, species that do not currently exist in the state, species at the extreme periphery of their range in North Carolina and non-native species without direct conservation concerns/impacts (e.g., goldfish) were not considered priority species.

- **Freshwater snails** – the species review data could not be used to prioritize snails species because we know so very little about the taxa as a whole. We used protection status, National Heritage Program ranks, and expert opinion to determine priority snail species.

During May – August of 2003, we compiled the information collected at each of the taxa committee meetings. Some committees (e.g., fish) were reconvened multiple times in order to clarify and finalize priority species listings. As a final consideration, each taxa list was sent back to members of the committees in order that they be afforded the chance to provide final feedback and suggest potential additions or deletions to the list, accompanied by reasoning. Changes to the lists were made when at least two independent reviewers had the same suggestion (except in the cases where there was only one reviewer). (See Table 2.5 for summary statistics).

Table 2.5. Priority species summary statistics, by group.

Group	Total # of species considered	# of priority species	# of priority species with State and/or Federal protection status[3]	# of priority species tracked by NC Natural Heritage Program
Birds	260	92	22	63
Amphibians	80	41	17	28
Reptiles	79	43	20	29
Mammals	80	38	16	27
Freshwater fish	231	83	44	60
Freshwater mussels	56	40	34	48
Crayfish	41	21	8	18
Freshwater snails	62	10	7	9
Total	**889**	**371**	**168**	**276**

Future species prioritization efforts: Our current priority species lists were built on the process outlined above and based on the extent of current information. In future editions of the Plan, as we make improvements to the prioritization process and as new information becomes available, these lists will be subject to modification.

Priority species are listed, by taxa, in the following tables (Tables 2.6-2.13). Extirpated and/or experimental species (and species with questionable status') are identified in Table 2.14.

[3] Endangered, Threatened, or Special Concern

Table 2.6. Bird species prioritized for conservation in North Carolina. *Breeding population focus, unless otherwise noted. Pelagic bird priorities are addressed separately within Chapter 5C (Marine Systems).*

Common Name	Scientific Name	NC Status[1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	NC PIF Priority Species	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Cooper's Hawk	*Accipiter cooperii*	SC	S3S4B, S4N, G5	X	X	X	
Sharp-shinned Hawk	*Accipiter striatus*	SR	S2B, S4N, G5	X		X	
Northern Saw-whet Owl	*Aegolius acadicus*	T	S2B, S2N, G5T?	X	X		S. Appalachian population
Bachman's Sparrow	*Aimophila aestivalis*	SC	S3B, S2N, G3	X	X		
Saltmarsh Sharp-tailed Sparrow	*Ammodramus caudacutus*		SUB, S4N, G4	X		X	
Henslow's Sparrow	*Ammodramus henslowii*	SR	S2B, S1N, G4	X	X	X	
Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*			X		X	Winter
Grasshopper Sparrow	*Ammodramus savannarum*		S3B, S1N, G5	X	X		
Anhinga	*Anhinga anhinga*	SR	S2B, SZN, G5		X		
Short-eared Owl	*Asio flammeus*		SUB, S3N, G5	X		X	Winter
American Bittern	*Botaurus lentiginosus*	SR	S1B, S3N, G4	X	X	X	Winter
Sanderling	*Calidris alba*			X	X		Winter & migration
Red Knot	*Calidris canutus*			X	X		Winter & migration
Chuck-will's-widow	*Caprimulgus carolinensis*			X	X		
Whip-poor-will	*Caprimulgus vociferus*			X	X		
Pine Siskin	*Carduelis pinus*		SZB, S4N, G5	X		X	Mtn. breeding populations
Brown Creeper	*Certhia americana*	SC	S3B, S5N, G5	X	X		Mtn. breeding populations
Chimney Swift	*Chaetura pelagica*			X	X		
Piping Plover	*Charadrius melodus*	T (T)	S2B, S2N, G3	X	X		Winter and breeding
Wilson's Plover	*Charadrius wilsonia*	SR	S3B, SZN, G5	X	X		
Lark Sparrow	*Chondestes grammacus*	SR	S1B, SZN, G5	X	X		
Common Nighthawk	*Chordeiles minor*				X		
Northern Harrier	*Circus cyaneus*	SR	S1B, S4N, G5	X	X		Winter, rare breeder
Sedge Wren	*Cistothorus platensis*			X		X	Winter
Yellow-billed Cuckoo	*Coccyzus americanus*				X		
Black-billed Cuckoo	*Coccyzus erythropthalmus*	SR	S2B, SZN, G5	X	X	X	Mtn. breeding populations
Northern Flicker	*Colaptes auratus*			X	X		
Northern Bobwhite	*Colinus virginianus*			X	X		
Eastern Wood-pewee	*Contopus virens*			X	X		
Yellow Rail	*Coturnicops noveboracensis*	SR	S2N, G4	X	X	X	Winter
Cerulean Warbler	*Dendroica cerulea*	SR	S2B, SZN, G4	X	X		
Prairie Warbler	*Dendroica discolor*			X	X		
Magnolia Warbler	*Dendroica magnolia*	SR	S1B, SZN, G5	X		X	
Chestnut-sided Warbler	*Dendroica pensylvanica*			X	X		
Wayne's Black-throated Green Warbler	*Dendroica virens waynei*	SR	S3B, SZN, G5	X			Disjunct subspecies; small isolated pops. at coast
Bobolink	*Dolichonyx oryzivorus*		SUB, SZN, G5	X	X	X	Erratic breeder, mainly migrant

Note: See Table Key on page 27

Table 2.6 *(continued)*. Bird species prioritized for conservation in North Carolina. *Breeding population focus, unless otherwise noted. Pelagic bird priorities are addressed separately within Chapter 5C (Marine Systems).*

Common Name	Scientific Name	NC Status[1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	NC PIF Priority Species	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Little Blue Heron	*Egretta caerulea*	SC	S3B, S3N, G5	X	X		
Snowy Egret	*Egretta thula*	SC	S3B, S3N, G5	X	X		
Tricolored Heron	*Egretta tricolor*	SC	S3B, S3N, G5	X	X		
Swallow-tailed Kite	*Elanoides forficatus*					X	Possible breeder
Alder Flycatcher	*Empidonax alnorum*	SR	S2B, SZN, G5	X	X		
Willow Flycatcher	*Empidonax traillii*		S3B, SZN, G5	X		X	
Horned Lark	*Eremophila alpestris*			X	X	X	Mtn. breeding populations
Peregrine Falcon	*Falco peregrinus*	E	S1B, S2N, G4	X	X		Mtn. breeding populations
American Kestrel	*Falco sparverius*		S3B, S5N, G5	X			Breeding status in decline over last few decades
Common Moorhen	*Gallinula chloropus*					X	
American Oystercatcher	*Haematopus palliatus*		S3B, S4N, G5	X	X		
Bald Eagle	*Haliaeetus leucocephalus*	T (T)	S3B, S3N, G4	X	X		Year round
Worm-eating Warbler	*Helmitheros vermivorus*		S3B, SZN, G5T?	X			Coastal pops. isolated and small; habitat very limited and declining
Black-necked Stilt	*Himantopus mexicanus*	SR	S2B, G5		X		
Wood Thrush	*Hylocichla mustelina*			X	X		
Orchard Oriole	*Icterus spurius*			X	X		
Mississippi Kite	*Ictinia mississippiensis*	SR	S2B, G5	X		X	
Least Bittern	*Ixobrychus exilis*		S3B, SZN, G5	X	X	X	
Loggerhead Shrike	*Lanius ludovicianus*	SC	S3B, S3N, G4T4	X	X		
Black Rail	*Laterallus jamaicensis*	SR	S3B, S2N, G4	X	X	X	
Swainson's Warbler	*Limnothlypis swainsonii*		S3B, SZN, G4	X	X		
Red Crossbill	*Loxia curvirostra*	SC	S3B, S3N, G5T?	X	X	X	S. Appalachian population
Red-headed Woodpecker	*Melanerpes erythrocephalus*			X	X		Winter & migration
Wood Stork	*Mycteria americana*	E (E)	S1N, G4		X		Post breeders
Yellow-crowned Night-heron	*Nyctanassa violacea*		S3B, SZN, G5	X		X	
Kentucky Warbler	*Oporornis formosus*			X	X		
Savannah Sparrow	*Passerculus sandwichensis*	SR	S1B, S5N, G5T3T4	X	X		Mtn. breeding populations
Eastern Painted Bunting	*Passerina ciris*	SR	S3B, SZN, G4	X	X		
Brown Pelican	*Pelecanus occidentalis*	SR	S3B, S4N, G4	X			Limited nesting sites in NC
Rose-breasted Grosbeak	*Pheucticus ludovicianus*		S3B, SZN, G5				Noticeable declines in breeders (mountains)
Red-cockaded Woodpecker	*Picoides borealis*	E (E)	S2, G3	X	X		
Hairy Woodpecker	*Picoides villosus*					X	
Glossy Ibis	*Plegadis falcinellus*	SC	S2B, SZN, G5	X	X		
Black-capped Chickadee	*Poecile atricapilla*	SC	S3, G5T?	X	X		S. Appalachian population

Note: See Table Key on page 27

Table 2.6 *(continued)*. Bird species prioritized for conservation in North Carolina. *Breeding population focus, unless otherwise noted. Pelagic bird priorities are addressed separately within Chapter 5C (Marine Systems).*

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	NC PIF Priority Species	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Vesper Sparrow	*Pooecetes gramineus*	SR	S2B, S2N, G5	X	X	X	Mtn. breeding populations
Sora	*Porzana carolina*			X		X	Winter
King Rail	*Rallus elegans*		S3B, S3N, G4G5	X	X	X	Year round
Virginia Rail	*Rallus limicola*			X		X	Winter
Black Skimmer	*Rynchops niger*	SC	S3B, S3N, G5	X	X		
American Woodcock	*Scolopax minor*			X	X		
Brown-headed Nuthatch	*Sitta pusilla*			X	X		
Yellow-bellied Sapsucker	*Sphyrapicus varius*	SC	S2B, S5N, G5T?	X	X		Mtn. breeding populations
Dickcissel	*Spiza americana*		S2B, SZN, G5	X	X	X	
Field Sparrow	*Spizella pusilla*			X	X		
Least Tern	*Sterna antillarum*	SC	S3B, SZN, G4	X	X		
Caspian Tern	*Sterna caspia*	SR	S1B, S2N, G5		X		Winter, uncommon breeder
Common Tern	*Sterna hirundo*	SC	S3B, SZN, G5	X	X		
Gull-billed Tern	*Sterna nilotica*	T	S3B, SZN, G5	X	X		
Eastern Meadowlark	*Sturnella magna*			X	X		
Eastern Kingbird	*Tyrannus tyrannus*			X	X		
Barn Owl	*Tyto alba*		S3B, S3N, G5	X	X		
Golden-winged Warbler	*Vermivora chrysoptera*	SR	S3B, SZN, G4	X	X		
Blue-winged Warbler	*Vermivora pinus*	SR	S2B, SZN, G5	X	X	X	
Canada Warbler	*Wilsonia canadensis*			X	X		
Hooded Warbler	*Wilsonia citrina*			X			PIF high priority; breeding habitat becoming limited

Note: See Table Key on page 27

Table 2.7. Mammal species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Star-nosed Mole	*Condylura cristata pop. 1*	SC	S2, G5T2Q		X	Coastal population
Rafinesque's Big-eared Bat	*Corynorhinus rafinesquii*	T	S3, G3G4	X		
Virginia Big-eared Bat	*Corynorhinus townsendii virginianus*	E (E)	S1, G4T2	X		
Least Shrew	*Cryptotis parva*				X	Species complex?
Carolina Northern Flying Squirrel	*Glaucomys sabrinus coloratus*	*E (E)*	S2, G5T1	X		
Silver-haired Bat	*Lasionycteris noctivagans*	SR			X	
Hoary Bat	*Lasiurus cinereus*	SR				
Northern Yellow Bat	*Lasiurus intermedius*	SR	SU, G4G5		X	
Seminole Bat	*Lasiurus seminolus*		S3B, SZN, G5		X	
Southern Rock Vole	*Microtus chrotorrhinus carolinensis*	SC	S3, G4T3	X		
Meadow Vole	*Microtus pennsylvanicus*				X	Species complex?
Long-tailed Weasel	*Mustela frenata*		S3S4, G5		X	
Least Weasel	*Mustela nivalis*	SR	S2, G5	X	X	
Southeastern Bat	*Myotis austroriparius*	SC	S2?, G3G4	X	X	
Gray Bat	*Myotis grisescens*	E (E)	SA, G3	X		
Small-footed Bat	*Myotis leibii*	SC	SUB, S2N, G3	X	X	
Northern Long-eared Bat	*Myotis septentrionalis*	SC	SUB, S3N, G4	X		
Indiana Bat	*Myotis sodalis*	E (E)	SUB, SZN, G2	X		
Woodland Jumping Mouse	*Napaeozapus insignis*				X	
Eastern Woodrat	*Neotoma floridana*	T (CP pop), SC (M pop)	CP: S1, G5T5 M: S3, G5T4Q	X		
Allegheny Woodrat	*Neotoma magister*	SC	S2, G3G4	X		
Hairy-tailed Mole	*Parascalops breweri*				X	
Cotton Mouse	*Peromyscus gossypinus*				X	
White-footed Mouse	*Peromyscus leucopus easti*	SC	S2, G5T1	X		Coastal subspecies
Old-field Mouse	*Peromyscus polionotus*	SR	S1, G5		X	
Eastern Mole	*Scalopus aquaticus*				X	Species complex?
Eastern Fox Squirrel	*Sciurus niger*	SR	S3, G5	X		
Masked Shrew	*Sorex cinereus*				X	Species complex?
Rock Shrew	*Sorex dispar*	SC	S2, G4		X	
Smoky Shrew	*Sorex fumeus*				X	
Southern Pygmy Shrew	*Sorex hoyi winnemana*		S3, G5T4		X	
Water Shrew	*Sorex palustris*	SC	S2, G5T3		X	
Eastern Spotted Skunk	*Spilogale putorius*		S3, G5		X	
Appalachian Cottontail	*Sylvilagus obscurus*	SR	S3, G4		X	
Marsh Rabbit	*Sylvilagus palustris*				X	
Southern Bog Lemming	*Synaptomys cooperi helaletes*	SR	S2, G5T3	X		Coastal subspecies
Manatee	*Trichechus manatus*	E (E)	S1N, G2	X	X	
Meadow Jumping Mouse	*Zapus hudsonius*		S3, G5		X	

Note: See Table Key on page 27

Table 2.8. Amphibian species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Mabee's Salamander	*Ambystoma mabeei*	SR	S3, G4	X		
Spotted Salamander	*Ambystoma maculatum*			X		
Marbled Salamander	*Ambystoma opacum*			X		
Mole Salamander	*Ambystoma talpoideum*	SC	S2, G5	X		
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	T	S2, G5	X		
Green Salamander	*Aneides aeneus*	E	S2, G3G4	X		
Oak Toad	*Bufo quercicus*	SR	S3, G5			
Eastern Hellbender	*Cryptobranchus alleganiensis allaganiensis*	SC	S3, G3G4	X		
Seepage Salamander	*Desmognathus aeneus*	SR	S3, G3G4	X		
Southern Dusky Salamander	*Desmognathus auriculatus*				X	
Shovel-nosed Salamander	*Desmognathus marmoratus*					Specific habitat association (high quality streams)
Pigmy Salamander	*Desmognathus wrighti*	SR	S3, G3G4	X		
Three-lined Salamander	*Eurycea guttolineata*					Limited knowledge; key breeding sites being lost to development
Junaluska Salamander	*Eurycea junaluska*	T	S2, G3	X		
Longtail Salamander	*Eurycea l. longicauda*	SC	S1S2, G5T5	X	X	
Dwarf Salamander	*Eurycea quadridigitata*	SC	S2, G5T2Q	X		
Sandhills Salamander	*Eurycea sp. 1*		S3?, G3?Q			Undescribed species, very limited range
Four-toed Salamander	*Hemidactylium scutatum*	SC	S3, G5	X	X	
Pine Barrens Treefrog	*Hyla andersonii*		S3S4, G4	X		
Barking Treefrog	*Hyla gratiosa*			X		
Northern Gray Treefrog	*Hyla versicolor*	SR	SU, G5		X	
Neuse River Waterdog	*Necturus lewisi*	SC	S3, G3	X		
Common Mudpuppy	*Necturus maculosus*	SC	SH, G5	X	X	
Tellico Salamander	*Plethodon aureolus*	SR	S2, G2G3Q		X	
Chattahoochee Slimy Salamander	*Plethodon chattahoochee*					Need to know more about their distribution within NC and be able to better identify
Northern Slimy Salamander	*Plethodon glutinosus sensustricto*				X	
Southern Ravine Salamander	*Plethodon richmondi*		S3, G5		X	
Southern Zigzag Salamander	*Plethodon ventralis*	SC	S1, G4	X	X	
Wehrle's Salamander	*Plethodon wehrlei*	T	S1, G5	X	X	
Weller's Salamander	*Plethodon welleri*	SC	S2, G3	X	X	
Crevice Salamander	*Plethodon longicrus*	SC	S1, G4T1Q	X		

Note: See Table Key on page 27

Table 2.8 *(continued)*. Amphibian species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Mountain Chorus Frog	*Pseudacris brachyphona*	SC	S1, G5	X	X	
Brimley's Chorus Frog	*Pseudacris brimleyi*		S3S4, G5	X	X	
Striped Southern Chorus Frog	*Pseudacris nigrita nigrita*			X		
Ornate Chorus Frog	*Pseudacris ornata*	SR	S3, G5	X		
Carolina Gopher Frog	*Rana capito*	T	S2, G3	X		
River Frog	*Rana heckscheri*	SC	SH, G5	X	X	
Eastern Spadefoot	*Scaphiopus holbrookii*			X		
Eastern Lesser Siren	*Siren intermedia intermedia*			X	X	
Greater Siren	*Siren lacertina*				X	
Many-lined Salamander	*Stereochilus marginatus*				X	

Table 2.9. Reptile species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
American Alligator	*Alligator mississippiensis*	T (T)	S3, G5	X		
Gulf Coast Spiny Softshell	*Apalone spinifera aspera*		S3, G5T5		X	
Eastern Spiny Softshell	*Apalone spinifera spinifera*	SC	S1, G5T5		X	
Loggerhead Sea Turtle	*Caretta caretta*	T (T)	S3B, S3N, G3	X		
Northern Scarletsnake	*Cemophora coccinea copei*			X	X	
Green Sea Turtle	*Chelonia mydas*	T (T)	S1B, SZN, G3	X		
Spotted Turtle	*Clemmys guttata*		S3, G5			Concerns over habitat loss and road mortality
Bog Turtle	*Clemmys muhlenbergii*	T (T)	S2, G3	X		
Eastern Diamond-backed Rattlesnake	*Crotalus adamanteus*	E	S1, G4	X		
Timber Rattlesnake	*Crotalus horridus*	SC	S3, G4	X		
Eastern Chicken Turtle	*Deirochelys reticularia*	SR	S3, G5	X	X	
Leatherback Sea Turtle	*Dermochelys coriacea*	E (E)	SAB, SZN, G3	X		
Corn Snake	*Elaphe guttata guttata*			X		
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	E (E)	SZN, G3	X		
Coal Skink	*Eumeces anthracinus*		S3, G5		X	
Broad-headed Skink	*Eumeces laticeps*				X	
Eastern Mudsnake	*Farancia abacura abacura*				X	
Common Rainbow Snake	*Farancia erytrogramma erytrogramma*				X	
Eastern Hog-nosed Snake	*Heterodon platirhinos*				X	
Southern Hog-nosed Snake	*Heterodon simus*	SC	S2, G2	X	X	

Note: See Table Key on page 27

Table 2.9 *(continued)*. Reptile species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Striped Mud Turtle	*Kinosternon baurii*		S3?, G5		X	
Mole Kingsnake	*Lampropeltis calligaster rhombomaculata*				X	
Eastern Kingsnake	*Lampropeltis getula getula*				X	
Outer Banks Kingsnake	*Lampropeltis getula sticticeps*	SC	S2, G5T2Q	X		
Scarlet Kingsnake	*Lampropeltis triangulum elapsoides*		S3, G5T5		X	
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	E (E)	SAB, SZN, G1	X		
Diamond-backed Terrapin	*Malaclemys terrapin*	SC	S3, G4T4	X		
Eastern Coachwhip	*Masticophis flagellum*	SR	S3, G5	X	X	
Eastern Coral Snake	*Micrurus fulvius*	E	S1, G5	X	X	
Carolina Watersnake	*Nerodia sipedon williamengelsi*	SC	S3, G5T3	X		
Smooth Greensnake	*Opheodrys vernalis*	SC	SH, G5		X	
Eastern Slender Glass Lizard	*Ophisaurus attenuatus longicaudus*		S3, G5	X	X	
Mimic Glass Lizard	*Ophisaurus mimicus*	SC	S2, G3	X	X	
Northern Pine Snake	*Pituophis melanoleucus melanoleucus*	SC	S3, G4T4	X		
Glossy Crayfish Snake	*Regina rigida*	SR	S2S3, G5			Incomplete data indicates knowledge deficits; rare
Pine Woods Littersnake	*Rhadinaea flavilata*		S3, G4		X	
Black Swamp Snake	*Seminatrix pygaea*	SR		X	X	
Pygmy Rattlesnake	*Sistrurus miliarius*	SC	S3, G5	X		
Loggerhead Musk Turtle	*Sternotherus minor*	SC	S1, G5		X	
Southeastern Crowned Snake	*Tantilla coronata*			X	X	
Eastern Box Turtle	*Terrapene carolina*					Concerns over habitat loss and road mortality
Common Ribbonsnake	*Thamnophis sauritus sauritus*				X	
Eastern Smooth Earthsnake	*Virginia valeriae valeriae*				X	

Note: See Table Key on page 27

Table 2.10. Freshwater fish species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Shortnose Sturgeon	*Acipenser brevirostrum*	E (E)	S1, G3	X		
Atlantic Sturgeon	*Acipenser oxyrhynchus*	SC	S3, G3	X	X	
Roanoke Bass	*Ambloplites cavifrons*	SR	S3, G3	X		
Snail Bullhead	*Ameiurus brunneus*		S3, G4		X	
River Carpsucker	*Carpiodes carpio*	SC	SH, G5	X	X	
Quillback	*Carpiodes cyprinus*			X	X	
Highfin Carpsucker	*Carpiodes velifer*	SC	S2, G4G5	X		
LittleTennessee Rosyside Dace	*Clinostomus funduloides ssp.*	SC	S2, G5T3Q	X		Otherwise known as "Smoky dace"
Blue Ridge Sculpin	*Cottus caeruleomentum*	SR	S1, G4	X		
Spotfin Chub	*Cyprinella monacha*	T (T)	S1, G2	X		
Thinlip Chub	*Cyprinella sp. (cf. zanema)*	SC	S2, G4T2Q	X		
Carolina Pygmy Sunfish	*Elassoma boehlkei*	T	S1, G2	X		
Everglades Pygmy Sunfish	*Elassoma evergladei*				X	
Banded Pygmy Sunfish	*Elassoma zonatum*				X	
Blackbanded Sunfish	*Enneacanthus chaetodon*		S3, G4	X	X	
Banded Sunfish	*Enneacanthus obesus*			X	X	
Blotched Chub	*Erimystax insignis*	SR	S2, G3G4	X		
Lake Chubsucker	*Erimyzon sucetta*				X	
Sharphead Darter	*Etheostoma acuticeps*	T	S1, G3	X		
Carolina Darter	*Etheostoma collis*	SC	S2, G3T3Q	X		
Turquoise Darter	*Etheostoma inscriptum*	SC	S1, G4	X		
Blueside Darter	*Etheostoma jessiae*	SC	SH, G4Q	X	X	Extirpated?
Kanawha Darter	*Etheostoma kanawhae*	SR	S2, S3, G4	X		
Pinewoods Darter	*Etheostoma mariae*	SC	S3, G3	X		
Johnny Darter	*Etheostoma nigrum*			X		
Waccamaw Darter	*Etheostoma perlongum*	T	S2, G1Q	X		
Riverweed Darter	*Etheostoma podostemone*	SC	S2, G4	X		
Glassy Darter	*Etheostoma vitreum*			X		
Wounded Darter	*Etheostoma vulneratum*	SC	S2, G3	X	X	
Tonguetied Minnow	*Exoglossum laurae*	SR	S2, G4	X	X	
Cutlips Minnow	*Exoglossum maxillangua*	E	S1, G5	X		
Banded Killifish	*Fundulus diaphanus*				X	
Lake Phelps Killifish	*Fundulus cf. diaphanus*	SR	S1,GUQ	X		Formery considered part of *F. waccamensis*
Lined Topminnow	*Fundulus lineolatus*			X	X	
Waccamaw Killifish	*Fundulus waccamensis*	SC	S1, G1QT1	X		
Least Killifish	*Heterandria formosa*	SC	S1, G5	X	X	
Rosyface Chub	*Hybopsis rubifrons*	T	S1, G4	X		
Roanoke Hog Sucker	*Hypentelium roanokense*	SR	S3, G4T2Q	X		
Mountain Brook Lamprey	*Ichthyomyzon greeleyi*				X	
Smallmouth Buffalo	*Ictiobus bubalus*				X	
Brook Silverside	*Labidesthes sicculus*				X	
Least Brook Lamprey	*Lampetra aepyptera*	T	S2, G5T3Q	X	X	

Note: See Table Key on page 27

Table 2.10 *(continued)*. Freshwater fish species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
American Brook Lamprey	*Lampetra appendix*	T	S1, G4	X	X	
Dollar Sunfish	*Lepomis marginatus*				X	
Spotted Sunfish	*Lepomis punctatus*		S3, G5		X	
Bluefin Killifish	*Lucania goodei*	SC	S1, G5	X		
Striped Shiner	*Luxilis chrysocephalus*	T	S1, G5			Range restrictions, phylogenetic differences in NC populations?
Pinewoods Shiner	*Lythrurus matutinus*	SR	S3, G3	X		
Waccamaw Silverside	*Menidia extensa*	T (T)	S1, G1	X		
Notchlip Redhorse	*Moxostoma collapsum*			X		
Shorthead Redhorse	*Moxostoma macrolepidotum*			X		
V-lip Redhorse	*Moxostoma pappillosum*			X		
Robust Redhorse	*Moxostoma robustum*	SC	S1, G1	X		
Sicklefin Redhorse	*Moxostoma spp 1*	SR	S1S2, G2G3Q	X		
Carolina redhorse	*Moxostoma spp 2*	SR	S1S2, S1G2Q	X	X	
Comely Shiner	*Notropis amoenus*				X	
Bridle Shiner	*Notropis bifrenatus*	SC	S1, G5	X	X	
Ironcolor Shiner	*Notropis chalybaeus*			X	X	
Yellowfin Shiner	*Notropis lutipinnis*	SC	S3, G4Q	X		
Taillight Shiner	*Notropis maculatus*		S2, G5	X	X	
Cape Fear Shiner	*Notropis mekistocholas*	E (E)	S1, G1	X		
Silver Shiner	*Notropis photogenis*				X	
Rosyface Shiner	*Notropis rubellus*				X	
Mimic Shiner	*Notropis volucellus*		S3, G5		X	
Mountain Madtom	*Noturus eleutherus*	SC	SH, G4	X	X	Extirpated?
Stonecat	*Noturus flavus*	E	S1, G5	X	X	
Carolina Madtom	*Noturus furiosus*	SC	S2, G3T2Q	X	X	
Orangefin Madtom	*Noturus gilberti*	E	S1, G2	X	X	
Broadtail Madtom	*Noturus n. sp.*	SC	S1,G2	X		
Tangerine Darter	*Percina aurantiaca*		S3, G4		X	
Blotchside Darter	*Percina burtoni*	E	S1, G2	X	X	
Logperch	*Percina caprodes*	T	S1, G5	X	X	
Longhead Darter	*Percina macrocephala*	SC	SX, G3	X	X	Extirpated?
Blackbanded Darter	*Percina nigrofasciata*	SR	S1, G5	X	X	
Sharpnose Darter	*Percina oxyrhynchus*	SC	S1, G4	X	X	
Olive Darter	*Percina squamata*	SC	S2, G3	X		
Sea Lamprey	*Petromyzon marinus*			X	X	
Kanawha Minnow	*Phenacobius teretulus*	SC	S2S3, G3G4	X		
Bluntnose Minnow	*Pimephales notatus*				X	
Sailfin Molly	*Poecilia latipinna*	SR	S2?, G5		X	2001 data; as of 2004, NCNHP no longer lists estuarine/marine species.
Brook Trout	*Salvelinus fontinalis*			X		
Bigeye Jumprock	*Scartomyzon ariommus*	T	S2, G4	X		
Sandhills Chub	*Semotilus lumbee*	SC	S3, G3	X		
Rustyside Sucker	*Thoburnia hamiltoni*	E	S1, G3	X		

Note: See Table Key on page 27

Table 2.11. Freshwater mussel species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Dwarf Wedgemussel	*Alasmidonta heterodon*	E (E)	S1, G1G2	X		
Appalachian Elktoe	*Alasmidonta raveneliana*	E (E)	S1, G1	X		
Carolina Elktoe	*Alasmidonta robusta*	SR	S1,G1	X		
Triangle Floater	*Alasmidonta undulata*	T	S2, G4	X		
Brook Floater	*Alasmidonta varicosa*	E	S1, G3	X		
Slippershell Mussel	*Alasmidonta viridis*	E	S1, G4G5	X		
Barrel Floater	*Anodonta couperiana*	E	SH,G4	X		
Alewife Floater	*Anodonta implicata*	T	S1, G5	X		
Purple Wartyback	*Cyclonaias tuberculata*	E	S1, G5	X		
Box Spike	*Elliptio cistellaeformis*		SU, G4Q	X		
Carolina Slabshell	*Elliptio congaraea*		S3, G4	X		
Spike	*Elliptio dilatata*	SC	S1, G5	X		
Pod Lance	*Elliptio folliculata*	SC	S1, G2G3Q	X		
Variable Spike	*Elliptio icterina*			X		
Yellow Lance	*Elliptio lanceolata*	E	S1, G2G3	X		
Cape Fear Spike	*Elliptio marsupiobesa*	SC	SU, G3Q	X		
Roanoke Slabshell	*Elliptio roanokensis*	T	S1, G2G3	X		
Tar River Spinymussel	*Elliptio steinstansana*	E (E)	S1, G1	X		
Waccamaw Spike	*Elliptio waccamawensis*	E	S1, G2Q	X		
Tennessee Pigtoe	*Fusconaia barnesiana*	E	S1, G2G3	X		
Atlantic Pigtoe	*Fusconaia masoni*	E	S1, G2	X		
Longsolid	*Fusconaia subrotunda*	SR	S1, G3	X		
Yellow Lampmussel	*Lampsilis cariosa*	E	S1, G3G4	X		
Wavyrayed Lampmussel	*Lampsilis fasciola*	SC	S1, G4	X		
Waccamaw Fatmucket	*Lampsilis fullerkati*	T	S1, G1Q	X		
Carolina Fatmucket	*Lampsilis radiata conspicua*	T	S1?, G5T2Q	X		
Eastern Lampmussel	*Lampsilis radiata radiata*	T	S1S2, G5T5	X		
Carolina Heelsplitter	*Lasmigona decorata*	E (E)	S1, G1	X		
Tennessee Heelsplitter	*Lasmigona holstonia*	E	S1, G3	X		
Green Floater	*Lasmigona subviridus*	E	S1, G3	X		
Tidewater Mucket	*Leptodea ochracea*	T	S1, G4	X		
Eastern Pondmussel	*Ligumia nasuta*	T	S1, G4G5	X		
Littlewing Pearlymussel	*Pegias fabula*	E (E)	S1, G1	X		
James Spinymussel	*Pleurobema collina*	SR (E)	S1, G1	X		
Tennessee Clubshell	*Pleurobema oviforme*	E	S1?, G3	X		
Creeper (Squawfoot)	*Strophitus undulatus*	T	S2S3, G5	X		
Savannah Lilliput	*Toxolasma pullus*	E	S1, G2	X		
Notched Rainbow	*Villosa constricta*	SC	S3, G3	X		
Eastern Creekshell	*Villosa delumbris*	SR	S3, G4	X		
Rainbow	*Villosa iris*	SC	S1, G5	X		
Cumberland Bean	*Villosa trabalis*	SR (E)	S1,G1	X		
Mountain Creekshell	*Villosa vanuxemensis*	T	S1, G4	X		
Carolina Creekshell	*Villosa vaughaniana*	E	S2, G2	X		

Note: See Table Key on page 27

Table 2.12. Freshwater crayfish species prioritized for conservation in North Carolina.

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Population Trend Concern[3]	Knowledge Deficiencies[4]	Additional Information[5]
Spinytail Crayfish	*Cambarus acanthura*	SR	S1, G4		X	
Greensboro Burrowing Crayfish	*Cambarus catagius*	SC	S2, G3	X		
Oconee Stream Crayfish	*Cambarus chaugaensis*	SC	S2, G2	X	X	
Carolina Ladle Crayfish	*Cambarus davidi*	SR	S2S3,G2G3			
Little Tennessee River Crayfish	*Cambarus georgiae*	SC	S2S3, G1	X	X	
Hiwassee Crayfish	*Cambarus hiwasseensis*		S3S4, G3G4		X	
Sandhills Spiny Crayfish	*Cambarus hystricosus*	SR	S2,G2			
Broad River Stream Crayfish	*Cambarus lenati*	SR	S2, G1G2	X	X	
Knotty Burrowing Crayfish	*Cambarus nodosus*	SR	S2, G4		X	
Hiwassee Headwaters Crayfish	*Cambarus parrishi*	SC	S2S3, G1	X	X	
French Broad River Crayfish	*Cambarus reburrus*	SR	S2S3, G3G4		X	
Broad River Spiny Crayfish	*Cambarus spicatus*	SC	S2, G3	X	X	
Tuckasegee Stream Crayfish	*Cambarus tuckasegee*	SR	S1, G1		X	
North Carolina Spiny Crayfish	*Orconectes carolinensis*	SC	S4, G3	X	X	
No common name until status finalized	*Orconectes sp. 1*	SR	S2?, G?		X	
Chowanoke Crayfish	*Orconectes virginiensis*	SC	S3, G3	X	X	
Edisto Crayfish	*Procambarus ancylus*		S3, G4G5			Distribution very uncertain, mostly because of taxonomic difficulties
Santee Crayfish	*Procambarus blandingii*		S3S4, G4			Distribution very uncertain, mostly because of taxonomic difficulties
Waccamaw Crayfish	*Procambarus braswelli*	SC	S2S3, G2G3	X	X	
Tar River Crayfish	*Procambarus medialis*		S2, G3		X	
Croatan Crayfish	*Procambarus plumimanus*	SR	S3, G4	X		

Note: See Table Key on page 27

Table 2.13. Freshwater snail species prioritized for conservation in North Carolina. *The Species Review process was not an effective tool for prioritizing snails species because we know so very little about the taxa as a whole that the criteria could not be assessed. We relied on listing status, the Natural Heritage program ranks, and expert opinion to determine priority snail species.*

Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]	Additional Information[5]
Waccamaw Snail	*Amnicola sp.*	SC	S1, G?	
Waccamaw Siltsnail	*Cincinnatia sp.*	SC	S1, G?	
Christy's Elimia	*Elimia christyi*	E	S1, G1	Previously know by *E. interputa*
Blackwater Ancylid	*Ferrissia hendersoni*	SC	S1, G5	
Greenfield Rams-horn	*Helisoma eucosmium*	E	S1, G1Q	
Seep Mudalia	*Leptoxis dilatata*	T	S1, G2?	
Smooth Mudalia	*Leptoxis virigata*	SR	SU, G2	
Magnificent Rams-horn	*Planorbella magnifica*	E	S1, G1	
Panhandle Pebblesnail	*Somatogyrus virginicus*	SR	S1?, G1G2	
Rotund Mysterysnail	*Viviparus intertextus*	SR	S2?,G3G4	

Table 2.14. Extirpated species, experimental populations, and/or species with questionable distributions in North Carolina. *For those reasons, the species were not included in the priority listings by habitat or river basin (Chapters 5A and 5B).*

Group	Common Name	Scientific Name	NC Status [1] (Federal Status)	Natural Heritage Program State and Global Rank[2]
Birds	Ivory-billed Woodpecker	*Campephilus principalis*	(E)	SX, GH
	Carolina Parakeet	*Conuropsis carolinensis*		SX, GX
	Passenger Pigeon	*Ectopistes migratorius*		SX, GX
Mammals	American Bison	*Bos bison*		SX, G4
	Gray Wolf	*Canis lupus*		SX, G4
	Red Wolf (experimental population)	*Canis rufus*	SR (E- XN)	S1, G1
	Elk (experimental population)	*Cervus canadensis*	SC	S1, G5
	North American Porcupine	*Erethizon dorsatum*		SX, G5
	Snowshoe Hare	*Lepus americanus*		SX, G5
	Fisher	*Martes pennanti*		SX, G5
	Eastern Cougar	*Puma concolor couguar*	E (E)	SH, G5TH
Mussels	Oyster Mussel	*Epioblasma capsaeformis*	EX (E)	SX, G1
	Cumberland Moccasinshell	*Medionidus conradicus*	EX	SX, G3G4
	Kidneyshell	*Ptychobranchus fasciolaris*	EX	SX, G4G5
	Pimpleback	*Quadrula pustulosa*	EX	SX, G5
	Purple Lilliput	*Toxolasma lividus*	EX	SX, G2
	Pistolgrip	*Tritogonia verrucosa*	EX	SH, G4
Freshwater fish	Lake Sturgeon	*Acipenser fulvescens*	SC	SX, G3G4
	Longear Sunfish	*Lepomis megalotis*	EX	SX, G5

Note: See Table Key on page 27

Table Footnotes

1 NC Status – Endangered (E); Threatened (T); Special Concern (SC); Significantly Rare (SR), Extirpated (EX). E, T, and SC status species are given legal protection status by the NC Wildlife Resources Commission. SR status is defined as any species which has not been listed by the NC Wildlife Resources Commission as Endangered, Threatened, or Special Concerns species, but which exists in the state in small numbers and has been determined by the NC Natural Heritage Program to need monitoring. Extirpated species are no longer believed to occur in the state. Federal status is indicated in parentheses.

2 A measure of rarity and threat status, used here as a metric of population abundance (rankings and information below taken from LeGrand and Hall 2001, then updated with LeGrand et al., 2004):

State rank

S1 (1–5 extant populations): Critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina.

S2 (6–20): Imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina.

S3 (21–100): Rare or uncommon in North Carolina.

S4 (100–1000): Apparently secure in North Carolina, with many occurrences

S5 (1000+): Demonstrably secure in North Carolina and essentially ineradicable under present conditions.

SA (1–?): Accidental or casual; one to several records for North Carolina, but the state is outside the normal range of the species.

SH (0?): Of historical occurrence in North Carolina, perhaps not having been verified in the past 20 years, and suspected to still be extant.

SR (--): Reported from North Carolina, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.

SX (0): Apparently extirpated from North Carolina.

SU (--): Possibly in peril in North Carolina but status uncertain; need more information

S? (--): Unranked, or rank uncertain

_B (1–?): Rank of breeding population in the state. Used for migratory species only.

_N (1–?): Rank of non-breeding population in the state. Used for migratory species only.

_Z_ (1–?): Population is not of signification conservation concern

Global rank - applies to the status of a species throughout its range, and based on data on the species' status range wide.

G1 (1–5 extant populations): Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction.

G2 (6–20): Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 (21–100): Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or because of other factors making it vulnerable to extinction throughout its range.

G4 (100–1000): Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 (1000+): Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GH (0?): Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the expectation that it may be rediscovered.

GX (0): Believed to be extinct throughout its range (e.g., Passenger Pigeon) with virtually no likelihood that it will be rediscovered.

GU (--): Possibly in peril range-wide, but status uncertain; need more information

G? (--): Unranked, or rank uncertain

G_Q (--): Questionable taxonomic assignment.

T_ (--): The rank of a subspecies or variety.

3 Species Review data indicated population trend concerns ranging from, at minimum, a perceived population decline, to Endangered status.

4 Species Review data indicated knowledge level deficiencies as summed across three metrics: knowledge of population status (P), knowledge of distribution (D), knowledge of limiting factors affecting the species (F).

5 Additional information, including population focus, pending status recommendations, and/or reasons for inclusion of species added during the final review phase of the prioritization process (meaning those that did not have an 'X' in the 'Population' or 'Knowledge' columns).

CP = Coastal Plain populations ; P= Piedmont populations ; M= Mountain populations (Southern Blue Ridge)

Habitats and River Basins

Employing a fine-filter/coarse-filter approach, we felt it appropriate to not only develop a set of species priorities, but to ensure that habitat-scale conservation priorities were an integral part of our Plan (indeed, we use habitat-scale approaches more often than species-specific approaches in order to accomplish conservation at a landscape level). So once we identified our set of priority species, we asked experts from each taxonomic committee to supply habitat association or river basin distribution information for each species on the list. Designations were identified in the following manner:

A NC Natural Heritage Program report (2001), developed from the *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990), was used as the basis for terrestrial habitat designations. Through Technical Committee feedback, designations were modified to improve the scale and specificity of particular habitats with respect to the conservation needs addressed in the Plan. This resulted in a total of 23 habitat types. A crosswalk was developed between these designations and the 1992 NC Gap Analysis Program (NC GAP) land cover classification in order to standardize habitat labels for mapping purposes (Appendix F). Habitats were linked to ecoregions using designations based on Bailey (1995) (Figure 2.2, Table 2.15). Appendix G indicates habitat associations for priority terrestrial species by taxonomic group. (See Chapter 5A for more on this topic).

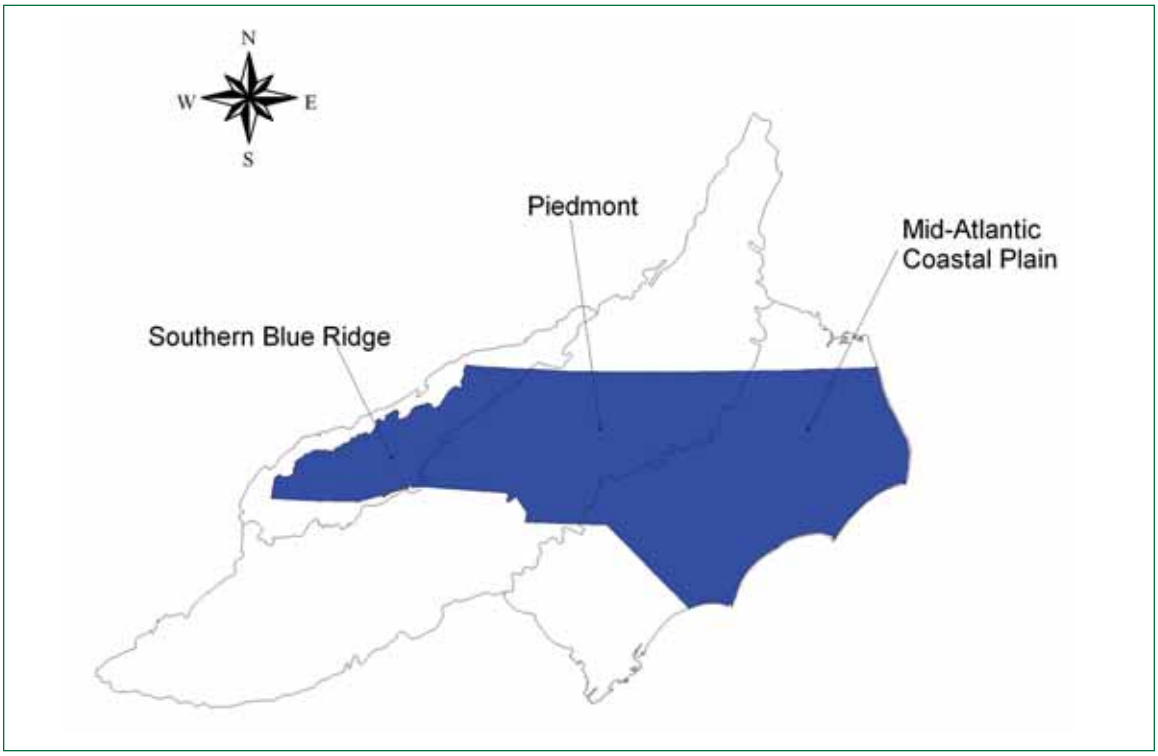


Figure 2.2. Ecoregional designations according to Bailey (1995) (data source: NC GAP).

Table 2.15. Terrestrial habitat, river basin, and coastal habitat designations.

		Ecoregion		
		Mid-Atlantic Coastal Plain	**Piedmont**	**Southern Blue Ridge**
Terrestrial habitats	Beach/dune	X		
	Estuarine communities	X		
	Maritime forest/shrub	X		
	Tidal swamp forest and wetlands	X		
	Nonalluvial mineral wetlands		X	
	Small wetland communities	X	X	
	Wet pine savanna	X		
	Pocosin	X		
	Dry longleaf pine forest[4]	X	*	
	Lakes and reservoirs	X	X	
	Riverine aquatic communities	X	X	X
	Floodplain forest	X	X	X
	Early successional	X	X	X
	Oak forest (& mixed hardwoods/pine)	X	X	X
	Dry coniferous woodlands	X	X	X
	Mesic forest	X	X	
	Low elevation cliffs/rock outcrops[4]		*	X
	High elevation rock outcrops			X
	Caves and mines			X
	Bogs and associated wetlands[4]		*	X
	Cove forest			X
	Northern hardwoods			X
	Spruce-fir forest			X
River basins	White Oak	Catawba		
	Lumber	Broad		
	Chowan	Savannah		
	Pasquotank	New		
	Tar-Pamlico	Watauga		
	Neuse	French Broad		
	Cape Fear	Little Tennessee		
	Roanoke	Hiwassee		
	Yadkin-PeeDee			
Coastal (estuarine and marine) habitats	Water column			
	Shell bottom			
	Submerged aquatic vegetation			
	Wetlands			
	Soft bottom			
	Ocean hard bottom			

[4]Some habitats are found at the periphery of or in scattered locations within a second ecoregion not designated in the table above. To reduce redundancy, we have simply made note of these instances within the text of the primary habitat section and we have indicated that recommendations therein would apply to the habitat, wherever it is found. A (*) indicates additional ecoregion(s) where the habitat can be found.

River basins served as the organizing theme for aquatic species (Table 2.15). Designations are based on the NC Division of Water Quality boundaries. Basin distributions were identified for all priority aquatic species. Appendix H indicates river basin distributions for priority aquatic species by taxonomic group. (See more about this in Chapter 5B).

Estuarine and marine habitat designations (referred to in detail within Chapter 5C), are based on the habitats included in the Coastal Habitat Protection Plan (Street et al., 2004) (Table 2.15).

References

Bailey, R. G. 1995. Descriptions of the ecoregions of the United States. Report #1391. U.S. Department of Agriculture, Forest Service.

Hunter, W. C., M. F. Carter, D. N. Pashley, and K. Barker. 1993. The Partners in Flight species prioritization scheme. Pages 109–171 *in* Status and management of neotropical migratory birds. U.S. Forest Service General Technical Report, RM 229.

LeGrand, H. E. and S. P. Hall. 2001. 2001 Natural Heritage Program List of the Rare Animal Species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs 54:1–57.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Raleigh, NC.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

CHAPTER 3.
THE STATE OF THE STATE

The Condition of Our Resources

The following section highlights basic information about natural resources in North Carolina. This information provides a benchmark by which to assess future needs and concerns associated with fish and wildlife species and their habitats.

Land Use

The Natural Resources Conservation Service conducts a National Resources Inventory (NRI) approximately every five years. This report is a key resource on the status, condition, and trends of soil, water, and land resources across the country. According to the 1997 NRI, the total surface area of North Carolina is 33,709,300 acres, including water areas (Figure 3.1). The vast majority of the state is characterized as nonfederal rural lands ('nonfederal' referring to all lands in private, municipal, state, or tribal ownership).

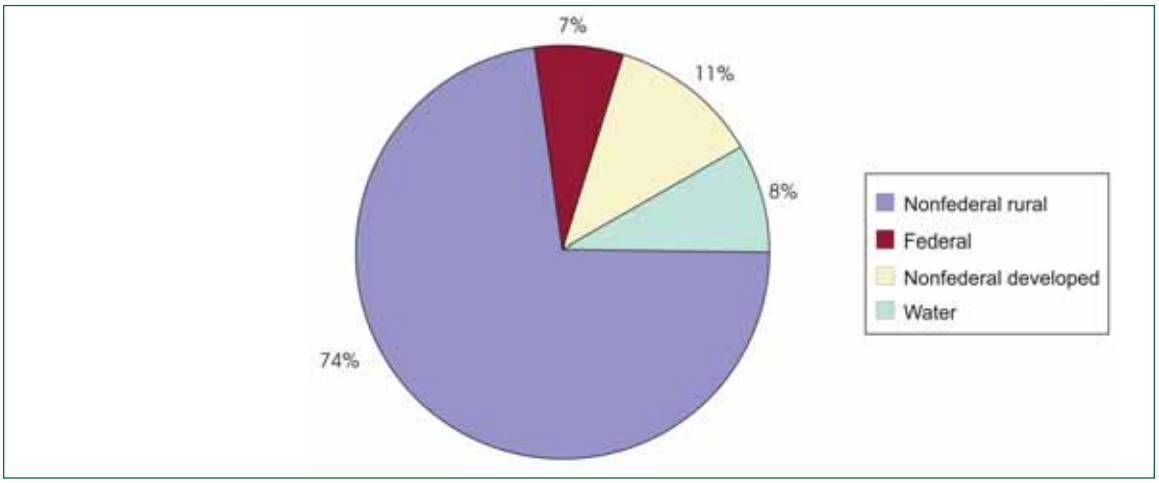


Figure 3.1. Broad land-use characterization in North Carolina (source: NRCS, 1997).

Land use on nonfederal lands in the state, which total 28,448,700 acres, is primarily forest land (Figure 3.2).

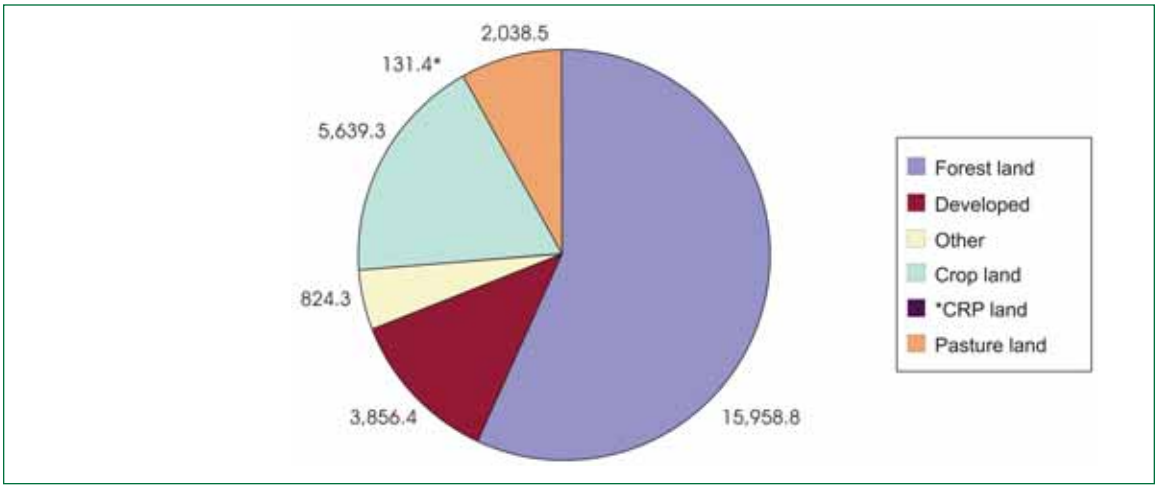


Figure 3.2. Detailed land-use on nonfederal lands in North Carolina (million acres) (source: NRCS, 1997).

Protected Species

In North Carolina there are 41 federally-endangered and threatened animal species protected by the US Fish & Wildlife Service under the Federal Endangered Species Act (16 U.S.C. 1531 to 5143). Twenty-nine of those species have recovery plans (Appendix I). In addition, there are 67 state endangered and threatened species, and 115 state species of Special Concern protected by the Commission under the State Endangered Species Act (General Statute 113–331 to 113–337).

There are 27 federally endangered and threatened plant species in North Carolina, protected under General Statute by the US Fish & Wildlife Service. The NC Plant Conservation Program, a unit of the Department of Agriculture and Consumer Services, is responsible for the protection of the 134 state endangered and threatened plant species and the 19 plant species of Special Concern in the state (General Statute Article 19B, 106:202.12–22).

Endangered Ecosystems

In an assessment of risk to ecosystems in the United States, seven southeastern states (Florida, Georgia, North Carolina, South Carolina, Virginia, Alabama, and Tennessee) made the 'extreme risk' category based on number of endangered ecosystems, percentage of imperiled species by state, and development pressures. Indeed, eight of the top 21 endangered ecosystems in the United States can be found in North Carolina (Noss and Peters 1995) *(position on list shown in parentheses)*:

- Southern Appalachian spruce-fir forest (2)
- Longleaf pine and savanna (3)
- Eastern grasslands, savanna, and barrens (4)
- Coastal communities in the lower 48 states (7)
- Large streams and rivers in the lower 48 states (11)
- Cave and karst systems (12)
- Ancient eastern deciduous forest (16)
- Southern forested wetlands (21)

Critical Areas for Freshwater Conservation

In recent years, three aquatic assessments have been undertaken by conservation organizations, each addressing freshwater biodiversity conservation at different scales. These assessments have largely built on the information gathered in previous efforts in order to identify significant regions and priority areas for freshwater conservation. The World Wildlife Fund conducted a conservation assessment of freshwater ecoregions of North America (Abell et al. 2000). The Nature Conservancy assessed small-scale watersheds across the country (Master et al. 1998) and subsequently identified priority areas within four freshwater ecoregions in the southeast (Smith et al. 2002). All three efforts identify the southeast as a key region for freshwater conservation efforts. Many of the critical areas identified in those efforts overlap North Carolina's borders:

- Abell et al. (2000) identified the entire South Atlantic freshwater ecoregion (southern Virginia through central Georgia) as a key region in which to focus aquatic conservation efforts in North America;
- 21 of the 327 key small watershed areas identified across the country by Master et al. (1998) are found in North Carolina;
- Smith et al. (2002) identified 70 sites for priority freshwater conservation areas in North Carolina (14 in the Tennessee-Cumberland Aquatic Region, 56 in the South Atlantic Aquatic Region).

Threats

Today, impacts to species and habitats across the country are ubiquitously tied to adverse anthropogenic activities. The following issues represent major threats to species and habitat diversity in North Carolina. Finding solutions to specific fish and wildlife conservation problems will have as much to do with addressing these overarching issues as it will with addressing more immediate sources of the problems. A key component to addressing these issues is the development of language conventions (among agencies and organizations) for defining and measuring threats, which will make it easier to set common priorities to address threats and to measure effectiveness at attaining threat-based objectives (Salafsky et al. 2003). (Discussion of more specific threats to terrestrial and aquatic species and habitats can be found in the individual sections of Chapter 5).

Human Population Growth and Development

From 1950–1990, the population of North Carolina grew by 63% (US Census Bureau 2000). In a 10-year period alone (1990–2000) the state has experienced a 21% increase in human population size, and growth is projected to increase by the same amount over the next 25 years (2000). Human population growth in turn results in greater demands on land and water resources to support those populations. Indeed, the state ranks sixth in the country for total acres of land developed between 1992 and 1997 (NRCS 2000). Subsequent impacts to terrestrial and aquatic systems include habitat degradation, fragmentation and destruction.

Physical Alteration of Terrestrial Habitats

Direct habitat destruction is the most widely acknowledged threat to biodiversity at the species and ecosystem level (Noss and Peters 1995). Across the southeast, less than 3% of presettlement upland longleaf pine communities (Frost 1993) and only 1% of presettlement canebreak and Atlantic white cedar communities exist today (Frost 1987). It is now estimated that half of North Carolina's original wetlands have been lost due to development and conversion to cropland (Mitsch and Gosselink 1993). Widespread fire suppression over the past century has contributed greatly to the alteration and succession of ecologically fire-dependent systems (e.g., longleaf pine, early successional habitats). Land fragmentation due to highway development, land-use conversion (e.g., from forests to plantations, farms, golf courses, housing developments) and alterations of landforms such as beach renourishment and spoil deposition banks are also significant threats (TNC 2000, TNC and NatureServe 2001). The Forest Service estimates that forest acreage in North Carolina has fallen by one million acres (5.6%) since 1990, primarily due to development (Brown 2004).

Physical Alteration of Aquatic Habitats

Destruction and degradation of habitat are widely cited as the greatest threats to aquatic species in the United States (Angermeier 1995, Warren et al. 1997, Williams et al. 1993). Physical alterations such as channelization and dredging, aquifer depletion, impoundment and dam construction, and flow modification have contributed directly to the decline of aquatic species in the south (Walsh et al. 1995, Etnier 1997). Increases in impervious surfaces, and subsequently stormwater flows, have caused changes in sediment transport and stream energy, which has led to limitations in the amount of suitable aquatic habitat and stream bed material, especially near urban areas. The Nature Conservancy (2000, TNC and NatureServe 2001) identifies altered surface hydrology (e.g., flood-control and hydroelectric dams, inter-basin transfers of water, drainage ditches, breached levees, artificial levees, dredged inlets and river channels), and a receding water table as among the most significant sources of biological and ecological stress, especially in the Coastal Plain.

Water Quality Impacts

In addition to physical alteration of aquatic habitat, sediments and contaminants delivered through point and non-point sources compound threats to aquatic systems (TNC 2000). Point source pollution is delivered primarily in the form of municipal wastewater and stormwater discharges. The majority of water quality problems in North Carolina, however, stem from non-point source pollution associated with land use activities such as development projects, forestry and agricultural practices, and road construction (NCDWQ 2000, SAMAB 1996).

Invasive and Exotic Species Introductions

Non-native and invasive species introductions (both plant and animal) continue to pose a threat to native wildlife in North Carolina. Introductions have occurred in a number of different ways, ranging from intended stockings, to range expansions, to the pet trade. Impacts on native species are equally varied; some exotics out compete native species (e.g., kudzu and Japanese stiltgrass), others cause hybridization (e.g., red-eared sliders breeding with native yellow-eared sliders), still others cause direct mortalities to our native resources (e.g., red imported fire ants, the hemlock wooly adelgid).

Recognizing the importance of addressing invasive and exotic species introductions and their impacts on our native wildlife resources, each state Scientific Council[1] is currently (as of 2005) developing an invasive and exotic species report. These reports will identify exotic and invasive species potentially injurious to native species and habitats, and guide policy and management strategies. The reports are scheduled for completion by the fall of 2005, at which time they will be presented to the Commission's Nongame Wildlife Advisory Committee. They will serve as key resources to broaden awareness and address necessary actions to control the impacts of invasive and exotic species in North Carolina.

Key Conservation Partners

Species and habitat conservation activities are carried out across the state by numerous agencies and organizations. Some key agency and non-profit groups are highlighted below. Each group serves a critical role in advancing the goal of maintaining and protecting our state's natural resources. There are also *numerous* other agencies and organizations (far too many to highlight individually) that serve a supporting role in protecting the natural resources of the state (e.g., through education, policy, and/or other forms of natural resource management).

State Agencies

North Carolina Wildlife Resources Commission

The mission of the Commission is to conserve, protect, manage, restore and regulate the wildlife resources of the state. Toward this mission, Commission biologists conduct a variety of management and conservation activities, ranging from surveys and inventories, to habitat management, to land acquisition. Since 1984, when the Nongame Program was begun, nongame wildlife conservation has been an active part of Commission activities *(for a history of the program, see NWCRC 1999)*. The Habitat Conservation Section within the Division of Inland Fisheries now oversees the Commission's Aquatic Nongame Program. The Wildlife and Lands Management Section within the Division of Wildlife Management oversees the Faunal Diversity (terrestrial nongame) Program. A standing Nongame Wildlife Advisory Committee provides external support and assistance to the Commission' nongame activities.

North Carolina Museum of Natural Sciences

Museum researchers maintain the state's extensive zoological collections, conduct primary research in the natural sciences, collaborate on research projects with area universities, state and federal agencies and international organizations, and interpret natural history to the public. Animal collections are maintained for terrestrial invertebrates, aquatic invertebrates, crustaceans, fish, amphibians, reptiles, birds and mammals. Scientists and policymakers rely on the collections and the data they contain for purposes as varied as judging the appropriateness of environmental permits, assessing historical pollutant levels at specific localities, and determining the level and/or significance of intraspecies differentiation in taxonomy. The Museum collections also play a major role in basic biodiversity research.

[1]Scientific Councils are made up of panels of expert biologists from across the state; each Council provides recommendations for species status listings to the Nongame Wildlife Advisory Committee. Councils exist for birds, mammals, amphibians and reptiles, freshwater fishes, freshwater and terrestrial mollusks, freshwater crustaceans.

North Carolina Natural Heritage Program

The Natural Heritage Program inventories, catalogues and facilitates protection of the rare and most outstanding elements of the natural diversity of North Carolina. These elements of natural diversity include plants and animals which are so rare, or natural communities which are so significant, that they merit special consideration as land-use decisions are made. The Natural Heritage Program follows methodology developed by The Nature Conservancy and shared by the Natural Heritage Network and NatureServe. By consolidating information about hundreds of rare species and natural communities, the program is able to ensure that the public is able to get the information needed to weigh the ecological significance of various sites, and to evaluate the likelihood and nature of ecological impacts resulting from land-use activities. This information supports informed evaluations of the trade-offs associated with biological diversity and development projects. Finally, Natural Heritage Program data can be used to help set priorities for the protection of North Carolina's most important natural areas.

North Carolina Division of Marine Fisheries

The Division of Marine Fisheries is responsible for the stewardship of the state's marine and estuarine resources. The Division's jurisdiction encompasses all coastal waters and extends to 3 miles offshore. Recognizing the need to both protect habitat and prevent overfishing, the North Carolina General Assembly passed the Fisheries Reform Act in 1997. The law contains the directive to protect and enhance habitats supporting coastal fisheries. The law requires cooperation among three rule-making commissions to develop, adopt, and implement plans and strategies to protect and restore fisheries habitats: Environmental Management Commission, Coastal Resources Commission, and Marine Fisheries Commission. The Division of Marine Fisheries was charged to coordinate the development of such strategies in a report entitled the Coastal Habitat Protection Plan (CHPP). The CHPP is organized across six key estuarine and marine fisheries habitats. It was completed and approved by the Commissions in late 2004.

North Carolina Division of Coastal Management

The Division of Coastal Management works to protect, conserve and manage North Carolina's coastal resources through an integrated program of planning, permitting, education and research. The Division carries out the state's Coastal Area Management Act (CAMA), the Dredge and Fill Law and the federal Coastal Zone Management Act of 1972 in the 20 coastal counties, using rules and policies of the Coastal Resources Commission. The Division of Coastal Management is part of the Department of Environment and Natural Resources. The Division also receives oversight (and part of its funding) from the Office of Ocean and Coastal Resource Management, part of the National Oceanic and Atmospheric Administration. The Division of Coastal Management is responsible for several programs, including permitting and enforcement, CAMA land-use planning, public beach and waterfront access, North Carolina Coastal Reserves, and grants for marine sewage pumpout. Division staff also collect and analyze data for erosion rates, wetlands conservation and restoration, and to assess the impacts of coastal development.

North Carolina Division of Forest Resources

The Division of Forest Resources is mandated to protect, manage and develop the forest resources of the state. The processes used to accomplish this mandate involve management of existing resources, development and creation of new and better forests, and protection of these valuable resources. The primary emphasis in conducting the programs under these objectives is directed at the 664,000 forest landowners who collectively own 11.54 million acres (69%) of the state's 16.77 million acres of privately owned forest land. The Division is directly involved with forest management assistance to private landowners, reforestation services, forest fire prevention and suppression, and insect and disease control programs. The Division also is involved in the operation of tree seedling nurseries, long-range forestry planning and technical development, water quality controls, urban forestry assistance, training and support to volunteer fire departments and forestry education.

North Carolina Division of Water Quality, Basinwide Planning Program

Basinwide water quality planning is a nonregulatory, watershed-based approach to restoring and protecting the quality of North Carolina's surface waters. Basinwide water quality plans are prepared for each of the 17 major river basins in the state and are updated at five-year intervals. While these plans are prepared by the Division of Water Quality, their implementation and the protection of water quality entail the coordinated efforts of many agencies, local governments and stakeholder groups in the state. The goals of basinwide planning are to: 1) identify water quality problems and restore full use to impaired waters, 2) identify and protect high value resource waters, and 3) protect unimpaired waters while allowing for reasonable economic growth. The Division of Water Quality accomplishes these goals by collaborating with other agencies to develop appropriate management strategies, assuring equitable distribution of waste assimilative capacity, evaluating the cumulative effects of pollution, and by improving public awareness and involvement.

Ecosystem Enhancement Program

The Ecosystem Enhancement Program (EEP) was created in 2003 out of a memorandum of agreement between the US Army Corps of Engineers, the NC Department of Environment and Natural Resources (NCDENR), and the NC Department of Transportation (NCDOT), effectively merging the NCDENR Wetlands Restoration Program with resources from the NCDOT Office of Natural Environment. The mission of the EEP is to restore, enhance and protect the state's wetlands, streams and streamside buffers, with an aim to improve the state's compensatory mitigation process for unavoidable impacts to wetlands and streams. EEP will identify and implement projects within the context of a watershed approach based on multiple scales of planning, provide functional replacement based on watershed needs through stream, buffer and wetlands projects, and provide watershed planning and project implementation in advance of impacts. The existing Watershed Restoration Plans, developed by the Wetlands Restoration Program in cooperation with, and on the same five-year planning cycle as the NC Division of Water Quality Basinwide Planning Program, are key to these efforts.

One North Carolina Naturally Initiative

The One North Carolina *Naturally* initiative promotes and coordinates the long-term conservation of North Carolina's land and water resources. The Office of Conservation and Community Affairs (within the NC Department of Environment and Natural Resources) manages the program by leading the development and implementation of a comprehensive statewide conservation plan involving government agencies, private organizations, landowners and the public. This voluntary program pursues the conservation of significant natural areas, working farms and forests, and our coastal estuarine system.

One NC *Naturally* also provides support for development of regional open space plans, providing assistance through regional meetings and resource materials. One NC *Naturally*'s regional planning process provides an effective forum for decision-making about conservation in our communities. By first working with local and regional groups to address the specific needs of each region, the state can move in an overall direction that does not conflict with goals of any particular region. Currently, 92 counties across North Carolina are involved in 14 local and regional open space planning efforts. Local and regional open space planning efforts provide invaluable new information to add to the statewide conservation plan. Data from each of these regional plans is incorporated into the web-based NC Conservation Land Map Viewer (http://www.onencnaturally.org/mapviewer/) where the data is continually updated. This online decision support tool can provide key information vital to successful planning efforts.

Federal Agencies

US Fish & Wildlife Service

The US Fish & Wildlife Service oversees five field units nation-wide: National Wildlife Refuges, National Fish Hatcheries, Law Enforcement, Ecological Services offices and Fishery Resources offices. Since the mid-1990s, the Fish & Wildlife Service has operated within an ecosystem-based approach, bringing individuals within each of the different programs together to tackle species and habitat conservation. There are 53 ecosystem units nationwide (based on US Geological Survey defined watersheds). Three ecosystem teams fall within North Carolina's boundaries, the Roanoke-Tar-Neuse-Cape Fear Ecosystem team, the Savannah-Santee-PeeDee Ecosystem team and the Southern Appalachian Ecosystem team. The US Fish & Wildlife Service operates 10 wildlife refuges in North Carolina, and oversees recovery plans for federally listed species occurring in the state. Wildlife Action Plans for each of the 10 refuges in the state are to be completed by 2006.

Natural Resources Conservation Service

The mission of the Natural Resources Conservation Service (NRCS), an agency within the US Department of Agriculture, is to provide leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment. In order to meet this mission, NRCS offers a variety of incentives-based programming aimed at species and habitat conservation, including Farm Bill programs like the Wetlands Reserve Program, Wildlife Habitat Incentives Program, and Conservation Reserve Program, among others. The NRCS provides assistance to land users for developing and implementing conservation plans on their lands. The National Resources Inventory, a nationwide survey conducted annually by the NRCS, is the Federal Government's principal source of information on the status, condition, and trends of soil, water and related resources in the United States.

National Oceanic and Atmospheric Administration Fisheries

The National Oceanic and Atmospheric Administration (NOAA) Fisheries unit (formerly known as the National Marine Fisheries Service) is the federal agency responsible for the stewardship of the nation's living marine resources and their habitat. NOAA Fisheries is responsible for the management, conservation and protection of living marine resources within the United States' Exclusive Economic Zone (waters three to 200 miles offshore). Using the tools provided by the Magnuson-Stevens Act, NOAA Fisheries assesses and predicts the status of fish stocks, ensures compliance with fisheries regulations and works to reduce wasteful fishing practices. Under the Marine Mammal Protection Act and the Endangered Species Act, NOAA Fisheries recovers protected marine species (e.g., whales, sea turtles) without unnecessarily impeding economic and recreational opportunities. NOAA Fisheries works to promote sustainable fisheries and to prevent lost economic potential associated with overfishing, declining species and degraded habitats. NOAA Fisheries strives to balance competing public needs and interest in the use and enjoyment of our oceans' resources.

US Forest Service

The US Forest Service, an agency within the US Department of Agriculture, manages public lands in national forests and grasslands. The mission of the Forest Service is to sustain the health, diversity and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. North Carolina falls within the Southern Region of the Forest Service (Region 8). There are four National Forests in North Carolina: Croatan, Uwharrie, Nantahala and Pisgah. Each has its own Land and Resource Management Plan (LRMP), a document that provides direction for the future management of the forest and its resources. The Croatan National Forest underwent a LRMP revision in 2003. Significant updates to the Nantahala, Pisgah, and Uwharrie National Forest plans are scheduled for 2008 – 2009, according to the Forest Planning schedule.

National Park Service

The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout the United States and the world. Across their properties, the National Park Service conducts ecosystem restoration, invasive species management, integrated pest management, migratory bird studies, threatened and endangered species management, wildlife health and disease studies, wildlife and habitat management, and cooperates with partner agencies and organizations to fulfill shared missions. The National Park Service manages 12 sites in North Carolina: Appalachian National Scenic Trail, Blue Ridge Parkway, Cape Hatteras National Seashore, Cape Lookout National Seashore, Carl Sandburg Home National Historic Site, Fort Raleigh National Historic Site, Great Smoky Mountains National Park, Guilford Courthouse National Military Park, Moores Creek National Battlefield, Overmountain Victory National Historic Trail, Trail of Tears National Historic Trail and Wright Brothers National Memorial.

Gap Analysis Project

The NC Gap Analysis Project is the state level representative of the National Gap Analysis Program sponsored by the Biological Resources Division of the US Geological Survey. The mission of Gap Analysis is to conduct regional assessments of the conservation status of native terrestrial vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. This is accomplished by addressing the following five objectives: (1) map the land cover of the United States, (2) map predicted distributions of terrestrial vertebrate species for the United States, (3) analyze the representation of vertebrate species and land cover types in areas managed for the long-term maintenance of biodiversity, (4) provide this information to the public and those entities charged with land use research, policy, planning and management, and (5) build institutional cooperation in the application of this information to state and regional management activities. NC Gap Analysis Program staff provided critical assistance in mapping species distributions and habitat types for the Plan.

Non-profit Organizations

The Nature Conservancy

The Nature Conservancy's mission is to preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive. This mission is carried out through partnerships, alliances, and collaborations with a variety of state and federal agencies, land trusts, and conservation groups. The Nature Conservancy has developed a strategic, science-based planning process, called *Conservation by Design*, which is used to help identify the highest-priority places—landscapes and seascapes that, if conserved, promise to ensure biodiversity over the long term. North Carolina falls within three The Nature Conservancy-defined ecoregions (the Mid-Atlantic Coastal Plain, the Piedmont, and the Southern Blue Ridge), each with its own ecoregional plan, the purpose of which is to identify priority conservation areas within the ecoregion.

North Carolina Audubon

The mission of the National Audubon Society's North Carolina State Office is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and North Carolina's biological diversity. The Important Bird Areas (IBA) Program is key to this mission. The IBA program operates under two objectives: 1) to identify those places that are essential to sustaining the diversity and abundance of naturally occurring populations of birds in North Carolina, 2) to protect or ensure the appropriate management of these sites for the long-term conservation of birds and their habitats. As of 2004, 92 sites have been approved as IBAs across the state. North Carolina Audubon is a key partner for beach-nesting bird and colonial waterbird conservation efforts in the state.

North Carolina Wildlife Federation

The mission of the North Carolina Wildlife Federation (NCWF) is to be the leading advocate for all North Carolina wildlife and its habitat. The goals of the NCWF are: 1) to advocate the conservation and enhancement of all wildlife and its habitat, 2) to advocate ethical and biologically sound hunting, fishing, and other outdoor activities, 3) to advocate education, for children and adults, that increases public awareness of wildlife, its dependence on habitat, and the importance of both to human existence, 4) in affiliation with member organizations, to communicate, cooperate and partner with the North Carolina General Assembly, state resource agencies, corporations, and other interested groups to advance the well being of wildlife and its habitat, and 5) in affiliation with the National Wildlife Federation, to support national and international issues of mutual interest. NCWF was instrumental in bringing about the creation of the Commission in the mid-1940s and they continue to be a key advocate for wildlife and wildlife-related policy in North Carolina.

The Conservation Trust for North Carolina

The Conservation Trust for North Carolina (CTNC) was created in 1991 to help protect North Carolina's land and water resources, both by direct action and by assisting private, local land trusts, other community groups, and private landowners. CTNC is the statewide land trust working with communities, landowners, local land trusts, and other conservation organizations to protect North Carolina's natural and cultural resources. CTNC serves as the resource center for North Carolina's 24 local and regional land trusts. It acts as a "hub" for information exchange, coordination, public policy representation, and financial assistance. CTNC works cooperatively with land trusts across the state to help landowners protect natural resources through voluntary conservation methods.

Administrative and Management Challenges

Agencies and organizations face many beaurocratic obstacles to administering and monitoring the efficacy of their programs. The following section was developed to highlight some of the ubiquitous challenges faced by agencies and organizations across the state with the thought that we cannot hope to change or reduce these challenges without addressing them head-on.

Fragmented Responsibility and Jurisdiction

Conservation of habitats and their associated flora and fauna is a process of managing the resources and the anthropogenic impacts to those resources. Yet species regularly migrate across political boundaries and the factors that can influence their abundance and distribution are many (e.g., habitat availability, air quality, water quality, habitat connectivity, habitat composition). What's more, the impacts to species and habitats can include any number of human influences: agricultural practices, road construction, urban sprawl, industrial water demand, municipal sewage treatment, invasive species releases. While species and habitats may be affected by the sum of these impacts, we must manage their influence in piecemeal fashion, under the jurisdiction of multiple regulatory agencies and organizations. Thus we have fragmented responsibility for managing the *resources* as well as the *impacts* to wildlife and habitats, both of which impose organization obstacles to effective conservation. Inter-agency technical guidance and the permit review process are two examples of how agencies attempt to bridge those gaps. Critical considerations include:

- How effective are technical guidance procedures to protect, conserve and reduce impacts to habitats and individual species?
- How many permit review recommendations actually get implemented?
- Are policies and regulations complimentary or consistent among agencies that have jurisdiction over a shared resource?
- Are permit conditions enforced?
- Are policy-based recommendations sound, e.g., minimum stream flows, instream mining restrictions, buffer policies, and breeding season moratoriums on development activities?
- What are the barriers to success and how do we measure success among so many entities?

Communication Challenges

Considering the diversity of goals and responsibilities among the many disparate units of government, effective and efficient communication among agencies is imperative, but challenging. If the goals and priorities of conservation agencies aren't even "part of the calculation" for other governmental entities that influence those very goals and priorities, again obstacles will be raised to practicing effective conservation. Clear communication of a larger suite of goals, including conservation goals, is needed throughout a broader portion of government if institutional obstacles to conservation are to be lessened. Within agencies, too, it is imperative that there is communication between programs, divisions, and departments so that the objectives and goals of each are in concert with, not in opposition to, one another. Natural resource agencies must also strive to work more closely with the broader non-governmental conservation organizations in order to identify common goals and work towards cooperative achievement of those goals. For example, critical considerations for the Commission might include:

- Is the Commission effective in communicating its messages to other agencies, organizations, user groups?
- Is it effective in influencing their decisions, in affecting change?
- What are the desired impacts of inter-agency communications; are the communications producing those impacts?

Agencies must also periodically examine their own organizational structures and processes to look for ways to remove impediments to doing good conservation on the ground. Within the Commission for example, nongame and permit review programs are relatively new (as of 2005) and their effectiveness is related to how well their functions are integrated into the larger agency program. Similarly, coordination among the Aquatic Nongame, Faunal Diversity, Land Management, Private Lands, Technical Guidance, Stream Restoration, and Permit Review functions is critical. Organizational considerations affect that coordination. The fractious structure will require extra effort to make sure that broad conservation goals are set and met and resources are allocated appropriately.

Information Management

Multiple agencies in the state collect and manage species and habitat information. Data are inevitably collected in different formats, using different managing systems, and for different purposes. The challenge agencies face is to reduce redundancy in data collection and improve data sharing capabilities. A more unified database management system, with access to as much data as possible, could help to identify data gaps (e.g., survey efforts needed), provide a one-stop comprehensive view of data collected about a particular species or habitat (rather than having to search multiple, independent databases), and ultimately lead to better resource efficiency. The ultimate goal of information management improvements is to better inform management decisions, using the most up-to-date and accurate information possible, regardless of who collected it. Critical considerations include:

- What type of information is available and from whom?
- How accessible is data?
- Is the most up-to-date data being used to inform decisions?
- Is data collection from one agency redundant of another?

References

Abell, R. A., D. M. Olsen, E. Dinerstein, P. T. Hurley, J. T. Diggs, W. Erichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America. A conservation assessment. Island Press, Washington, D.C.

Angermeier, P. L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. Conservation Biology 9:143–158.

Brown, M. J. 2004. Forest Statistics for North Carolina, 2002. Southern Research Station. US Department of Agriculture, Forest Service, Asheville, NC.

Etnier, D. A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pages 87–104 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Frost, C. C. 1987. Historical overview of Atlantic white cedar in the Carolinas. Pages 257–264 *in* A. D. Laderman, editor. Atlantic white cedar wetlands. Westview Press, Boulder, CO.

Frost, C. C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. Pages 17– 43 *in* S. H. Hermann, editor. Proceedings of the Tall Timbers fire ecology conference, No. 18. Tall Timbers Research Station, Tallahassee, FL.

Master, L. L., S. R. Flack, and B. A. Stein, editors. 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, VA.

Mitsch, W. J., and J. G. Gosselink. 1993. Wetlands, 2nd edition. John Wiley & Sons, New York.

Natural Resources Conservation Service (NRCS). 1997. 1997 National Resources Inventory. U.S. Department of Agriculture, Washington, D.C.

Natural Resources Conservation Service (NRCS). 2000. 1997 National Resources Inventory, revised December 2000. U.S. Department of Agriculture, Washington, D.C.

N.C. Division of Water Quality (NCDWQ). 2000. Water quality citizen's guide. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 1999. North Carolina wildlife diversity plan. Division of Wildlife Management, N.C. Wildlife Resources Commission.

Noss, R. F, and R. L. Peters. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Defenders of Wildlife.

Salafsky, N., D. Salzer, J. Ervin, T. Boucher, and W. Ostlie. 2003 (DRAFT). Conventions for defining, naming, measuring, combining, and mapping threats in conservation. An initial proposal for a standard system. Foundations of Success, Bethesda, MD.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment aquatic technical report. Report 2 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

The Nature Conservancy (TNC). 2000. Conservation by design: a framework for mission success. The Nature Conservancy, Arlington, VA.

The Nature Conservancy (TNC) and Natureserve. 2001. Mid-Atlantic Coastal Plain Ecoregion Plan. The Nature Conservancy, Durham, NC.

U.S. Census Bureau. 2000. 1990 to 1999 total population estimates. U.S. Census Bureau, Population Distribution Branch. http://www.census.gov/population.html

Walsh, S. J., N. M. Burkhead, and J. D. Williams. 1995. Southeastern freshwater fishes. Pages 144–147 *in* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our living resources: a report to the Nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of Interior, National Biological Service, Washington, D.C.

Warren, M. L., P. L. Angermeier, B. M. Burr, and W. R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pages 105–164 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18:6–22.

CHAPTER 4.

STATEWIDE CONSERVATION STRATEGIES

The following sections detail four important conservation issues across the state of North Carolina. As such, the conservation strategies necessary to address these issues should be considered within the context of a state-wide framework, but must also be sensitive to local or regional distinctions. Strong partnerships among agencies, organizations, academics, and industry will be critical to meeting these challenges.

A. Urban Wildlife Management Strategies

Challenges and Opportunities

The rapid urbanization of North Carolina creates many wildlife challenges and opportunities. Where humans and wildlife meet, there is potential for conflict, but also opportunity for sustaining compatible terrestrial and aquatic wildlife populations and increasing people's awareness of and appreciation for wildlife.

North Carolina's estimated population growth is 34,500 people annually with 14,500 acres developed in association with that increase (Costa and Petersen 2002). Some counties are growing faster than others, but regardless, effective planning and concentrated development should be encouraged across North Carolina to combat suburban sprawl and loss of wildlife habitat. Open spaces within the urban/suburban environment are crucial for populations of development-sensitive wildlife species; these areas may include fields, forests, and riparian corridors. Open spaces serve many purposes, such as filtering pollutants from the air and water, conserving water and soil, supplying habitat for pollinators and the plants that require them for reproduction, and furnishing adequate space and habitat for breeding, foraging, travel and cover for wildlife (Lerner and Poole 1999).

Even though urban and suburban areas often contain more generalist wildlife species and offer limited opportunities for land protection and management, wildlife conservation programs should not ignore these lands. Indeed, rapid development and urban/suburban sprawl spreading out and away from urban centers are resulting in significant impacts on natural resources across North Carolina. Watersheds and ecosystems that were once considered relatively unaffected by growth are starting to see the impacts of widespread development, resulting in reductions in habitat quality and quantity and negative effects on listed and sensitive species (e.g., Goose Creek in Mecklenburg County; M. Fowlkes, pers. comm.). For these reasons, it is becoming increasingly important that natural resource management agencies proactively work with local governments in urban and urbanizing areas (especially those with a high percentage of annual population growth expected) to ensure protection of the public's fish and wildlife resources and to minimize primary and secondary impacts from development.

As urban populations often seem disconnected from nature, these people may not always perceive that wildlife or habitat loss are critical threats that could impact them directly. However, the same environmental degradation that threatens wildlife populations can menace drinking water supply, air quality, or other factors of immediate interest to city dwellers. Drawing those connections for urbanites may create a new constituency for wildlife and habitat protection based on enlightened self interest. For example, the Statewide Comprehensive Outdoor Recreation Plan suggests a link between access to open space and the overall mental and physical health of nearby residents (NCDPR 2003). Children especially benefit from the exploration of their natural world as it increases their knowledge of environmental issues, appreciation of nature, and their potential willingness to participate in conservation actions as adults (Leedy and Adams 1984).

An urban wildlife program can serve to maximize biodiversity within urban areas, build critical public support for conservation efforts, and assist in guiding development pressures to help ensure the conservation of species and habitats in presently rural areas. By conserving and helping to

manage remnant tracts of wildlife habitat close to urban centers, we can provide convenient outdoor recreation and education opportunities and begin to address the alienation from nature experienced by many urban residents (Leedy and Adams 1984). Furthermore, some of the development pressure on the rural fringes of urban centers is from people who wish to "get back to nature" and who want to live in an area where outdoor recreation and wildlife viewing opportunities are easily accessible. Providing more natural public lands within urban areas will help to make cities more livable and may reduce the pressure to develop rural farms and woodlands.

It is encouraging to note that there is increasing cooperation between state agencies and local governments in North Carolina to encourage municipalities, citizens, and developers to become better stewards of our natural resources. For example, the Commission has been working with local municipalities in the greater Charlotte area to create ordinances that address environmental protection and endangered mussel protection in the Goose Creek watershed, and with various municipalities in Wake County to develop a Master Secondary and Cumulative Mitigation Plan for the county. In partnership with the NC Division of Parks and Recreation, the Commission published a guidance document related to mitigating secondary and cumulative impacts for wildlife resources (NCWRC 2002) and is currently working on a complementary document with the NC Department of Environment and Natural Resources, the US Fish & Wildlife Service, and the NC Department of Transportation to educate municipalities about secondary and cumulative impacts and the environmental review process ("Swimming with the Current," *in draft 2005*). Other initiatives across the state include the Mecklenburg County Surface Water Improvement and Management Ordinance (Mecklenburg County DEP 1999) and the Chatham County Compact Communities Ordinance (www.co.chatham.nc.us).

Following are some of the most important issues that should be addressed in strategic urban wildlife program planning, along with examples of some efforts that are addressing those needs.

Land Protection and Management

- *Assist local and state entities (including land trusts) in purchasing or acquiring easements on properties.* Habitat loss and conversion are widely cited as two of the most critical threats to fish and wildlife resources in North Carolina. The conservation of habitat through land conservation around urban centers is a critical priority. (For a more directed discussion of land conservation needs, see Chapter 4C).
- *Promote and coordinate with regional open space and land-use planning initiatives.* In the most urbanized areas across North Carolina, there may be little opportunity left to purchase substantial parcels of land. However, initiatives aimed at making the most compact use of existing urban centers (e.g., infilling and reuse of vacant lots) can still provide significant positive impacts to wildlife resources by reducing sprawl (Lerner and Poole 1999; NCWRC 2002). Some urban areas in North Carolina have already prioritized open space conservation, such as the Triangle GreenPrint Regional Open Space Assessment (NCDPR et al. 2002), the Voices and Choices of the Carolinas initiative in Mecklenburg County (2004), and the city of Cary Open Space and Historic Resources Plans (http://www.townofcary.org/depts/dsdept/P&Z/openspace/openspacehome.htm). At a statewide level, the One North Carolina *Naturally* program is providing a key 'umbrella' role to improve the efficacy of regional and local land-use planning efforts by streamlining communications, GIS and data resources, and coordination of efforts (NCDENR 2003).
  - *Assist in the development and management of greenways.* A greenway plan is being developed for North Carolina, and research at NC State University is helping to define how greenways can be improved for wildlife (Hess 2004). Preliminary findings suggest that greenways that are wide (100–300 meters), maintained in native vegetation, and adjacent to canopy cover provide the best wildlife habitat and corridors for dispersal (Hull 2003; Novotny 2003; Vidra 2004). In addition to their value as wildlife habitat, greenways generally create good "habitat for people" by diversifying the landscape (Adams and Dove 1993) and providing more scenic, alternative transportation routes (North Carolina Greenways Advisory Panel 1994). Developers and realtors are keenly aware of the selling power of a tranquil setting that is pedestrian-friendly (Arendt 2004, Leedy and Adams 1984). Encouraging the building of compact communities

surrounded by interconnecting greenways helps lower property taxes by concentrating the tax-supported infrastructure such as roads, schools, sewer lines, and 911 services (Lerner and Poole 1999). Concurrently, sewer lines and other areas already designated as required open spaces should be incorporated into a greenway system (North Carolina Greenways Advisory Panel 1994).

  - *Enhance the effective size of existing preserve or land-holdings by promoting habitat management on surrounding private lands.* When tracts abut private lands, there is opportunity to work with adjacent landowners to help them realize the benefits of their lands as buffers for the preserve and as an extension of the preserve itself. Landowners should be introduced to any available cost share programs (e.g., Farm Bill programs) and habitat improvement advice (e.g., Forest Stewardship Program, Forest Landbird Legacy Program) that fits their needs. (For more about private land management issues, see Chapter 4B).

- *Improve management for wildlife on existing public lands.* Many city and county parks in North Carolina have been developed with human recreation as the top priority, but opportunities also exist to improve habitat management and wildlife-related recreation and education on these public lands. This involves hiring staff who are knowledgeable about wildlife and habitat management and who are cognizant of managing the natural resources of the parks in addition to the recreational facilities (or having existing staff consult with certified wildlife biologists). Often, city parks and greenways are so manicured that they are devoid of the intermediate canopy layer as well as the shrub and herb layer, thereby reducing usage by wildlife species that may otherwise utilize the area (Hull 2003). In addition, wide trails may disrupt sensitive species or habitat are as by creating breaks in the forest cover. The Mecklenburg County Park and Recreation Department is a prime example of a parks system that has made natural resources management a priority by conserving habitat integrity and educating the public by offering guided hikes and programs about the environment. They can serve as a model for other parks and recreation programs that wish to better integrate natural resources management into traditional programming methods.
- *Protect and adequately buffer high priority habitats.* In urban and urbanizing areas, high priority areas include riparian forests, floodplains, isolated wetlands, and sites with known sensitive or listed species occurrences. Adequate buffering of these habitats is a critical need. In addition to protecting wildlife habitat, water quality is also preserved and downstream impacts are reduced when water sources are buffered. Buffering helps to maintain species diversity across the landscape, improving the survival of species for future generations. Buffering may include the purchase of a property, acquisition through a site easement, or involving the landowner(s) in dialogue about the management of a particular property or properties.
- *Prioritize stream restoration efforts in areas with sensitive species or significant aquatic resources (e.g., trout waters).* Restoration efforts must be directed towards the most critical areas, not just where it is easy to do. The Watershed Enhancement Program (within the Commission's Division of Inland Fisheries) is involved in restoration and priority site identification through coordination of mitigation needs with the Ecosystem Enhancement Program. The Clean Water Management Trust Fund is a major funding contributor to these efforts, as are mitigation banking dollars from NC Department of Transportation and US Army Corps of Engineers projects.
- *Expand technical guidance to developers to promote site design techniques that minimize impacts and maximize benefits to wildlife and habitat (e.g., urban development projects, roads, wastewater treatment plants, stormwater treatment sites, utility stream crossings).* One key technique is to create wildlife-friendly stormwater and wastewater wetlands. Most stormwater and wastewater impoundments have been developed primarily with water control in mind. If designed to serve wetland functions, these areas can substantially control stormwater runoff and pollution. These shallow retention ponds can be improved for wildlife by creating gently sloping sides, establishing appropriate native plants, creating coves and islands, and drawing down the water levels during the spring and fall migrations to benefit wading birds and shorebirds. Constructed wetlands provide opportunity to regain some of the natural functions of wetlands and offset some of the significant losses in wetland acreage (Adams and Dove 1993).

- *Improve citizen education on impacts from homes.* Wildlife agencies, nonprofit organizations, local governments and Home Owner Associations should be encouraged to promote the following: the use of non-phosphate detergents; the reduced use of fertilizers and herbicides/pesticides; washing vehicles away from waterways and storm drains to reduce phosphates entering the water; the proper disposal of oils, antifreeze, and other household products as well as pet waste and yard waste; the removal of invasive exotic plants; and indoor cats. For those citizens wanting to learn more on the impacts of their homes and yards on wildlife as well as how to create backyard oasis for species, the following organizations' programs may be of assistance: Audubon At Home, Cornell Lab of Ornithology Citizen Science Program, the North Carolina Wildlife Federation Backyard Habitat Program, the American Bird Conservancy's Cats Indoors! Campaign, and North Carolina Partners in Flight.

Policy and Land Use Planning

- *Work with local municipalities (commissions, planning boards, and other government entities) to promote ordinances that protect natural resources and improve water quality.*
  - *Stormwater management.* Increasing the effectiveness of ordinances on the 'front-end' (i.e., during initial planning of development projects) is a critical step to streamlining the 'back-end' (i.e., the environmental review process). If site improvements that are now made as a result of the environmental review process could instead be incorporated into the initial site design (through adherence to set ordinances), the environmental review process would be more efficient for both developers and reviewers. The Commission has produced a document with detailed recommendations related to cumulative and secondary impacts, which serves as a key resource on this topic (NCWRC 2002). A complimentary document currently in development is the result of a partnership between the Commission, the NC Department of Environment and Natural Resources, the US Fish & Wildlife Service, and the NC Department of Transportation to educate municipalities about secondary and cumulative impacts and the environmental review process ("Swimming with the Current," *in draft 2005*). Other sources of recommendations can be gleaned from the Environmental Protection Agency's Low Impact Development approaches (US EPA 2002).
  - *Lights out for sea turtles.* Light on beaches can deter nesting sea turtles or disorient hatchlings. The Commission's Faunal Diversity Program works with beach communities to get ordinances passed so lighting will not disturb nesting or hatchling sea turtles. A continued effort needs to be made to work with additional townships to further this endeavor.
- *Promoting "Smart growth."* Higher density development should be encouraged within existing urban boundaries and around existing infrastructure, and discouraged on urban fringes and in high diversity or ecologically sensitive areas. It is important to have large contiguous sections of land left intentionally as fields and forests available to wildlife. The use of low-impact development techniques should be promoted. An emphasis should be placed on long-range future planning rather than on trying to deal with current or imminent projects, except where critical resources are threatened. One group that is working to promote the idea of compact neighborhood design, multiple-use communities, and planned development is the North Carolina Smart Growth Alliance.
- *Work with homebuilders and developers to adopt voluntary conservation guidelines, including promoting the principles of "conservation design."* Many housing developments and golf courses can be designed in a way that minimizes disturbance to wildlife habitats and maximizes aesthetic and conservation values, without sacrificing economic gain. By clustering houses on only half of the buildable land and placing the rest in a conservation easement, developers can provide their homeowners with attractive open space while preserving wildlife habitat (Arendt 2004). Research has also shown that green space can encourage business. It is easier to attract and retain employees in areas characterized by a high-quality living environment. This equates to areas with green space for recreating and relaxing. Two such companies that cited greenways as a deciding factor in their move to North Carolina include Reichold Chemical Company (Research Triangle Park, NC) and Caterpillar Inc. (Morganton, NC) (Lerner and Poole 1999).

Nuisance Wildlife Control

Wildlife conservation in urban areas necessarily relates to managing human/wildlife interactions. Though most nuisance wildlife issues may not relate directly to a conservation concern (e.g., a listed species or an endangered habitat), our efforts to solve nuisance wildlife problems are critical to improving the perception of urban wildlife issues in general.

Nuisance wildlife problems can occur when wildlife are attracted to human dwellings for food or shelter, when wildlife populations are enhanced by the presence of humans, and when wildlife is displaced by human development. Wildlife species that can be compatible with human development include some bats, foxes, raccoons, opossums, squirrels, deer, pigeons, starlings, house sparrows, Canada geese and chimney swifts, among others. Many wildlife damage problems can be addressed by changing the perceptions and expectations of homeowners with regards to living with wildlife.

- *Promote proactive measures for residents to head off wildlife conflicts before they occur.* Many animal damage problems can be blocked with simple measures and prior planning. Planning around nuisance wildlife should start at the very first stages of creating a development or a new house, and should be continued by individual homeowners and homeowners associations.
- *Improve coordination of animal damage response efforts.* Presently the Commission, NC State University Cooperative Extension Service, the US Department of Agriculture Wildlife Services, and county and local wildlife control officers all play a role in responding to wildlife damage problems. Continued coordination and improved sharing of resources among these entities will make response efforts more effective. One advancement on existing coordination could be the creation of a central wildlife damage hotline.
- *Promote and distribute wildlife nuisance guidelines.* The Commission has developed nuisance wildlife recommendations and guidelines on some issues (e.g., resident geese, black bear). Nuisance guidelines developed by the US Department of Agriculture (APHIS 1994) are another key source of information used by Commission outreach specialists for wildlife damage related inquiries.
- *Make sure that certified damage control agents are educated on appropriate control techniques, especially for sensitive species.* Currently, the training to become an approved Wildlife Damage Control Agent involves several phases. First, a daylong course must be completed that covers rules, laws, health issues, and how to handle animals in a humane fashion. Second, the applicant must pass a written test given by the NC State University Cooperative Extension Service. Lastly, successful applicants must renew their certification every three years. Records of activities must be maintained and reported quarterly (Bromley et al. 2005). Potential reevaluation of the methods used for the removal of sensitive or tracked species (such as bats and some snakes) may be necessary to ensure the most appropriate handling of these sensitive species.

Public Education

The primary goal of education and outreach in urban and suburban areas is to increase awareness of and appreciation for wildlife-related issues in the urban landscape and to inspire people to take action towards protecting their local environment. (For more about education, outreach, and recreation prioirities, see Chapter 4D).

- *Expand delivery of wildlife-related programs and field trips to key audiences (e.g., schools, civic groups, watershed associations, planning boards).* The goal of these programs (as above) should be to increase awareness of and appreciation for local wildlife species and habitats and to create a connection between urban publics and nature. These local connections can be emphasized by promoting to the audience an awareness of where they live in their watershed and how their actions affect the world around them.
- *Target developers, local government staff, and elected officials.* Developers are impacting the land now. Educating them on ways to minimize impacts (e.g., impervious surface effects on stormwater drainage) and working to adjust regulations to provide more benefit to water quality and wildlife needs to occur immediately. Home Owner Association backing may be able to assist

in strengthening the cause. The newly created Urban Wildlife Program within the Commission's Faunal Diversity Program is striving to bring wildlife expertise to planning and zoning boards since they designate lands for development and protection. This pilot project seeks to create a new niche that links local governments to wildlife professionals for increased communication and cooperation, ultimately decreasing the potential for costly disagreements on land usage patterns before they arise. Another education tool is the draft *(as of 2005*) "Swimming with the Current" document, a partnership between the Commission, the NC Department of Environment and Natural Resources, the US Fish & Wildlife Service, and the NC Department of Transportation to educate municipalities about secondary and cumulative impacts and the environmental review process.

- *Constituency building.* Supporting and encouraging public comment to local officials or commissioners to voice their opinions on natural resources issues will create a more informed and sympathetic electorate and representatives. Partnerships with strong advocacy groups like North Carolina Audubon, the NC Coastal Federation, and the NC Wildlife Federation will strengthen constituency building efforts.
- *Promote schoolyard habitat programs.* The NC Museum of Natural Sciences is one entity that currently has such a program. It is called Using the Outdoors to Teach Experimental Science and includes lesson plans and classroom presentations where students plan, establish, maintain, and collect data on a bird and butterfly garden on the school grounds. Other opportunities to establish similar schoolyard programs should be encouraged and supported by natural resource agencies and organizations in North Carolina.
- *Establish demonstration areas for backyard wildlife habitat improvements.* Residents who develop backyard habitat areas can be recognized and rewarded, such as through the NC Wildlife Federation's Backyard Habitat Program. Demonstration areas on private company lands are also appropriate to mention. The Wildlife Federation's Wildlife and Industry Together (WAIT) program helps industrial grounds convert from manicured spaces to native habitat. If the proposed plan is approved and followed through, a site may receive certification and a sign advertising their involvement in the program. WAIT certified sites in North Carolina include IBM, Research Triangle Foundation, and the North Carolina Museum of Art. Other participants include the Environmental Protection Agency, Craig Davis Properties, and GlaxoSmithKline. Additionally, the NC Division of Forest Resources Urban and Community Forestry Grant Program funded the development of a wildlife-friendly landscape demonstration at the Turner House on the campus of NC State University.
- *Encourage landscaping design that creates plant community structure and native plant diversity beneficial to wildlife.* Promoting the use of native plants in landscaping, publicizing native plant nurseries, partnering with UNC Botanical Garden and North Carolina Exotic Pest Plant Council, and distributing NC State University Cooperative Extension Service backyard wildlife publication series are some examples of how to accomplish this goal. Integration of urban wildlife management ideas into Horticultural Sciences, Landscape Architecture, Forestry, Zoology, Natural Resources and other appropriate college curricula may also increases professional awareness of urban wildlife issues and to help generate additional public interest in urban wildlife.
- *Master Gardener and Master Wildlifer Programs.* The NC State University Cooperative Extension Service offers short courses on plant identification, propagation, and maintenance as well as wildlife identification, ecology, and habitat protection/creation. These programs should be encouraged to continue and expand as they help educate citizens on our natural resources.
- *Cornell Lab of Ornithology Citizen Science Programs*. The Cornell Lab of Ornithology offers many opportunities for citizens to use their skills and dedication related to birds to assist scientists in studying bird populations and distribution as well as reproductive and disease patterns.

- *American Bird Conservancy's Cats Indoors! Campaign.* The target of this campaign is to encourage people to keep their pet cats inside to help minimize impacts to wildlife. Cats are exotic predators in the environment and efficient killers. Even well-fed cats will kill small mammals, insects, birds, amphibians, and reptiles, some of which may be species of conservation concern. Cats are estimated to kill millions of wildlife species a year and are having a direct impact on certain populations.

Wildlife-related Recreation

The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reports that fishing, hunting, and wildlife-watching expenditures have increased over a ten year interval in North Carolina (1991–2001); approximately 2.2 million people participated in wildlife-watching in the state in 2001 (USFWS and US Census Bureau 2003). Recreational enthusiasts are a large constituency that must be appreciated and provided with opportunities to recreate. This population also represents an opportunity for wildlife agencies to increase public appreciation for and awareness of wildlife and their habitat requirements.

- *Establish and promote Watchable Wildlife sites.*
- *(See public education section above)*

Data Collection

- *Involve the public through volunteer and citizen science opportunities.* Citizen science projects help to involve the public in a hands-on way and create a sense of ownership and accomplishment among participants.
  - The Cornell Lab of Ornithology coordinates several bird-related citizen science projects such as Project FeederWatch, the Great Backyard Bird Count, House Finch Disease Survey, Urban Bird Studies, PigeonWatch, the Birdhouse Network, Birds in Forested Landscapes, House Finch Nest Survey, and Golden-winged Warbler Atlas Project.
  - *Watershed and stream monitoring and cleanup.* Continued expansion of citizen water quality monitoring, watershed education, and cleanup efforts will be important in North Carolina. Extensive citizen water quality monitoring already occurs in the northeastern part of the state, begun through an initiative of the Pamlico-Tar River Foundation and coordinated through the Albemarle-Pamlico National Estuary Program (http://www.ecu.edu/icmr/cmn/). In the western portion of the state, numerous watershed groups participate in water quality monitoring through the Southern Appalachian Volunteer Environmental Monitoring project coordinated by Southern Appalachian Man and the Biosphere (http://www.samab.org/). These efforts do a great deal to connect local citizens to the importance of their local watersheds and water quality resources and human impacts on those resources.
- *Evaluate the utility/effectiveness of greenways/wildlife corridors.* Current research at NC State University is exploring this topic to answer the questions: What purpose do greenways serve for wildlife? Are existing greenways serving this purpose? How could greenways be improved to benefit wildlife and habitat?
- *Improve the quality of property or site evaluations.* There is a need to improve the quality of habitat assessments currently being conducted by private consultants, land trust volunteers, and others related to site evaluations for development, wetlands mitigation, or land purchases. Establishing something akin to a series of "rapid habitat assessment teams"—a network of experts in various taxa groups that could evaluate a property when biological information is needed to inform a development or land acquisition project (e.g., identification and delineation of streams and wetlands, biological surveys and inventories)—might facilitate better evaluations.
- *Urban residents polling.* Human dimensions survey information should be collected on urban resident attitudes toward wildlife and open space and steps they are willing to take or have their governments take to preserve open space. Also, the perceived needs and desires of the public for urban wildlife programs should be evaluated.

Management of Artificial Structures

- *Identify key structures where wildlife can be safely managed and enhanced.* While some species coexist with humans and even prosper in their presence, others need additional assistance as their habitat is altered. Some species have become reliant on our structures for their continued survival and are thus impacted by changes to those structures (e.g., chimney swift use of smokestacks and chimneys, purple martin colonies reliance on manmade gourds and houses). Activities to benefit wildlife species using urban structures include preserving old chimneys for chimney swifts; identifying structures used by peregrine falcons for nesting and foraging and protecting these from disturbance; identifying, enhancing and protecting structures used for bat roosts; and promoting bird boxes of various sizes and shapes for eastern bluebirds, American kestrels, wood ducks, purple martins, and other cavity nesters.

References

Adams, L. W. and L. E. Dove. 1993. Urban wetlands for stormwater control and wildlife enhancement. National Institute for Urban Wildlife. Columbia, MD.

American Bird Conservancy. 2005. Cats Indoors! Campaign. Accessed from the World Wide Web on January 19, 2005: http://www.abcbirds.org/cats/.

Arendt, R. G. 2004. Conservation design: a workshop on growing greener communities. N.C. State University, Raleigh, NC.

Audubon International. 2005. Audubon at home. Accessed from the World Wide Web on January 19, 2005: http://www.audubon.org/bird/at_home.

Bromley, P. T., C. W. Betsill, and J. F. Heisterberg. The North Carolina wildlife damage control program brochure. N.C. State University Cooperative Extension, N.C. Wildlife Resources Commission, and the U.S. Department of Agriculture. Accessed from the World Wide Web on January 19, 2005: http://www.ces.ncsu.edu/nreos/wild/pdf/wildlife/wildlife_damage_class.pdf

Cornell Lab of Ornithology. 2005. Citizen science programs. Accessed from the World Wide Web on January 19, 2005: http://www.birds.cornell.edu/LabPrograms/citSci/.

Costa, L. and A. Petersen. 2002. The state of open space 2002: The Status of the Triangle's Green Infrastructure. Triangle Land Conservancy. Raleigh, NC.

Hess, G. Greenways for wildlife website. 2004. Accessed from the World Wide Web on January 19, 2005: http://www4.ncsu.edu/~grhess/research/greenways/.

Hull, J. R. 2003. Can urban greenways provide high quality avian habitat? Masters Thesis, N.C. State University, Raleigh, NC.

Leedy, D. L. and L. W. Adams. 1984. A guide to urban wildlife management. National Institute for Urban Wildlife. Columbia, MD.

Lerner, S. and W. Poole. 1999. The Economic benefits of parks and open space. The Trust for Public Land. Accessed from the World Wide Web on January 19, 2005: http://www.tpl.org/content_documents/.

Mecklenburg County Department of Environmental Protection (DEP). 1999. Surface Water Improvement and Management (SWIM) Ordinance. Charlotte, NC.

Mecklenburg County Park and Recreation Department. 2005. Nature center programs. Accessed from the World Wide Web on January 19, 2005: http://parkrez.co.mecklenburg.nc.us.

N.C. Department of Environment and Natural Resources (NCDENR). 2003 (DRAFT). One NC Naturally draft conservation plan. N.C. Department of Environment and Natural Resources, Raleigh, NC.

N.C. Division of Parks and Recreation (NCDPR). 2003. Statewide comprehensive outdoor recreation plan (SCORP). N.C. Department of Environment and Natural Resources, Division of Parks and Recreation, Raleigh, NC.

N.C. Division of Parks and Recreation (NCDPR), Triangle J Council of Governments, and Triangle Land Conservancy. 2002. Triangle GreenPrint regional open space assessment. Accessed from the World Wide Web on January 19, 2005: http://www.trianglegreenprint.org.

N.C. Department of Transportation (NCDOT). 2004. Ecosystem Enhancement Program (EEP) 2004 Annual Report. Accessed from the World Wide Web on January 19, 2005: http://www.nceep.net.

N.C. Greenways Advisory Panel. 1994. Report to the Governor.

N.C. Museum of Natural Sciences (NCMNS). 2005. Using the Outdoors to Teach Experimental Science (UTOTES). Accessed from the World Wide Web on January 19, 2005: http://www.naturalsciences.org/education/utotes.

N.C. Smart Growth Alliance website. 2005. Accessed from the World Wide Web on January 19, 2005: http://www.ncsmartgrowth.org/smrtgrth.html.

N.C. State University (NCSU) Cooperative Extension Service website. 2005. Accessed from the World Wide Web on January 19, 2005: http://www.ces.ncsu.edu.

N.C. Wildlife Federation. 2005. Accessed from the World Wide Web on January 19, 2005: http://www.ncwf.org.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Novotny, K. E. 2003. Mammalian nest predator response to greenway width, habitat structure, and landscape context. Masters Thesis, N.C. State University, Raleigh, NC.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). 1994. Prevention and control of wildlife damage (Vol. I & II). University of Nebraska Cooperative Extension, Great Plains Agriculture Council Wildlife Committee, Animal Damage Control.

U.S. Department of the Interior, Fish & Wildlife Service, United States Department of Commerce, U.S. Census Bureau. 2003. The 2001 national survey of fishing, hunting, and wildlife-associated recreation: North Carolina.

U.S. Environmental Protection Agency (US EPA). 2002. National Pollutant Discharge Elimination System (NPDES). Public Education and Outreach on Storm Water Impacts: Low Impact Development. Accessed from the World Wide Web on January 19, 2005: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/edu_7.cfm.

Vidra, R. I. 2004. Implications of exotic species invasion for restoration of urban riparian forests. Doctoral Thesis, N.C. State University, Raleigh, NC.

Voices and Choices of the Carolinas. 2004. State of the region report. Accessed from the World Wide Web on January 19, 2005: http://www.voicesandchoices.org.

B. Private Lands Habitat Management Strategies

Private lands comprise approximately 90% of land holdings in North Carolina (North Carolina Gap Analysis Project data) (Figure 4B.1). It is therefore especially important to effectively engage private landowners in the management and conservation of fish and wildlife species and their associated habitats and communities. We're faced with the challenge of building more effective partnerships with private landowners and lands managers that minimize government imposed regulations, red-tape, and restrictions. Without conservation efforts on private lands and programs benefiting private landowners, our state's wildlife resources will face difficult times in the coming years.

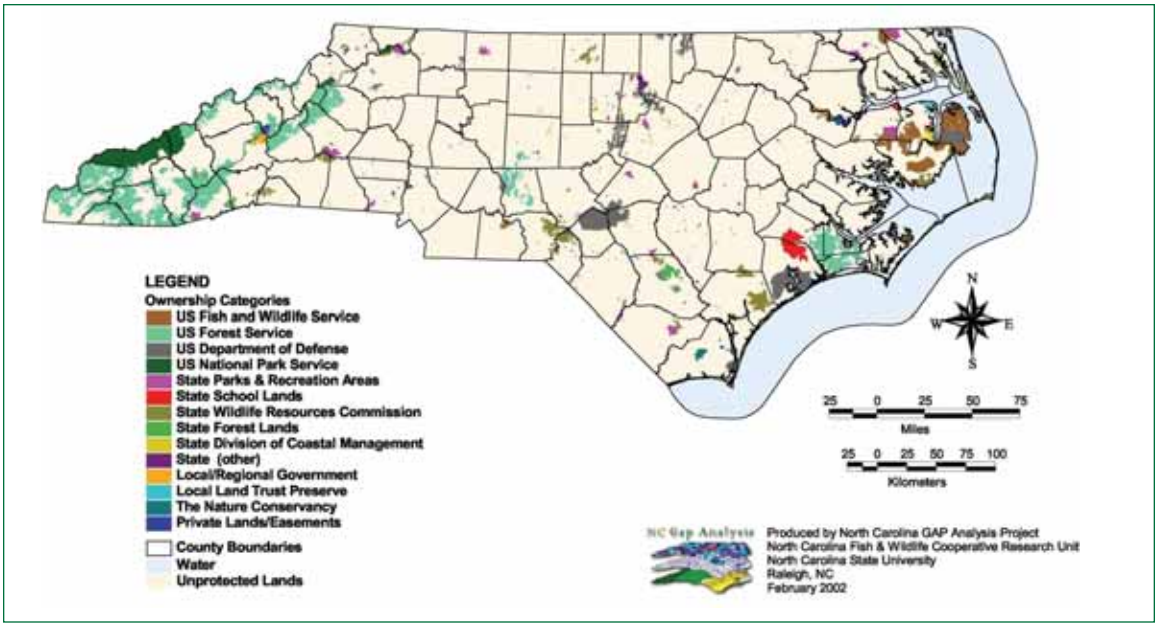


Figure 4B.1. North Carolina stewardship map by ownership, 2002 (source: NC GAP).

Private Lands Programs

State and federal agencies in North Carolina have long recognized the need to work effectively with private landowners and have responded by developing numerous private lands programs to address a variety of needs:

Partners for Fish and Wildlife – This is a voluntary program of the US Fish & Wildlife Service, designed to provide technical and financial assistance to landowners who want to restore and enhance fish and wildlife habitats on their property. All projects must benefit federal trust resources, which include migratory birds, threatened and endangered species, and anadromous or migratory fish.

Forest Landbird Legacy Program – This is a voluntary, multi-agency conservation program for private non-industrial forest landowners in all parts of North Carolina who want to manage mature forest habitat to benefit forest landbirds (especially those priority species identified by Partners in Flight). The Forest Landbird Legacy Program is a partnership between the US Fish & Wildlife Service, the Commission, and the Natural Resources Conservation Service.

Safe Harbor Program – Safe Harbor Agreements are voluntary arrangements between the US Fish & Wildlife Service and cooperating non-Federal landowners. The Program benefits endangered and threatened species while giving private landowners assurances from additional restrictions. To become a Safe Harbor Forest, the landowner works with the US Fish & Wildlife Service to determine a set number of the endangered or threatened species that will be maintained on the

property as habitat is improved. In exchange for this voluntary cooperation, the landowner is assured that no future restrictions on land use will be imposed.

Landowner Incentive Program – This federal program is usually administered by state fish and wildlife agencies. In 2004, there was $30 million available for states and tribes. The program's purpose is to support on-the-ground projects that enhance, protect, or restore habitats that benefit at-risk species on private lands. The state agency provides technical assistance to interested landowners, and evaluates and ranks proposals. The agency then submits the state's application package to the US Fish & Wildlife Service to compete with other states for a portion of the federal funding. High priority projects benefit multiple at-risk species, have permanent benefits, and involve multiple project partners.

Farm Bill Conservation Programs – In North Carolina, the Natural Resources Conservation Service and the Farm Services Agency administer Farm Bill programs, each of whom provide financial and technical assistance to landowners for particular natural resource needs.

- Conservation Reserve Program
- Conservation Security Program
- Environmental Quality Incentives Program
- Farm and Ranch Land Protection Program
- Grassland Reserve Program
- Wetland Reserve Program
- Wildlife Habitat Incentives Program

From a wildlife habitat perspective, the value of Farm Bill programs varies depending on individual implementation and management regimes. Two programs that are particularly beneficial to wildlife include the Wetland Reserve Program and the Wildlife Habitat Incentives Program. Still, all Farm Bill programs have the potential to help private landowners accomplish wildlife conservation goals.

Conservation Reserve Enhancement Program – The Conservation Reserve Enhancement Program is a joint effort of the North Carolina Division of Soil and Water Conservation, the NC Clean Water Management Trust Fund, the Ecosystem Enhancement Program, and the US Department of Agriculture to address water quality problems of the Neuse, Tar-Pamlico and Chowan river basins as well as the Jordan Lake watershed area. It is a voluntary program that seeks to protect land along watercourses that is currently in agricultural production. The objectives of the program include: installing 100,000 acres of forested riparian buffers, grassed filter strips and wetlands; reducing the impacts of sediment and nutrients within the targeted area; and providing substantial ecological benefits for many wildlife species that are declining in part as a result of habitat loss. Program funding combines Federal Conservation Reserve Program funding with State funding from the Clean Water Management Trust Fund, Agriculture Cost Share Program, and North Carolina Wetlands Restoration Program.

Agriculture Cost Share Program – Financial incentives to address agriculture's contribution to nonpoint source water pollution in North Carolina are provided through the Agriculture Cost Share Program. This program is administered by the NC Division of Soil and Water Conservation in the Department of Environment and Natural Resources. The Cost Share program was authorized in 1983 as a pilot program in 16 counties to address nonpoint source problems in the nutrient sensitive waters of Jordan Lake, Falls Lake, and the Chowan River. Due to the program's success, it has been extended to all 96 Soil and Water Conservation Districts (Districts) that includes all 100 counties. Participating farmers receive 75% of predetermined average costs of installed best management practices (BMPs) with the remaining 25% paid by farmers directly or through in-kind contributions. The program also provides local Districts with matching funds (50:50) to hire personnel to plan and install the needed BMPs.

Forest Legacy Program – The Forest Legacy Program was created by Congress in the 1990 Farm Bill. Administered by the NC Division of Forest Resources, its purpose is to help landowners, state and local governments, and private land trusts identify and protect environmentally important forest lands that are threatened by present and future conversion to non-forest uses. The most important part of Forest Legacy is the private landowner who wants to conserve the special values of their land

for future generations. Owners can do this in trust with the State government and receive a fair price for the commitment. Willing owners who are accepted into the program can sell the right to develop the land to the state government, who will pay for these rights at full fair market value. The owner keeps any remaining property rights and usually continues to live on and work/manage the property. Property taxes are paid by the owner on any retained rights as determined by local assessors.

Forest Stewardship Program – The Forest Stewardship Program, funded by the NC Division of Forest Resources and administered by the Division of Forest Resources and the NC Wildlife Resources Commission, is a cooperative effort to help owners realize the objective of managing their forests for the benefits they desire. The program is voluntary, and participants receive recognition for achievements in promoting total forest resource management. Landowners receive technical assistance in developing a stewardship management plan. The forest stewardship plan is based on the landowner's objectives, and activities are scheduled to enhance the forest for wildlife, soil and water quality, timber production, recreational opportunities, and natural beauty.

Forest Land Enhancement Program – Though not currently active, the Forest Land Enhancement Program provided cost-shared forest management improvements that are still needed in North Carolina. The program replaced two previous conservation incentives programs: the Stewardship Incentive Program and the Forestry Incentives Program. State forestry agencies could use Forest Land Enhancement Program funds to provide assistance to Non-industrial Private Forest owners to achieve a broad array of forest management objectives.

Forest Development Program – The Forest Development Program, administered by the NC Division of Forest Resources, is a continuing effort designed to encourage private landowners to reforest after harvest and to place their idle and under-productive forest land into full timber production. Forest industry contributes the majority of the funding for this program through a special assessment paid on all timber harvested in North Carolina. To qualify for a cost-sharing reimbursement, an applicant must own land suitable for growing commercial timber. A forest management plan approved by a representative of the Division of Forest Resources is required.

Cooperative Upland habitat Restoration and Enhancement Program (CURE) – The CURE program is designed to increase early successional habitats and improve associated wildlife (including small game and songbird) populations on private land in North Carolina. The CURE Program aims to create enough early successional habitat on private land cooperatives (>5000 acres) to have a measurable impact on local wildlife populations. Through the CURE program, the Commission offers guidance, labor and financial assistance to qualified landowners who sign five-year contracts with the Commission. During the first phase, one cooperative was established within each of three focal areas in the state which represent the best mix of conditions for early-successional habitat development. This initial phase of the pilot program will end in 2006. A program review is currently underway, the results of which will guide the direction of the next phase.

Successful private lands management ultimately involves effective partnerships forged among private landowners and land managers, organizations and agencies (e.g., the Commission, NC Division of Forest Resources, US Fish & Wildlife Service), non-governmental organizations (e.g., the American Farmland Trust, Quail Unlimited, The Nature Conservancy), private industry, County Commissioners, Soil and Water Conservation Districts, and county planning and zoning boards.

Note: For another useful source of information about private lands programming, tools and examples from across the nation, contact Defenders of Wildlife (www.defenders.org) for a final working paper entitled Voluntary Conservation Tools and Programs (Hummon and Cochran 2005).

Challenges and Opportunities

A number of issues make private lands management and conservation a constant challenge, including population growth (and subsequent development), loss of habitat, and economic tradeoffs. Rapid population growth and associated development throughout the southeast continues to result in a net loss of wildlife habitat. From 1950-1990, the population of North Carolina grew by 63% (US Census Bureau 2000). The loss of habitat to "clean farming" practices and some types of intensive forest management continues to be a significant obstacle in private-lands habitat management. Specific challenges include a lack of field borders and brushy field edges, larger fields unbroken by usable habitat, relatively low use of no-till farming practices, significant declines in bottomland hardwood forests and wetlands, loss of pocosin/Carolina bay habitats, and management practices that reduce habitat diversity in forest stands (such as chemical application to control ground cover vegetation). Forest conversion has also created large patches of monotypic forested habitat that does not meet the diverse needs of some wildlife species. The Forest Service estimates that forest acreage in North Carolina has fallen by one million acres (5.6%) since 1990, primarily due to development (Brown 2004).

Driven by technological advances and economic and social pressures, land management practices on private lands have changed dramatically over the past 60 years. Combating future habitat loss is an uphill battle considering future population growth projections. In a 10 year period alone (1990–2000), North Carolina experienced a 21% increase in human population size, and growth is projected to increase by the same amount over the next 25 years (US Census Bureau 2000). Without sufficient incentives, landowners often perceive wildlife as an unaffordable cost, even a liability (Higbe 1981, Noonan and Zagata 1982). Wildlife conservation on private lands must be economically viable in order to reverse negative trends in species and habitat losses. This challenge involves successfully engaging land use planners, developers, zoning boards, and homebuilders associations, in addition to traditional landowners and other traditional stakeholders.

Following are some of the most important issues, and recommendations, to be addressed in strategic private lands planning:

Incentives and Economics

- *Tax structure.* Currently, the tax structures present a disincentive for private landowners to manage wildlife habitat on a large scale (Cobb et al. 2002). Land use evaluations for county tax purposes provide lower tax rates for forestry, agriculture, and horticulture, but not for wildlife habitat management. Tax assessment amendments are needed.
- *Market solutions.* Private landowners are working to meet an economic bottom line. In order to make wildlife a 'part of the equation' we must promote market-based solutions that are economically viable.

Management Issues

- *Land management.* A great deal of land in North Carolina is passively managed because landowners cannot justify the expense of more active land management (e.g., thinning forest stands, maintaining field borders). We must work to encourage and assist landowners in active land management to maintain working lands (e.g., "no till" agriculture, establishment of field borders, restoration of native warm season grasses, prescribed burning).
- *Prescribed burning.* Prescribed burning presents the largest management issue. Historical and continuing fire suppression has created a need for agencies and other large scale land managers to initiate active fire management to mimic native community conditions. Current legislation allows landowners to prescribe burn with reduced liability on 60 acres or less. A Certified Prescribed Burner must be used on burn blocks larger than 60 acres. Certified Prescribed Burners experience difficulty in finding liability insurance to operate. These legal and liability issues are an enormous constraint and will require political action and support to mitigate.

- *Best management practices.* Currently, forestry BMPs are focused exclusively on water quality concerns. Poor water quality, however, also poses a significant threat to aquatic habitat. We must work to ensure that BMPs are robust enough to protect aquatic habitat in addition to water quality, demonstrate to landowners how such related efforts can be beneficial (to natural resources and them as owners), and encourage adoption of BMPs by linking with eligibility in other landowner assistance programs and by promoting comprehensive natural resource planning.
- *Forest management.* To diversify forest practices and reduce the outright conversion of forested habitats through intensive silviculture, we must promote markets, incentives, and technical assistance for alternative management styles for interested landowners.
- *Long-term planning.* Much manpower of natural resource agencies is tied up in reactive management (taking care of problems) instead of proactive planning (looking for opportunities). As our population grows, the number of problems increases and continues to pull manpower away from proactive efforts. We must work to increase the resources (staffing and funding) needed to enable proactive approaches to programs aimed at facilitating and expanding wildlife conservation on private lands (i.e., private lands conservation programming).

Outreach and Awareness/Technical Assistance

- *Technical guidance.* Technical guidance is a limiting factor, both in the amount of initial guidance available and in the ability to subsequently follow up on management efforts. Federal funding provides money to initiate technical guidance, but resources are scant to monitor existing projects. There is a significant need for increased and targeted outreach and technical guidance to private landowners to help them understand the different types of assistance and management practices available, to get participant sign-up, to provide initial and ongoing management guidance, and to encourage participation by other key landowners. There is also need for more interagency cooperation to better serve the needs of landowners with multiple or varying objectives (e.g., for landowners wishing to manage their property for wildlife, wildlife biologists should be on hand to provide advise, in addition to foresters or agricultural extension agents).
- *Local leadership.* We are limited in our ability to reach key private landowners. We must develop effective strategies for reaching key landowners who are influential in their communities and are likely to influence other landowners. We must continue to work with key groups who interact with private landowners (e.g., NC Division of Forest Resources, Natural Resources Conservation Service, US Fish & Wildlife Service, Farm Service Agency, Soil and Water Conservation Districts, Cooperative Extension, and local land trusts) to increase awareness and interest programs to benefit species and habitats on private lands.
- *Long-term support.* Many land protection efforts limit their focus to the initial acquisition or easement protection, without a long-term plan for conservation restoration, management, monitoring, or land stewardship. We must highlight and support opportunities for ongoing land management and restoration efforts on protected lands by coordinating protection and management assistance programs, and stewardship funding.
- *Local governments.* Some agency efforts to work with county governments and local zoning boards to promote land protection have been poorly received. Some officials perceive that the ideas of economic development/progress and wildlife habitat conservation are in direct conflict. We must find ways to reduce the perceived conflicts and reach common ground on issues of development, ordinances, zoning regulations, etc. through progressive partnerships that focus on common goals and objectives. We must do a better job of demonstrating how conservation activity can be a boon to local economies as opposed to an obstacle.

Participation in Conservation Programs

- *Program simplicity.* Every year private land conservation programs gain additional support, but also increase in complexity. Each year there are more programs, more choices, and more agencies and organizations involved in private lands issues. This translates to confusion among landowners in terms of what programs they qualify for and who administers such programs. And from a

programming standpoint, it makes it more and more difficult to come up with simple, clear, straightforward solutions. Private land programs need to be more streamlined, better coordinated, and more effectively presented to the public.

- *Program coordination.* The coordination role for private-lands programming has never been stable; different agencies oversee different programs. Key agencies and organizations involved in private lands programming in North Carolina should strive for better program coordination, with the goal of providing clear and consistent leadership on programming options to landowners.
- *Local leadership*. 'Centralized' leadership does little to gain the trust of local landowners, as it removes the groups they trust from decision-making and priority setting. While striving for clearer and more straightforward programming (to reduce confusion over program requirements, etc.) we must grow the level of responsibility and authority of local organizations (e.g., county commissioners, Soil and Water Conservation Districts) to implement state-sanctioned programs and strategies at the local level, with heavy input from landowners, to maintain and nurture their trust.

Corporate Landowners

- *Incentives.* Currently, there are no existing large-scale incentive programs designed to improve wildlife stewardship by corporate landowners. But there are incentives that could be available to pay for training contract burners or legislative action to reduce liability, which could do as much as a direct habitat management incentive. We must continue to develop and offer incentives for corporate landowners in order to affect positive on-the-ground impacts on the considerable corporate landholdings in the state.
- *Prescribed burning.* Burning on private and corporate timber lands has drastically declined over the past 20 years, in part due to changes in silvicultural practices, lack of internal resources/trained private contractors, smoke management issues, and potential liability. We must increase the number and availability of private contractors to conduct burning on private and corporate lands.
- *Large land holders.* Timber Investment Management Organizations (TIMO) are now the largest group of timberland owners in the South. Some TIMOs employ their own foresters and property managers, others use consulting foresters. Timber investments are usually managed in one of two ways: separate accounts (where investors purchase timberland with the intent to manage it for returns over an indefinite term), and close-ended accounts (in which multiple investors purchase timberland for a set period, e.g., 10–15 years, and then sell). In order to influence TIMO land management to include considerations for wildlife and habitats, we must work with TIMO employed land managers (or the appropriate contracting organizations) to influence TIMO land management practices. We must also seek ways to integrate a conservation ethic into the decision making process of the parent financial organizations. Especially in the case of close-ended holdings, land conservation agencies and organizations must also explore acquisition opportunities for those TIMO lands that are up for sale. Such acquisitions will be a challenge because TIMO profits are directly related to the sale price.

Research

- *Size and scale impacts.* We do not fully understand all the effects of different management scales and patch size on species composition. We need to encourage large-scale monitoring and research (e.g., timber company lands) vs. smaller tracts, to evaluate differences in species composition/management impacts (e.g., how large is large enough to support long-term viable populations of species of concern?). We must also move beyond presence/absence studies on private lands and assess species productivity to better understand the conservation needs of species of concern.
- *Monitoring and evaluation.* We need to evaluate the effectiveness of programs focused on species and habitats in order to justify programs and articulate the benefits of funding such programs. Before and after population evaluations on small scale projects are challenging, but are necessary to show benefit to the species for which we are undertaking the project.

Priority Focus Areas

- *Small land holdings.* The vast majority of forest and agricultural landowners in North Carolina own less than 50 acres (NASS 2002, Butler and Leatherberry 2004). While there is efficiency to be gained in targeting large landowners, we must also facilitate options for neighboring landowners to work together in order to conserve larger, contiguous tracts of land under multiple ownerships and thereby affect landscape-scale wildlife and habitat conservation.
- *Setting priorities.* Currently, many natural resource agencies that work with private landowners take opportunities as they come; we wait for landowners to call us. If we could expand our prioritization of areas in the state in which to focus our programming efforts, and if we had the resources to support land protection specialists, we could actively seek out landowners. We must identify priority areas in which to engage in private lands programming to increase our effectiveness and our odds of being successful. (For more about land conservation priorities, see Chapter 4C).
  - The Commission's CURE Program focal areas in the upper Coastal Plain and western Piedmont of North Carolina are a logical place to continue work for early successional habitat restoration and management (Howell et al. 2002).
  - Other key lands in which to focus private lands initiatives include floodplain zones, land adjacent to existing conservation holdings, corporate lands (e.g., timber company lands, TIMOs), and Tobacco Settlement buyout lands.
- *Proactive efforts.* Land conservation often becomes a higher priority for a community once significant development has occurred and open space has been lost. However within these areas, opportunities for large-scale, unfragmented land conservation have been lost and land prices can become prohibitively high. There is need to focus private land conservation in areas where land values aren't prohibitive, but those same areas are often where local leaders are trying to draw in industry to improve economic development. We must develop strategies to focus land conservation in affordable areas and we must make a legitimate connection between economic viability and private land conservation.

Coordination and Communication

- *Professional organizations.* We must continue to work with professional organizations to improve training opportunities for and expand contacts and communication with private landowners (e.g., Association of Consulting Foresters).
- *Partnerships.* Agencies, professional societies (e.g., North Carolina Chapter of The Wildlife Society), organizations, and universities concerned with natural resource protection should seek partnership opportunities in order to facilitate publication development and dissemination, to identify shared goals and objectives, and to reduce redundant efforts.

Forestry Summit and Working Lands Summit Recommendations

Recognizing the importance of both forestry and agricultural resources in perpetuating private lands conservation in North Carolina, in 2004 the One North Carolina Naturally Program helped sponsor two Forestry Summits (led by the NC Division of Forest Resources) and the Summit on Working Lands Conservation (led by the NC Association of Soil and Water Conservation Districts). The Summit on Working Lands Conservation resulted in a working lands conservation plan *(draft in progress as of spring 2005)*. The recommendations put forth in those summits addressed the following issues:

Forestry Summit Issues

- Urbanization
- Increased Risk of Wildfire
- Natural Disasters
- Forest Health
- The Next Generation: Reaching Tomorrow's Forest Landowners Effectively
- Necessity of Present Use-Value Taxation & the Right to Practice Forestry
- Value of Professional Forestry Assistance and Forestry Associations
- Growth of the NC Forest Development Program and other Cost Share
- Sustainability of Forest Industry Markets and Wood/Fiber Product Research
- Working Lands Opportunities with Conservation Easements and Trust Funds

Working Lands Summit Issues

- Private Lands; Public Benefits
- Balancing State Policies and Priorities in Conservation
- Local Leadership and Partnerships
- Existing Tools
- New Tools
- Limited Resource and Beginning Farmers and Landowners
- Working Lands Conservation Funding

As the issues and recommendations addressed within each of these efforts reinforce many of the same needs addressed above, we support implementation of the Forest and Working Lands summit recommendations. We direct readers to Appendix J to view the recommendations and summary reports for both summits.

References

Brown, M. J. 2004. Forest Statistics for North Carolina, 2002. Southern Research Station. US Department of Agriculture, Forest Service, Asheville, NC.

Butler, B. J., and E. C. Leatherberry. 2004. America's family forest owners. Journal of Forestry 102:4–9.

Cobb, D. T., T. L. Sharpe, D. Sawyer, and D. O. Baumbarger. 2002. Integrating early-successional wildlife and habitats into North Carolina's 21st centry landscape. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 56:124–135.

Higbe, M. 1981. Farmers and wildlife- why is there a rift and how can we bridge it? Pages 53–59 *in* R. T. Dumke, G. V. Burger, and J. R. March, editors. Wildlife management on private lands. Wisconsin Chapter of The Wildlife Society, Milwaukee, WI.

Howell, D. L., D. T. Cobb, and T. L. Sharpe. 2002. Selection of focal areas for northern bobwhite habitat enhancement on private lands in North Carolina. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 56:159–170.

Hummon, C., and B. Cochran. 2005. Voluntary conservation tools and programs. Defenders of Wildlife, Portland, OR.

National Agricultural Statistics Service (NASS). 2002. 2002 Census of Agriculture. U.S. Department of Agriculture, Washington, D.C.

N.C. Division of Forest Resources (NCDFR). 2004 (DRAFT). 2004 North Carolina Forestry Summit Report. N.C. Department of Environment and Natural Resources, Division of Forest Resources, Raleigh, NC.

N.C. Association of Soil and Water Conservation Districts and N.C. Division of Soil and Water Conservation. 2005 (DRAFT). A North Carolina plan for working lands conservation: summary of principles and action steps. N.C. Department of Environment and Natural Resources, Division of Soil and Water Conservation, Raleigh, NC.

Noonan, P.F. and M.D. Zagata. 1982. Wildlife in the market place: using the profit motive to maintain wildlife habitat. Wildlife Society Bulletin 10:46–49.

U.S. Census Bureau. 2000. 1990 to 1999 total population estimates. U.S. Census Bureau, Population Distribution Branch. http://www.census.gov/population.html

C. Land Conservation Strategies

Land conservation planning, land protection, and land acquisition are conservation tools employed by numerous agencies and organizations in North Carolina, with varying degrees of focus. Land conservation for the benefit of wildlife is a primary goal of the NC Wildlife Resources Commission. The Commission uses many tools to achieve this goal, including wildlife and forest management, fee simple land acquisition, easement acquisition, stream restoration, technical guidance to private landowners, and regulatory actions. As related to the Plan, the Commission's primary objective for land conservation is to achieve species, habitat and ecosystem conservation. Yet this objective is just one of several land conservation objectives held by the Commission and other agencies and organizations in the state, who are also primary land conservation partners. Other objectives include the provision of public recreation opportunities, open space, water quality protection, and military activity buffers, just to name a few[1]. Land acquisition is a major tool used by the Commission to achieve these objectives.

As one of the most expensive conservation tools, land acquisition is largely driven by the availability of funding opportunities, as well as local land markets and owner interest in selling. Public agencies and organizations, therefore, often work in cooperation to acquire and then manage lands that become available for purchase. Numerous funds are available in North Carolina to support particular types of land conservation; successful acquisition is a matter of matching site priorities with the appropriate trust fund donor. Key funding sources in North Carolina include the:

- **Clean Water Management Trust Fund** – This fund supports projects to enhance or restore degraded waters, protect unpolluted waters, and/or contribute toward a network of riparian buffers and greenways for environmental, educational, and recreational benefits.
- **Land and Water Conservation Fund** – This federal fund supports acquisition and development of public outdoor recreation areas and facilities. The program is intended to create and maintain a nationwide legacy of high quality recreation areas and facilities.
- **Natural Heritage Trust Fund** – This fund provides grants to state agencies to support the acquisition of the most significant natural and cultural lands of our state and to support the inventory of natural areas.
- **Parks and Recreation Trust Fund** – This fund primarily supports state and local parks and recreation projects (e.g., recreational trails, greenways, community centers).
- **North Carolina Farmland Preservation Trust** – This fund supports the preservation of active farmland on prime soils in the state, and depends on annual appropriations by the General Assembly.

The Ecosystem Enhancement Program, developed through a 2003 Memorandum of Agreement between the NC Department of Environment and Natural Resources, the NC Department of Transportation, and the US Army Corps of Engineers, also has huge potential to dictate future land acquisitions in North Carolina through a watershed approach to compensatory mitigation from unavoidable impacts to stream and wetlands associated with highway development projects. Private land trusts, local and state government agencies and other groups also contribute significantly to land protection through fee simple acquisition and conservation easements.

Since the creation of these trust funds, the Commission has purchased more approximately 162,000 acres in acquisitions, in large party by working cooperatively with non-profit land trusts. The Commission will continue to use land acquisition to help meet our conservation objectives and will continue to work cooperatively with non-profit land trusts and other agencies and organizations to do so.

[1]The discussion that follows has primary bearing on land conservation activities aimed at the conservation and protection of species, habitats, and ecosystems in North Carolina.

> *Note:* A look at land management practices on private lands is an essential part of a complete discussion about land conservation issues in North Carolina. For a more directed discussion of private lands issues, see Chapter 4B, Private Lands Habitat Management Strategies.

Agencies and organizations involved in land protection and acquisition often focus and prioritize their efforts by applying criteria that help them identify important land acquisition areas. These criteria may include Natural Heritage Program element occurrence data, water quality data, important wildlife corridor areas, important wildlife habitat areas, key aquatic sites, degree of habitat connectivity, and proximity to existing protected lands. These types of analyses help agencies and organizations be more efficient at buying or protecting land. Not only can these analyses indicate where land acquisition should be focused, but they can also provide documentation to make projects more competitive for grants.

Land Conservation Partners

Partnerships are a critical aspect of land acquisition and conservation efforts across North Carolina. The following section highlights the land conservation principles, strategies, and priorities of a number of key land acquisition partners in North Carolina.

The NC Wildlife Resources Commission purchases and manages land in three classifications: Game Lands, wildlife conservation areas, and other recreational sites. Game Lands are managed for a variety of species and thus require a variety of land management techniques. Wildlife conservation areas and other recreational sites are managed on a site specific basis, according to the intended use and function of the site. Land acquisition increased dramatically with the creation of the Natural Heritage Trust Fund and Clean Water Management Trust Fund. Commission staff use these funds to protect natural areas and water quality and to add land to the Game Land program managed by the Division of Wildlife Management. In an effort to manage and plan for the increased acquisition program, the Division created a Land Acquisition Committee. The Committee initially contained staff from the Land Management Section of the Division of Wildlife Management but membership was later extended to include staff from the Research and Surveys and Nongame Sections. The expanded Committee developed a list of acquisition priority criteria that allowed for the creation of land acquisition focus areas (Figure 4C.1). The Committee actively searches for land acquisition opportunities in these focus areas (but will also consider quality tracts that do not fall in a focus area). In 2005, the Committee will expand, once again, to include Division of Inland Fisheries staff working with aquatic nongame, stream restoration, and fisheries management. New funding opportunities for stream restoration and easement acquisition will require an agency approach to land acquisition and the newly expanded Committee should answer the challenge.

The Land Acquisition Committee meets periodically to discuss land acquisition projects and to plan for funding cycles. Priorities of the Committee necessarily reflect the mission of the agency. Their objectives include the expansion and connection of existing Game Lands; the provision of public hunting and fishing opportunities; the protection of wildlife migration corridors and connectivity of priority habitats; and the protection and restoration of aquatic habitats.

Opportunity, a factor that by definition is not easily anticipated, also plays a significant role in Commission acquisitions and cannot be eliminated from the decision-making process. An available site that may not currently support a known Heritage-tracked species or a key habitat type still has the potential of such in the future (through surveys, inventories, restoration efforts). Other aspects of opportunity include landowner interest in selling, funding streams, and project negotiations for mitigation sites.

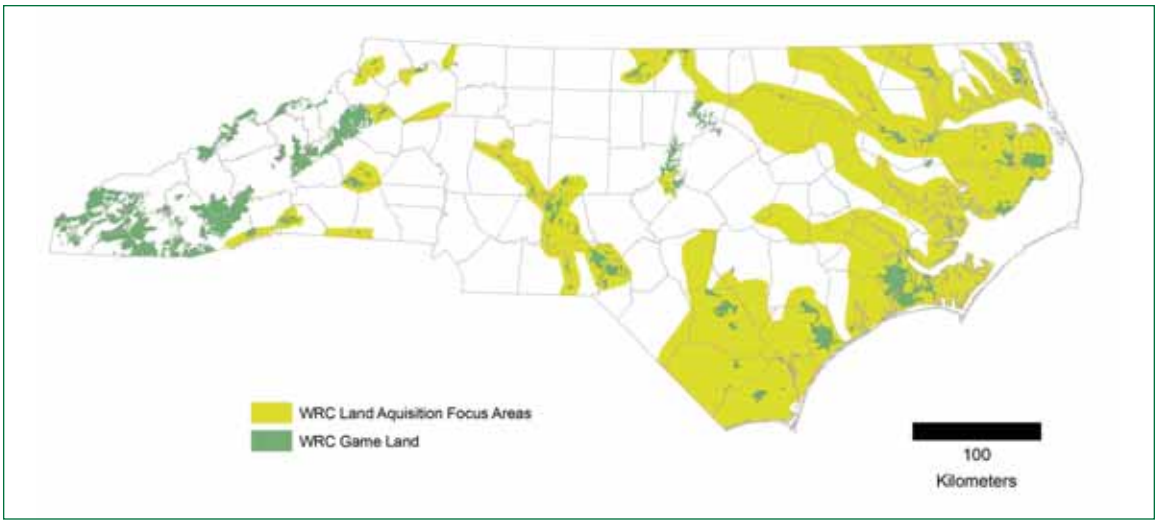


Figure 4C.1. Commission Game Lands and future focus areas, 2001

The NC Natural Heritage Program collects and manages information on rare plant and animal populations and significant natural communities across the state. Using this information, the NC Natural Heritage Program has identified more than 2,000 natural areas of national, state and regional significance in North Carolina, termed Significant Natural Heritage Areas (NCNHP 2005) (Figure 4C.2). A natural area's significance may be due to the presence of rare species, rare or high quality natural communities, or other important ecological features. While 500 of these natural areas have been protected (as of 2005), the majority of the sites remain unprotected and additional important natural areas are being identified each year. An important new component of this effort has been a comprehensive assessment of aquatic habitats and the identification of Aquatic Significant Natural Heritage Areas (utilizing data from the Commission and other partners). Conservation of these areas will protect the state's rare aquatic fauna. The NC Natural Heritage Program has also recently completed (as of 2005) a conservation assessment for the North Carolina Coastal Plain, focusing on both the quality of habitats at particular locations, and the integrity of their connections to other such habitats across broad areas of the landscape, in an effort to inform biodiversity inventory and conservation efforts.

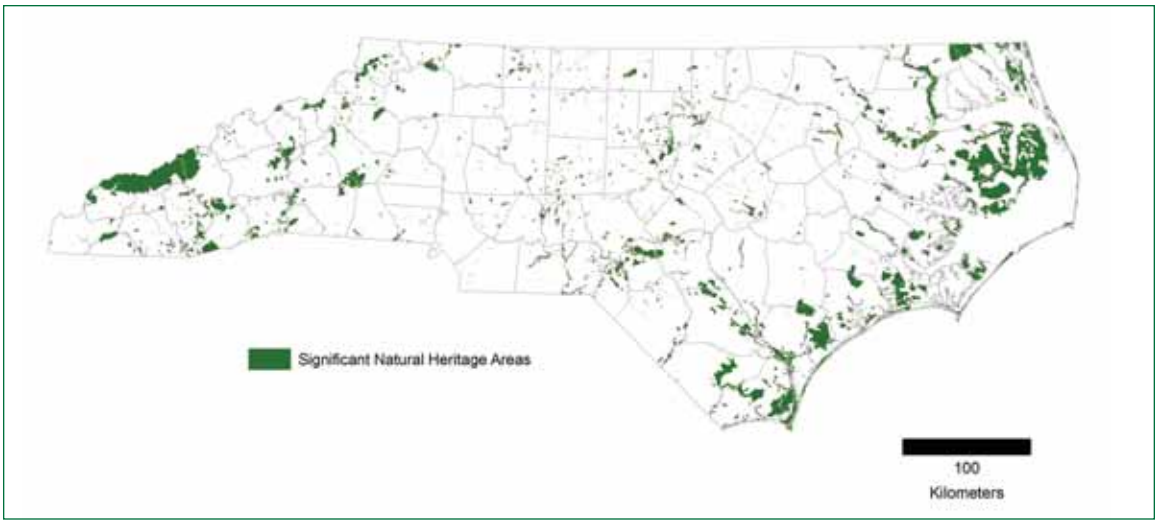


Figure 4C.2. Significant Natural Heritage Areas in North Carolina, 2005.

The Nature Conservancy works to protect biological diversity and functional landscapes through land conservation. Toward that end, their efforts to set ecoregional site conservation priorities represent some of the most directed work in this arena (Groves et al. 2003). The process relies heavily on Natural Heritage Program data and expert feedback. Within the three ecoregions that overlap North Carolina's borders (the Southern Blue Ridge, Piedmont, and Mid-Atlantic Coastal Plain), The Nature Conservancy (TNC) has identified a total of 464 sites in the state that, if protected, would likely ensure the survival of the three ecoregion's native plants, animals, natural community types, and critical ecological processes (TNC and SAFC 2000, TNC and NatureServe 2001, M. Bucher, pers. comm. 2004). TNC has also conducted a freshwater biodiversity assessment of the southeastern United States (Smith et al. 2002). That effort helped to identify critical areas for freshwater biodiversity conservation in the region, among them approximately 70 priority sites in North Carolina (Figure 4C.3).

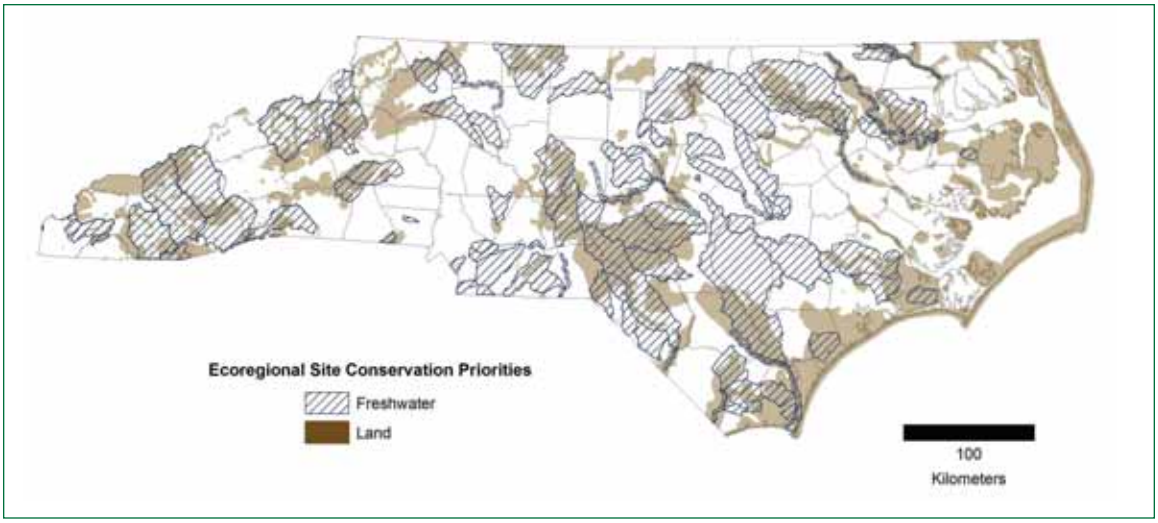


Figure 4C.3. Priority conservation areas of The Nature Conservancy in North Carolina, 2005.

The 24 land trusts that operate in the state also contribute significantly to land conservation, both through outright land acquisition and through conservation easements with landowners. The umbrella organization representing all of the individual land trusts in North Carolina is the Conservation Trust for North Carolina (CTNC). It acts as a "hub" for information exchange, coordination, public policy representation, and financial assistance. CTNC works cooperatively with private, local and regional land trusts across the state to help landowners protect natural resources through voluntary conservation methods. According to CTNC, the cumulative total of land protected by North Carolina's private land trusts is 161,900 acres in 820 places as of 2003 (72,510 of those acres are protected by conservation easement). 2004 figures (which were not available before the completion of the Plan) are expected to increase this figure significantly.

The One North Carolina *Naturally* Initiative promotes and coordinates the long-term conservation of North Carolina's land and water resources. The Office of Conservation and Community Affairs (within the NC Department of Environment and Natural Resources) manages the program by leading the development and implementation of a comprehensive statewide conservation plan involving government agencies, private organizations, landowners and the public. This voluntary program pursues the conservation of significant natural areas, working farms and forests, and our coastal estuarine system. One NC *Naturally* also provides support for development of regional open space plans, providing assistance through regional meetings and resource materials. One NC *Naturally's* regional planning process provides an effective forum for decision-making about conservation in our communities. By first working with local and regional groups to address the specific needs of each region, the state can move in an overall direction that does not conflict with goals of any particular region. Currently, 92 counties across North Carolina are involved in 14 local and regional open space planning efforts. Local and regional open space planning efforts provide

invaluable new information to add to the statewide conservation plan. Data from each of these regional plans is incorporated into the web-based NC Conservation Land Map Viewer (http://www.onencnaturally.org/mapviewer/) where the data is continually updated. This online decision support tool can provide key information vital to successful planning efforts.

Many other state agencies (e.g., NC Division of Water Quality, NC Division of Parks and Recreation), organizations (e.g., NC Audubon), and initiatives (e.g., Triangle Greenprint, Voices and Choices of the Central Carolinas) also set their own land conservation targets, in many cases using information generated through the aforementioned efforts. While, again, it should be noted that there are many potential objectives related to land conservation efforts (species and habitat protection being just one), all of the groups above contribute significantly towards efforts to conserve and protect land in North Carolina.

Conservation Opportunity Areas in North Carolina

The Commission, the NC Natural Heritage Program, and The Nature Conservancy have long been partners in land conservation and protection efforts in North Carolina to meet the shared objectives of species and habitat conservation. To date these partnerships have been largely *ad hoc*. Yet with new initiatives on the horizon in North Carolina aimed at increasing the level of funding available for land conservation in the state (e.g., Land for Tomorrow Coalition), these groups view the development of the Plan as an opportunity to be more systematic and comprehensive in identifying shared land conservation priorities. So, as part of our Plan development process, we assembled these land conservation players to compare the processes each group uses to set land conservation priorities. Our goals were to, for each group's set of priority sites, identify key habitat types and threat levels associated with each site, and using that information, identify shared land acquisition priorities that the three groups could cooperatively work towards. Though we were unable to finalize those efforts within the timeframe of the initial Plan development process, we will continue discussions among these groups to work towards this goal in the near future[2].

Relative to Commission priorities, the areas shown in Figure 4C.1 and the habitat priority types listed in Box 1 must be considered among other land conservation objectives of the agency. These priorities can be complementary to one another, but are not always necessarily synonymous. Again, land acquisition committee objectives include:

- Expand and connect existing Game Lands and Wildlife Conservation Areas
- Provide public hunting, fishing, and wildlife observation opportunities
- Provide wildlife migration corridors and connectivity of priority habitats

In addition, the Commission's Division of Inland Fisheries plans to complete a watershed prioritization analysis in 2005 at the 14-digit hydrologic unit level to identify land conservation priorities. This project will integrate information from our partners (as described previously) with the objective of protecting and enhancing water dependent fauna.

Box 1: Priority Habitat Types

The following habitat types were identified as being especially key for land acquisition by Commission biologists involved in the Plan development process, due to a combination of factors (species assemblages supported by those habitats, threats/risks to the habitat, and/or uniqueness or rarity of the habitat type):

- Beaches and estuarine islands
- Coastal wetlands
- Maritime forest
- Longleaf pine forest
- Small wetland communities
- Mountain bogs
- Piedmont early successional habitat
- Floodplain forest
- High elevation habitats
- Caves/mines
- Rock outcrops
- Streams and key aquatic habitats (*see maps in Chapter 5B*)
- Strategic parcels (e.g., large unfragmented tracts, tracts in close proximity to existing holdings)

[2] Efforts to expand involvement by other potential land conservation partners in the state (e.g., the Department of Defense, the US Fish & Wildlife Service) should also be considered.

Conservation Planning Concepts and Case Studies

The discussions above lend assistance to prioritization among sites and focus areas in North Carolina (which may range in size from small isolated tracts to multi-county regions). Within a particular site or focus area (e.g., among individual tracts of land), there are some key conservation planning concepts to consider in order to reach the maximum potential of a site and to fulfill the priorities of all partners, such as core areas, buffers, corridors, and managed areas. So we now explore in detail two land conservation efforts underway in the state, case studies that represent successful land conservation partnerships accomplished at the local or regional scale, which serve as examples of how to affect meaningful conservation on the ground.

CASE STUDY 1. North Carolina Sandhills Conservation Partnership

The North Carolina Sandhills region is approximately one million acres in extent, covering all or parts of eight counties. It is best known for being the home of the longleaf pine ecosystem, an ecosystem known for its incredible species diversity. The North Carolina Sandhills also contain the second largest concentration of the endangered red-cockaded woodpecker in existence. However, over the years, the longleaf pine ecosystem in the North Carolina Sandhills has been diminishing due to rapid changes in land use patterns. Fragmentation, loss and lack of management of longleaf pine habitat caused a significant reduction in the number of red-cockaded woodpecker groups in the North Carolina Sandhills. Loss of longleaf pine habitat has occurred to such an extent that this habitat type has been identified as a globally threatened status by The Nature Conservancy.

Competing land uses include military training on Fort Bragg and Camp Mackall, horse farms, residential and commercial development and golf course construction. Traditional private forested lands are being converted at a rapid rate leaving a fragmented mosaic of land use patterns surrounding and separating two distinct aggregations of public lands; approximately 170,000 acres in the Fort Bragg/Weymouth Woods/McCain complex and the approximately 65,000 acres in the Sandhills Game Land/Camp Mackall complex. Since the late 1970's these public lands have fast become the last bastions of managed longleaf pine habitat and associate natural species diversity in the North Carolina Sandhills.

To attempt to turn the tide of this habitat loss on private lands, in 1995 the US Fish & Wildlife Service and the US Army collaborated to open a new US Fish & Wildlife Service project office in the heart of the Sandhills with staff dedicated to one mission, reach out to private landowners to encourage them to restore, manage and protect longleaf pine habitat on their property. Today, through the NC Sandhills Safe Harbor Program, the US Fish & Wildlife Service is working with over 91 landowners on 48,000 acres of land to provide longleaf pine habitat that supports 56 groups of red-cockaded woodpeckers.

In 1995, the Army Environmental Center and Fort Bragg also entered into a cooperative agreement with The Nature Conservancy, establishing the Private Lands Initiative. The primary purpose of the Private Lands Initiative is to purchase fee simple ownership of or perpetual easements on key conservation lands specifically to permanently protect and manage longleaf pine habitat for red-cockaded woodpeckers. Under the cooperative agreement, The Nature Conservancy holds title and management responsibility for any lands purchased under the Private Lands Initiative or has the option of transferring ownership to another partner such as the NC Wildlife Resources Commission or the NC Division of Parks and Recreation.

In order to sustain the longleaf pine ecosystem and recover the North Carolina Sandhills population of red-cockaded woodpeckers, both public and private lands need to be managed in concert. A collaborative process to integrate private and public land management concerns and objectives was needed to provide a vehicle to focus the efforts of a variety of stakeholder groups. Thus was born the North Carolina Sandhills Conservation Partnership (NCSCP) (Figure 4C.4). The mission of the NCSCP is:

> *To coordinate the development and implementation of conservation strategies for the red-cockaded woodpecker (Picoides borealis), other native biota, longleaf pine and other ecosystems in the Sandhills of North Carolina.*

The NCSCP was formed in 2000 with the specific intent to facilitate collaboration between various federal, state and non-profit conservation groups for the purpose of conserving the vanishing longleaf pine ecosystem and recovering the endangered red-cockaded woodpecker in the North Carolina Sandhills (see USFWS 2003 for recovery plan). The current Steering Committee members represent the US Fish & Wildlife Service, US Army at Fort Bragg, US Army Environmental Center, NC Wildlife Resources Commission, NC Division of Parks and Recreation, The Nature Conservancy, Sandhills Area Land Trust and the Sandhills Ecological Institute. The NCSCP continues to seek input from over 18 stakeholder organizations as it continues to develop a landscape-level strategic conservation plan for the Sandhills. County and municipal viewpoints about conservation issues have been provided through the Fort Bragg/Pope Air Force Base Regional Land Use Commission.

This group was revitalized for the sole purpose of providing community based input into the partnership's planning process.

The NCSCP has six active stakeholder working groups that are charged with developing selected sections of a Sandhills Conservation Plan. These sections include a reserve design, communications plan, and strategies for land protection, red-cockaded woodpecker recovery, and natural resource management. The development and implementation of the Sandhills Conservation Plan is supported by the GIS working group which has since evolved into the Sandhills GIS Association. This association is tasked with developing strategies to share, store and disseminate data to benefit the NCSCP mission, other regional initiatives and individual stakeholders. A Sandhills GIS Coordinator position, regional database and server have been created to support the NCSCP and its mission.

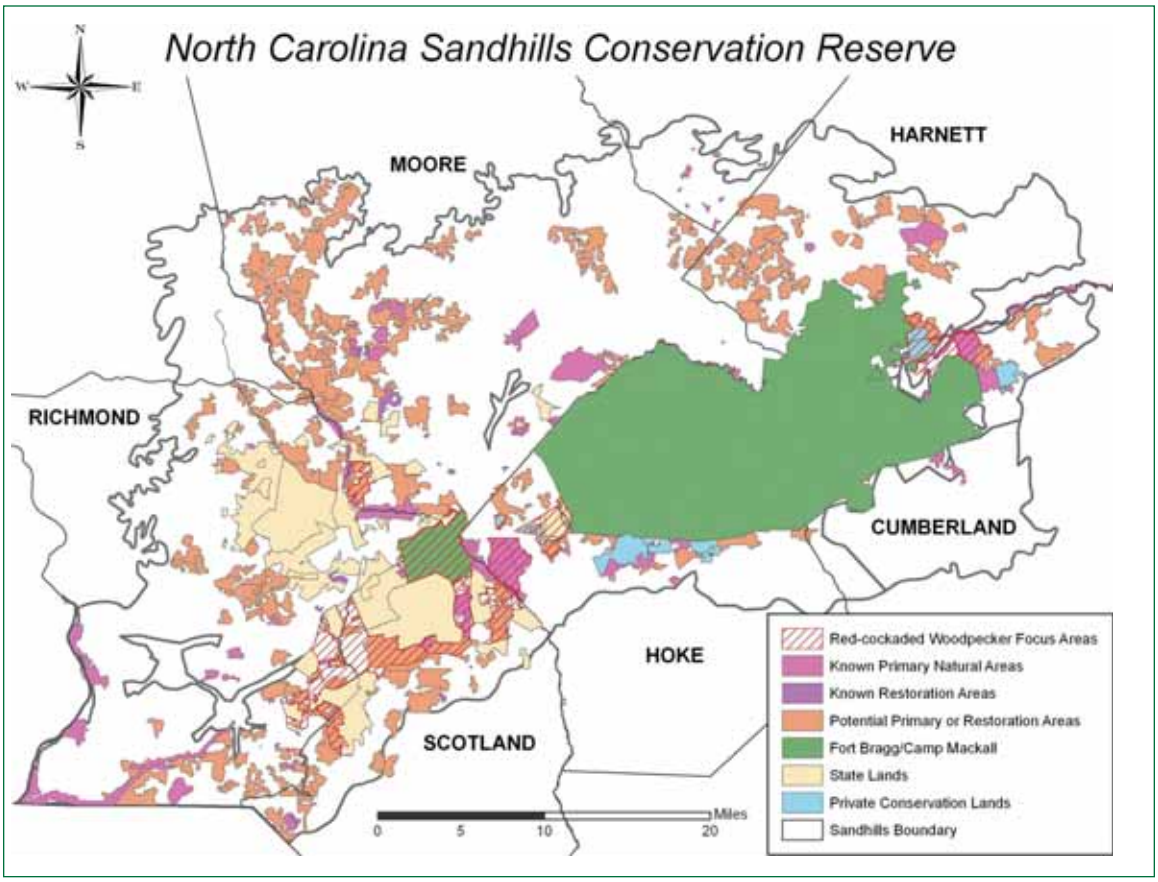


Figure 4C.4. North Carolina Sandhills Conservation Reserve.

The final Sandhills Conservation Plan will include: a reserve design identifying and ranking those areas of the Sandhills that are critical for red-cockaded woodpecker recovery and to sustain other identified conservation targets; a landscape-scale resource management strategy emphasizing collaborative methods to "seamlessly" manage longleaf pine communities across ownership boundaries; land protection strategies and options necessary to acquire in-perpetuity protection of lands identified in the reserve design; a communications plan to ensure continued coordination among stakeholders and support of the general public; a GIS model to assist in designing the Sandhills conservation reserve, implement management recommendations and to monitor success of the various strategic components of the plan.

Reserve Design

The intent of the reserve design is to identify areas of the Sandhills landscape requiring some level of conservation protection and management based on 1) the presence or predicted presence of important federal or state species and natural communities and/or 2) other resources. The reserve design working group based its initial draft 2002 reserve design (Schafale 2002) on aerial photo interpretation, data from the North Carolina Natural Heritage database, data collected during county-wide natural community inventories, and field surveys of specific properties enrolled under the Sandhills Safe Harbor program. Specifically, this information included element of occurrence data for federally-listed species, state listed rare species and natural community types. Spatial data (e.g., land cover, soils and hydrology) was used in combination with biological descriptors, such as species habitat requirements, to identify and rank possible conservation targets within the Sandhills reserve using a GIS.

The interim reserve design identifies parts of the landscape that have biological or spatial significance in their own right, or are important because they provide habitat corridors between or buffer adjacent existing core natural resource lands, such as those found on the Sandhills Game Lands and Fort Bragg. Corridors in general address the needs of species to disperse or move between larger natural areas that are spatially fragmented. Lands within corridors can also provide all or part of the habitat required by a given species or guild of species. Buffering critical core natural resource areas with lands that have some type of compatible land use is also critical to ensuring the long-term ecological health of the core lands.

The interim reserve design also includes priority focus areas identified in the Sandhills red-cockaded woodpecker recovery strategy as critical to restoring the demographic and genetic viability necessary to recover the Sandhills red-cockaded woodpecker population. The result is an initial portfolio of existing and potentially high or medium quality longleaf pine habitat that is either intact or potentially restorable. Further field data collection is needed to assess the accuracy of the modeling process used to predict the location of these longleaf pine communities on the Sandhills landscape. Once the list of conservation targets based on Natural Heritage data species is finalized, other data will be added to the GIS analysis for use in ranking the protection priority of the acquisition targets. These data include ownership information, land use, spatial relevance of target parcels to proposed corridor or buffer areas, proximity to existing public conservation lands, and threat level. The goal of using both biological and non-biological information is to find balance between ecosystem and single species management objectives as well as other major concerns of the stakeholders, such as encroachment of incompatible development adjacent to public lands. The reserve design will be continuously updated and refined as new information becomes available.

The final Sandhills reserve design will focus on protecting specific portions of the landscape necessary to sustain key conservation targets at the species, community and ecosystem levels. The 2002 interim reserve design incorporates:

- Core public lands that vary in primary land use but all of which are actively managed to promote conservation of longleaf pine habitat and associated natural communities;
- Properties owned and managed by conservation organizations such as The Nature Conservancy and the Sandhills Area Land Trust;
- Known Significant Natural Heritage Areas designated by the North Carolina Natural Heritage Program;
- Predicted areas of high, medium and low value longleaf pine habitat and, specific focus areas identified by the Red-cockaded Woodpecker Working Group as requiring protection in order to achieve recovery of the Sandhills red-cockaded woodpecker populations.

In 2004, a *Site Conservation Plan for the North Carolina Sandhills* (Nelson 2004) was completed using The Nature Conservancy's 5-S process (see Groves et al. 2003). This plan seeks to establish baselines for the current health status of the selected targets in the areas of size, condition and landscape context. It lists specific conservation targets, potential threats to the health of these conservation targets, strategies to abate these threats and general measures of success. It is intended to be used as a guide for additional GIS analyses that will update and expand the 2002 interim reserve design to include additional targets beyond longleaf pine habitat and red-cockaded woodpeckers.

NCSCP Success Highlights

- The NC Department of Agriculture, the NC Division of Parks and Recreation, the NC Wildlife Resources Commission and The Nature Conservancy have agreed to manage their lands to promote recovery of the Sandhills population of red-cockaded woodpeckers. Originally, only Fort Bragg had the responsibility to mange at the recovery level. This is a significant contribution to the Sandhills recovery effort.
- Since 2000, fee simple ownership or conservation easements have been purchased on 8,227 acres of new lands which are now under in-perpetuity protection and management.
- In 2001, four of the partners, the US Fish & Wildlife Service, Army Environmental Center, The Nature Conservancy and the Sandhills Area Land Trust co-located in a new Conservation Center of the Sandhills, a "store front" office accessible to the public. The ability to communicate in-person on a daily basis has proven invaluable in leveraging individual organization's contacts and resources and has resulted in a much more efficient approach to acquiring conservation protection of key lands in the Sandhills.
- The Sandhills Regional Database was established in 2004. New regional datasets have been created and are available to participating stakeholders.

The NCSCP model has been exported to other areas of the state. One example is the Onslow Bight Conservation Forum (following case study). It has also contributed to the establishment of a much larger endeavor called the Sustainable Sandhills Initiative. Sustainable Sandhills is a cooperative venture involving numerous stakeholders from the Sandhills region of North Carolina. It promotes consensus, cooperation, shared visions and collaborative actions. Sustainable Sandhills is a model for regional sustainability planning that preserves natural resources and enhances economic development, improving the quality of life in the region for current and future generations. To learn more about the NCSCP effort contact Pete Campbell (pete_campbell@fws.gov) and see Nelson (2004).

Supporting references

Groves, C. R., M. W. Beck, J. V. Higgins, and E. C. Saxon. 2003. Drafting a conservation blueprint: a practitioner's guide to planning for biodiversity. Island Press, Washington, D.C.

Nelson, L. 2004. Final draft site conservation plan for the North Carolina Sandhills. Unpublished.

Schafale, M. 2002. North Carolina Sandhills reserve design biological analysis. Unpublished.

US Fish & Wildlife Service (USFWS). 2003. Recovery plan for the red-cockaded woodpecker (*Picoides borealis*): second revision. US Fish & Wildlife Service, Atlanta, GA.

CASE STUDY 2. North Carolina Onslow Bight Conservation Forum

The Onslow Bight Landscape area of eastern North Carolina contains a unique landform of barrier islands, marshes, riverine wetlands, pocosins, longleaf pine savannas and many other coastal ecosystems (Figure 4C.5). The area supports nationally significant occurrences of animal and plant communities, several of which are endemic to the region. The rural character of the area, coupled with the flora and fauna and supporting geophysical characteristics, have created a natural environment with abundant opportunities to enjoy fishing, hunting, camping, hiking, canoeing, and other resource-based outdoor recreational opportunities. Many residents, permanent and seasonal, have chosen the area because of the many amenities afforded by the natural environment. The Onslow Bight landscape area also includes two military installations, Marine Corps Base Camp Lejeune and Marine Corps Air Station Cherry Point.

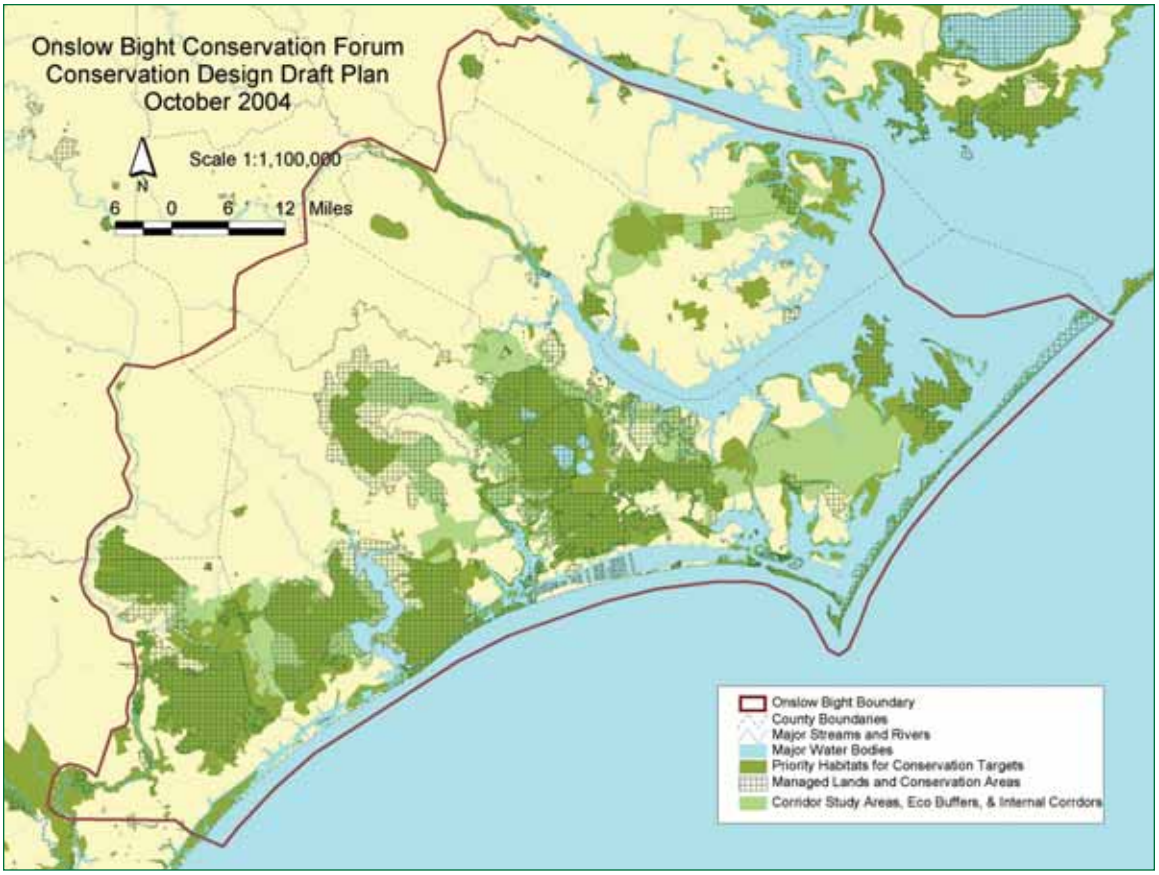


Figure 4C.5. Onslow Bight region, North Carolina, 2004.

However, rapid population growth is fueling urbanization, changing the area's rural character, threatening its natural resources, and encroaching on key military installations and their activities. For the last several years Camp Lejeune has been focused on the development of a buffer of compatible land use surrounding its military ranges. Seeing the success that Fort Bragg has had in the Sandhills region with a landscape-scale collaborative conservation effort (*see previous case study*), Camp Lejeune joined a forum of regional land managers and conservation organizations, the North Carolina Onslow Bight Conservation Forum, to enhance cooperation and communication regarding regional conservation issues within the Onslow Bight landscape. The participants in the forum include: The Nature Conservancy, NC Department of Environment and Natural Resources, NC Department of Transportation, NC Wildlife Resources Commission, the NC Coastal Land Trust, representatives of the Marine Corps (both Cherry Point and Camp Lejeune), the US Fish & Wildlife Service, the US Forest Service, the Natural Resources Conservation Service, the North Carolina Coastal Federation, and others. The mission of the North Carolina Onslow Bight Conservation Forum (NCOBCF) is:

To provide for open discussion among the participants concerning the long-term conservation and enhancement of biological diversity and ecosystem sustainability throughout the Onslow Bight landscape compatible with the land use, conservation and management objectives of the participating organizations and agencies.

The Onslow Bight Conservation Design Plan (2004) is the first iteration of this conservation vision. The plan defines conservation targets, sets forth conservation priorities within the landscape, and articulates certain actions that NCOBCF members may take individually or in mutual cooperation to work towards the vision. This plan will evolve as conservation work by members and other organizations proceeds and as additional data and information are acquired. The Conservation Design Plan presents acquisition/protection strategies as well as management and action strategies.

The Onslow Bight landscape includes many large areas managed for various purposes including conservation, as well as numerous smaller conservation sites and unprotected Significant Natural Heritage Areas (SNHA) designated by the NC Natural Heritage Program. The larger managed areas are Holly Shelter Game Land, Angola Bay Game Land, Camp Lejeune Marine Corps Base, Croatan National Forest, Hofmann Forest, Cherry Point Marine Corps Air Station, Cedar Island National Wildlife Refuge, North River Farms, Cape Lookout National Seashore and Goose Creek Game Land.

Conservation targets at the species, community and ecosystem level were set for the Onslow Bight landscape in order to be explicit about what features of biodiversity the initiative is trying to conserve and where. Conservation of terrestrial, wetland and aquatic targets within the Onslow Bight landscape will require conservation-minded management on lands determined to be critical to the long-term protection of the targets. These target areas include lands currently managed by public agencies and conservation non-profits, and lands requiring acquisition from, or formal management agreements with, willing landowners. Long-term conservation will also require identifying and abating threats to the ecological functions of these lands and to implementing necessary management activities. In order to accurately describe conservation strategies, different types of land (and waters) are defined as follows:

- *Core Areas* – Contain conservation targets having biological significance; contain SNHAs, pristine and intervening habitat; serve primary needs of the targets; land containing habitat in good natural condition or mixed with highly restorable habitat.
- *Managed Area* – Land under management by a single public or non-profit entity; management goals may be quite varied throughout the area and conservation may be a secondary goal or limited to certain sites within the managed area; core areas, corridors and buffers may exist within managed areas and may overlap onto land outside.
- *Isolated Sites* – Small sites not extensive in area nor clustered with other sites that contain important habitat for conservation targets. The isolated sites may not have landscape function that sites in core areas or corridors have, but are still important.
- *Corridor Study Areas* – Generally large areas that have been mapped by the Onslow Bight Conservation Design subcommittee that connect core areas for the purpose of defining where to focus conservation strategies; broad corridors may contain core areas and may exist inside and out of managed areas.
- *Functional Corridors* – Land connecting core areas that contains habitat suitable for the specified conservation targets and is managed for the same; ecologically functional such that species may move through; may require restoration. Functional corridors generally exist or should be established within the mapped broad corridor study areas.
- *Buffer* – Land typically alongside core areas and functional corridors that serves to protect these areas from outside threats; may contain lower quality or non-restorable habitat; land use and management within buffers intended to prevent activities that may result in management changes or restrictions on adjoining core areas and corridors, or degrade conservation targets (e.g., smoke buffers that preclude development)

The **Core Areas** are places with known site-specific significant resources, such as habitat for rare species or high quality or rare natural communities. They are usually in good ecological condition but may be somewhat degraded or in need of restoration even though significant resources are still present. These are the areas most worthy of preservation and natural area management as core areas of a reserve system. They are the areas that are the most threatened in the sense that they have the most to lose ecologically. Core areas that currently exist within managed areas should be managed for the conservation targets and, if possible expanded in area. Action should also be taken to create functional corridors between core areas within a managed area or between adjoining managed areas. As noted above, ecosystems are not closed systems, and areas outside of core areas may be utilized for foraging and movement. These ecosystem functions should be considered, for conservation of at-risk species, as well as for general wildlife and plant life, since they are interconnected.

The NCOBCF designated 10 **Conservation Corridor Study Areas**, intended to be the best locations where functional corridors can be developed that connect major core areas. Designing the corridor study areas primarily involved the assessment of landscape conditions based on 1998 infrared photography. The corridor study areas include some areas that are currently not suitable for restoration, such as non-timber croplands and rural residential development along roads. Further conservation planning will be required in most of these broad corridors to determine a more precise functional corridor. As its primary goal such planning must seek suitable habitat that would allow easy movement of the corridor's conservation targets. Such habitat may need to be continuous between core areas or might be discontinuous such as "stepping stones" of habitat appropriate for the movement of such species as the red-cockaded woodpecker.

They also designated **Managed Areas Ecological Buffers**, which identify certain areas within one-half mile of the management boundaries of Camp Lejeune and Croatan National Forest. They may overlap with corridor study areas but are different in purpose. These buffers contain two types of natural or managed forest lands, 1) those with reasonable restoration potential and 2) those which offer a smoke buffer to the managed areas.

The following conservation strategies are priorities to protect the conservation targets of the Onslow Bight landscape (each strategy is developed in detail in OBCDC 2004):

- Acquisition of land from willing landowners
- Management of core areas and functional corridors
- Working with private landowners
- Enhance conservation habitat within pine plantations at targeted sites
- Incorporate wildlife planning into road project design
- Engage in regional and local planning
- Cooperate in research
- Develop measures of conservation success
- Develop an outreach/education strategy

The Onslow Bight effort represents a successful example of how on-the-ground conservation can be achieved through partnership. Existing Coastal Plain assessments (e.g., Hall et al. 1999) paired with ongoing landscape analyses being conducted in the Coastal Plain region (Hall 2004) will provide additional assessments that will be incorporated in the NCOBCF conservation design plan as they are available. To learn more about the NCOBCF effort and for detailed objectives to meet the above strategies, contact Fred Annand with The Nature Conservancy (fannand@tnc.org).

Supporting References

Hall, S.P. 2004. Assessment of terrestrial habitat quality and landscape integrity in the Albemarle-Pamlico Estuarine Study Area, using a Habitat/Indicator-Group analysis. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S. P., M. P. Schafale, and J. T. Finnegan. 1999. Conservation assessment of the Southeast Coastal Plain of North Carolina, using site-oriented and landscape-oriented analyses. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Onslow Bight Conservation Design Committee (OBCDC). 2004 (DRAFT). Onslow Bight conservation design plan. North Carolina Onslow Bight Conservation Forum.

Conclusions

Agencies and organizations across North Carolina have demonstrated that by reducing redundancy of effort, increasing communication and coordination among partners, and by working together towards shared goals (even if for different objectives), land conservation initiatives can meet with great success. Efforts to perpetuate regional and cooperative approaches to land conservation paint a brighter future for North Carolina than any single entity could have brought about on their own. Still, long-term success may require a continued commitment by agencies and organizations (in terms of management/maintenance efforts and expenses) to carry land conservation projects beyond the initial 'acquisition' phase. Increased funding for land conservation-related activities is a necessary piece of the "success" equation.

References

Groves, C. R., M. W. Beck, J. V. Higgins, and E. C. Saxon. 2003. Drafting a conservation blueprint: a practitioner's guide to planning for biodiversity. Island Press, Washington, D.C.

N.C. Division of Parks and Recreation, Triangle J Council of Governments, and Triangle Land Conservancy. 2002. Triangle GreenPrint regional open space assessment, Raleigh, NC.

N.C. Natural Heritage Program (NCNHP). 2005. North Carolina Natural Heritage Program biennial protection plan: list of Significant Natural Heritage Areas. N.C. Department of Environment and Natural Resources, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

The Nature Conservancy (TNC) and Southern Appalachian Forest Coalition (SAFC). 2000. Southern Blue Ridge ecoregion conservation plan. The Nature Conservancy, Durham, NC.

The Nature Conservancy (TNC) and NatureServe. 2001. Mid-Atlantic Coastal Plain ecoregion plan. The Nature Conservancy, Durham, NC.

D. Education, Outreach and Recreation Strategies

Introduction

Education, outreach, and recreation needs often take a back-burner to more imminent needs associated with species and habitat protection in an atmosphere of limited funding, personnel and resources. Indeed, when forced to take a 'triage/reactive' approach to conservation, these types of activities often appear more expendable. Yet there is a critical link to be made between education/outreach/recreation initiatives and positive impacts on conservation problems.

Education, outreach, and recreation initiatives are important components of successful wildlife conservation because they provide a way to connect natural resource agencies and organizations to the broader conservation community. This community includes both the urban public and private landowners, user groups (e.g., birders, hikers, paddlers, sportsmen and women), as well as local governments, corporations, and other natural resource stakeholders. State fish and wildlife agencies have a mandate to manage shared public wildlife resources for this constituency. And although the promotion of projects for outdoor enthusiasts, such as birding or canoe trails, may not directly result in species de-listing or reverse habitat loss trends, these types of efforts are indeed creating strong supporters for broader agency goals.

Effective conservation can only be an integral feature of human society when it is a priority for most of its citizens. Here in North Carolina, as with many states across the country, as our population centers become increasingly urban, there appears to be a growing disconnect between people and the outdoors, nature, and wildlife, which can lead to misconceptions, distrust, and fear. Education, outreach, and recreation opportunities are tools to engage citizens in conservation and move closer to our fifth Plan goal—*Support educational efforts to improve understanding of our wildlife resources among the general public and conservation stakeholders*. The task is great; we must seek to improve understanding, interest and knowledge about wildlife species and their habitats, identify threats to wildlife and habitats, understand human impacts on wildlife and habitats, and increase conservation funding in general.

Both the process and content of conservation education and outreach influence its effectiveness. It is important that the goals and purpose of the Plan and progress implementing the Plan be well articulated to the public. Successful conservation will require close coordination between those implementing the conservation strategies and those providing outreach communication and educational opportunities to the greater citizenry. The Commission must keep the public informed about what they're doing, and why, to maintain and gain support among the public about the purpose and reason behind conservation and management activities. Public constituents play a key role in influencing legislators, who in turn affect policy and funding decisions. We need strong public support to increase further conservation funding.

At the national level, the International Association of Fish & Wildlife Agencies (IAFWA) has recently identified conservation education as a national priority by committing to develop a national strategic plan for conservation education. The following guidelines were developed by participants at the IAFWA Summit on Conservation Education, December 2004:

- A national perspective is needed to guide development of an effective conservation education.
- A definition of conservation education in the context of agency missions and goals is needed.
- Conservation education is mission critical, and support at all levels of the agencies, among partners, and key decision-makers is vital.
- Funding for conservation education is paramount to agencies and must be significant and stable. Additional, long-term funding sources will be identified as part of the strategic plan.
- The full potential of conservation education in state/provincial fish and wildlife agencies can only be realized through strong partnership support and collaboration.
- Conservation education must be responsive to, integrated with and/or correlated to all applicable professional and learning standards based on sound educational theory.

A draft National Conservation Education Plan was considered at the organization's March 2005 Business Meeting.

Key Partners

North Carolina Office of Environmental Education – The Office of Environmental Education, within the NC Department of Environment and Natural Resources, serves a coordinating role among schools, colleges, state and federal agencies, citizens groups, and the business/industrial community in promoting environmental education and natural resource stewardship in North Carolina. As a guardian of the North Carolina Environmental Education Plan, the Office looks to the plan's 14 objectives to guide its efforts:

- In-service professional development
- Pre-service teacher education
- Higher education
- Clearinghouse
- Curriculum correlation
- Model library collections
- North Carolina environmental data
- Measures and evaluation
- Environmental education centers
- Government agencies
- Funding
- Partnerships
- The media
- Adult education.

The Office of Environmental Education runs the Environmental Education Certification Program for North Carolina. The Office also provides teacher guides, state curriculum guides, guides to environmental education centers around the state, and adult education programming.

North Carolina Division of Parks and Recreation – The NC Division of Parks and Recreation offers educational opportunities for educators, groups and classes, and park visitors. Nearly every state park has a specially designed educational program based on the park's primary features or themes. The programs, called Environmental Education Learning Experiences (EELE), include a workshop for educators and a binder full of information and student activities. EELE's are specially designed educational programs correlated to the North Carolina competency-based curriculum in science, social studies, mathematics and English/language arts. Each program includes pre-visit, on-site and post-visit student activities that have measurable objectives, background information, vocabulary, references and step-by-step activity instructions.

North Carolina Wildlife Resources Commission, Division of Conservation Education – The Commission's Division of Conservation Education works to increase the public's knowledge of North Carolina's wildlife and the habitats they depend upon. They provide publications and programs through which the general public and educators can learn about wildlife, natural history and outdoor skills. The Division also runs three wildlife education centers around the state, and provides additional educator training, distance learning opportunities, and in-service training opportunities. The Division houses the agency communication department, the Public Information and Outreach program, publishes *Wildlife in North Carolina* magazine, and under Special Publications, 40 books, newsletter, posters, booklets, pamphlets, and reports annually.

The three education centers, the Pisgah Center for Wildlife Education (mountain region), Centennial Campus Center for Wildlife Education (central region), and the Outer Banks Center for Wildlife Education (eastern region), each provide regionally-tailored on-site programming for audiences who visit the facilities.

The Division of Conservation Education focuses education training opportunities on professional educators and civic groups, who in turn carry what they learn to larger audiences. There is one Education Specialist per region focused on providing educator training, distance learning opportunities, and in-service training opportunities. The programs they offer include:

Project WILD – Project WILD is an interdisciplinary, comprehensive curriculum program designed for adults who work in both formal and informal education settings to integrate components of wildlife education into all major subject areas in grades K-12 and in college. The materials can also be used with youth groups. Project WILD (and Aquatic WILD) activity guides contain numerous activities that focus on terrestrial and aquatic wildlife and ecosystems. The newest updates to the Project WILD curriculum adhere to 'No Child Left Behind' educational standards. WILD Education Site workshops are an extension of Project WILD that provide participants with a guide to designing and setting up outdoor classrooms that integrate teaching and wildlife habitat.

Advanced Project WILD – Advanced Project WILD workshops are focused on a specific topic to allow participants a more in-depth look at the subject matter (e.g., bats, songbirds, black bears, wetland wildlife). These workshops often utilize existing education materials or programs developed by conservation organizations or programs (e.g., Bat Conservation International, Shorebird Sister Schools Program, Partners in Flight, Partners in Amphibian and Reptile Conservation).

CATCH – CATCH is an interdisciplinary program that provides opportunities for adults to teach youth ages 8–15 about aquatic environments through learning activities, educational materials, aquatic field trips and fishing experiences in a school or youth group setting. CATCH emphasizes conservation habits, outdoor ethics, fish and aquatic species information, water safety tips, and practical fishing skills.

Division staff train teachers and youth group leaders to present the programs above in their schools or organizations.

Other educational opportunities that the Division offers include:

Outdoor Skill Experiences – Outdoor skill experiences are hands-on, participatory training that increase a person's ability to enjoy and experience wildlife resources (e.g., orienteering, fly fishing, cooking game).

Becoming an Outdoors Woman – Becoming an Outdoors Woman program workshops are designed to provide opportunities for women to learn skills that enhance and encourage participation in hunting, angling and other outdoor activities. Beyond Becoming and Outdoors Woman workshops are advanced sessions that give participants the opportunity to expand their knowledge and skills on a more focused topic.

Youth Hunts – Youth hunts are organized to provide quality hunting opportunities for youth ages 12–15 who are beginning hunters to have a real advantage in taking their own first deer or other species in a controlled and managed area. These hunts include a special educational orientation and scout day prior to the day of the hunt.

In order to further the goals of the Plan, the Commission's three Centers for Wildlife Education and their outreach education specialists will implement the following three objectives. These objectives will guide the design, development and presentation of the agency's educational and interpretive programs, publications, workshops and exhibits:

1. Identify and emphasize connections among natural features, selected wildlife species and conservation activities of the Commission.

   Example: Advanced WILD Geology Workshops that present the geology of the Appalachian Mountains and discuss how that ancient geological formation has influenced speciation, such as the many endemic salamander species found in North Carolina and the Commission's role in protecting those species and their habitats.

2. Emphasize the conservation of aquatic resources.

   Example: Exhibits displaying "What is Your Ecological Address" will present the major river basins of North Carolina and important interconnections between humans and other species that inhabit aquatic areas.

3. Emphasize the importance of professional management in the conservation of natural resources.

   Example: Project WILD Science and Civics: Present workshops for high school teachers, such as wildlife management practices for sustaining longleaf pine ecosystems and their inhabitants (e.g., red-cockaded woodpeckers).

The Commission published magazine, *Wildlife in North Carolina*, is an important outlet for information dissemination about fish and wildlife conservation projects and initiatives across the state. *Wildlife in North Carolina* will include Habitats of Concern as one the categories in its 2005 Wildlife in North Carolina photo competition. Entries in this category will feature one of the key habitats identified within the Plan. This highly visible effort will support educational efforts to

improve understanding of our wildlife resources among the general public and conservation stakeholders, and encourage readers and contributors to conserve and enhance habitats and the communities they support.

The Public Information and Outreach Section of the Division of Conservation Education works with other Commission educators, biologists, administrative staff, engineers, and enforcement officers to disseminate information to a range of publics about Commission activities. The information is relayed through media advisories, fact sheets, press releases, news-feature articles, op-ed pieces, television and phone interviews, "media day" events, the Commission's web site and the Commission's wildlife advisories hotline. The outreach section's future communications work will include substantial information dissemination about the Commission's role in developing and implementing the Plan. Specific ideas include a regular schedule of nongame news releases, an annual "Nongame and Habitat Conservation Media Day," and an annual feature related to a Plan implementation project in *Wildlife in North Carolina*.

The Special Publications editor creates or edits and produces one million copies of print publications annually for sale or distribution to sportsmen, educators, youth, and the general public.

There are also numerous other entities involved in education, outreach, and recreation programming in North Carolina, including local governments, federal agencies, and non-profit organizations. The Mecklenburg County Parks and Recreation Department and the Town of Cary Parks, Recreation and Cultural Resources Department are two examples of active parks and recreation programs in the state, offering visitors and educators a wide variety of programming opportunities. The National Parks Service and the US Fish & Wildlife Service (National Wildlife Refuge system) are key federal partners, both of whom offer visitors educational opportunities tailored to the park or refuge they are visiting.

Important Issues and Concerns

Education and outreach needs specific to particular species groups or habitats that were addressed within the appropriate habitat or river basin section of the Plan can be summarized as follows:

Coastal management issues – Humans have great influence and impact on our coastal beaches, dunes and estuarine habitats. Improved public education is critical to reducing human-induced threats about the impacts of, for example:

- Commercial and recreational activities such as boating and fishing (e.g., collisions, ghost line impacts, by-catch concerns) on coastal wildlife such as diamondback terrapins, sea turtles, marine mammals.
- Tourist related impacts like beach lighting and beach management practices (e.g., fencing, dredging, beach renourishment) on beach nesting sea turtles and birds.

Prescribed fire – The importance of continued use and reintroduction of prescribed fire as a habitat management tool was emphasized across multiple habitats. Support for prescribed fire practices will require effective education and outreach to the communities and private landowners affected by this management practice.

Sensitive sites – As much as management or acquisition activities, education about human impacts on sensitive sites such as isolated wetlands, bogs, caves and mines, and rock outcrops will be critical for the continued protection of these sites.

Broader operational-based education and recreation concerns established in the North Carolina Wildlife Diversity Plan (NCWRC 1999) include:

Conservation Education

- Inadequate production and distribution of wildlife education materials.
- Current wildlife education programs not able to meet public's growing needs.
- Inadequate funding sources for programs and materials aimed at conservation education.
- Insufficient number of nature centers devoted to the state's nongame wildlife.

Recreation

- Birding and Watchable Wildlife are not supported in proportion to their recreational, educational and economic value.
- State managed trail systems are inadequate in serving the needs of recreational users.
- The potential for campgrounds and picnic areas to serve as wildlife educational facilities is not being utilized.
- As recreation activities increase, wildlife/human interaction and associated risk to both groups will also rise.
- Inadequate funding sources for recreational opportunities and programs.

Still other education-related issues are identified in existing conservation planning documents, for example:

> *North American Bat Conservation Partnership Strategic Plan* – "Throughout North America, sensational and inaccurate presentation of public health issues involving bats has created an exaggerated fear of these ecologically important species. The resulting unwarranted public perception presents an especially serious threat to bat survival. Although general public awareness of the values of bats has increased over the past two decades, ignorance remains an important impediment to bat conservation. Medical professionals, government agencies, private industry, and educators often lack materials necessary to educate the public about how to safely share their communities with bats" (http://www.batcon.org/nabcp/newsite/index.html).

Broad Strategies

The following information was taken from the North Carolina Wildlife Diversity Plan (NCWRC 1999) and provides a broad overview of the needs and direction of conservation education and recreation for the Commission. Since 1999, substantial progress has been made towards meeting some of the program priorities below (e.g., the Commission now has a wildlife nature center in each region of the state). Still, others have not been fully realized to-date. Where possible, the program priorities identified below should now be addressed within the context of other priorities identified within the Plan.

Conservation Education Priorities

Wildlife Nature Centers

- Develop Commission-owned wildlife nature centers in each physiographic region and support projects at existing centers.
- Develop materials and traveling displays for use across the state at schools, universities, science museums and aquariums to increase awareness of wildlife concerns.

Wildlife Education Programs

- Improve the Commission's capabilities to provide instructor training in Project Wild & CATCH and coordinate support for other state environmental education programs.
- Develop and improve guides for construction/development of outdoor classrooms.
- Develop demonstration projects for wildlife education programs.

Wildlife Educational Materials

- Develop and distribute wildlife educational materials to the public school systems.
- Develop public informational materials on wildlife species, management programs, and habitat conservation.

Wildlife Education Grants

- Encourage development of educational materials and programs on fish and wildlife through an annual Wildlife Education Grants program.

Recreation Priorities

Watchable Wildlife

- Promote the North Carolina Watchable Wildlife Viewing Program through development of highway map guides and informational materials for significant public sites.
- Develop guides, informational materials, and workshops on wildlife photography.
- Develop structures and stations for fish and wildlife viewing and photography.
- Encourage commercial guided trips through development of training programs and informational materials.

Paddling

- Develop and maintain canoe, kayak, and whitewater paddling access points.
- Develop and maintain marked canoe trails along major streams and rivers.
- Encourage commercial guided trips through development of wildlife training programs and informational materials.

Hiking

- Support and assist with maintenance to the State Trails and Rails to Trails systems.
- Develop and maintain hiking trails on state-owned game lands.

Camping

- Develop and maintain hiking trails and viewing sites associated with state-maintained camp grounds, picnicking areas, and visitor centers.
- Develop wildlife-related displays and educational materials at state-owned campgrounds, picnicking areas, and visitor centers.
- Produce wildlife-related educational programs at state-owned campgrounds, picnicking areas, and visitor centers.

Birding

- Develop and maintain Coastal, Piedmont, and Mountain Birding Trails development projects.
- Assist with the organization, promotion, and operation of local Birding Festivals.
- Develop Birding Guides to North Carolina species and Birding Lists for significant public-owned properties.

Diving

- Develop guides and materials for recreational diving.

Wildlife Recreation Grants

- Encourage development of fish and wildlife-related recreation programs through an annual Wildlife Recreation Grants program to promote nature tourism and wildlife viewing.

Specific Needs and Recommendations

An abundance of education, outreach, and recreation programs already exist. Therefore, any conservation communication activities related to Plan implementation should involve the development and fostering of partnerships in order to incorporate targeted conservation topics into existing programs, and if need be, develop new targeted projects. Emphasis should be on local programs where individuals have the opportunity to have personal experiences that may foster greater appreciation and concern for local conservation issues.

Conservation Education

- Supply additional funding to support more regional education staff to conduct Project WILD training.
- Works towards better coordination among biologists and educators to develop effective education and outreach materials for endangered/rare species.
- Work towards better coordination among biologists and educators to develop and implement Advanced Project WILD workshops that highlight high priority species, species groups, and habitats.
- Promote and expand inter-divisional projects/publications to improve efficiency and effectiveness at reaching shared goals.
- Look to existing education/outreach goals, priorities and ideas listed in existing conservation plans, for example:
  - North American Bat Conservation Partnership Strategic plan (http://www.batcon.org/nabcp/newsite/index.html)
  - The North American Waterbird Conservation Plan (Kushlan et al. 2002)
  - Southeastern Coastal Plains-Caribbean Regional Shorebird Plan (Hunter et al. 2000)
  - NC Partners in Flight Bird Conservation Plan (Johns et al. 2005)
- Work towards improved communication among Commission divisions so that field activities are translated to appropriate education/outreach materials.

Outreach

- Continue to use the local news media to highlight 'success stories' and bring a local connection to broader conservation issues.
- Improve understanding among Commission divisions of the critical role that outreach plays in the implementation of Commission projects; in order to maximize education potential, outreach cannot not be an afterthought, but rather an integral component of project planning.
- Work with Outreach staff, Special Publications Editor, and Commission magazine staff during Plan implementation to translate the conservation priorities of the Plan (in terms of priority species and habitats) into effective education and outreach tools (e.g., magazine articles, press releases, op-ed pieces, television and phone interviews, "media day" events, videos, and publications).

Recreation

- Fully support and promote the North Carolina Bird Trail initiative now underway, a partnership between the Commission, North Carolina Audubon, North Carolina Sea Grant, and North Carolina Cooperative Extension (www.ncbirdingtrail.org).

References

Hunter, W. C., J. Collazo, B. Noffsinger, B. Winn, D. Allen, B. Harrington, M. Epstein, and J. Saliva. 2000. Southeastern Coastal Plain – Carribean Regional Shorebird Plan, Version 1. US Fish & Wildlife Service, Atlanta, GA.

Johns, M., M. Brooks, J. Gerwin, and K. O'Kane. 2005. A bird conservation plan for North Carolina. North Carolina Partners in Flight.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

N.C. Wildlife Resources Commission (NCWRC). 1999. North Carolina wildlife diversity plan. Raleigh, NC.

CHAPTER 5.

SPECIES AND HABITAT ASSESSMENTS AND CONSERVATION STRATEGIES

Linking Terrestrial and Aquatic Systems

Early in the Plan text development process we discussed the value of different organizational styles with respect to linking terrestrial and aquatic systems. Within the framework that we settled on, we found it necessary to address the specific needs of terrestrial and aquatic species separately within the Plan. However, we do not wish to perpetuate the notion that aquatic and terrestrial systems should be thought of as separate and disconnected entities; these systems are highly connected and are heavily influential on one another (e.g., upland land clearing activities can result in increased erosion and sedimentation in adjacent lowland and riparian habitats; water quality impacts can reduce aquatic species population sizes, leading to food limitations for terrestrial species with an aquatic food base). Within the following sections (Chapters 5A, 5B, 5C), we have identified conservation strategies that, when implemented in coordination, capture ecosystem level actions that emphasize the cumulative positive impacts to both terrestrial and aquatic communities. We support the view that the North Carolina conservation community as a whole should work towards more comprehensive management and conservation of aquatic and terrestrial resources alike.

Population Objectives

Due to the strategic (not operational) nature of this report, we have not identified population objectives for each and every species mentioned herein. However, as a starting reference, we include a list of existing resources that provide this type of information for species groups appropriate to North Carolina (Table 5.1).

For the majority of our fish and wildlife taxa, we are, as of yet, unable to assess specific population objectives, due to data limitations and knowledge gaps that must first be filled. Birds and marine fish species are two groups for which data does exist to assess population level objectives. These objectives have been developed through the cooperative efforts of specific conservation partnerships (e.g., the North American Bird Conservation Initiative, regional Fisheries Management Councils). Recovery plans for species on the Federal Threatened and Endangered species list also identify population objectives related to species recovery thresholds. Priorities for other species groups now focus on simply collecting enough information to support valid population size estimates.

Table 5.1. Sources of population objectives for species groups in North Carolina.

Group	Conservation Plan	Citation/Resource
Landbirds	Partners in Flight South-Atlantic Coastal Plain Bird Conservation Plan	Hunter et al. 2001
	Partners in Flight Piedmont Bird Conservation Plan	Cooper and Demarest 1999
	Partners in Flight Southern Blue Ridge Bird Conservation Plan	Hunter et al. 1999
	Partners in Flight North American Landbird Conservation Plan	Rich et al. 2001
Waterbirds	North American Waterbird Conservation Plan	Kushlan et al. 2002
	Southeast US Region Waterbird Conservation Plan	SAMBI 2004
Waterfowl	North American Waterfowl Management Plan	NAWMP Committee 1998
Shorebirds	Southeastern Coastal Plain - Caribbean Regional Shorebird Plan	Hunter et al. 2000
SAMBI area waterfowl, waterbirds, shorebirds, landbirds	South Atlantic Migratory Bird Initiative implementation plan	Watson and McWilliams 2004
Endangered and threatened species	Species recovery plans (see Appendix I)	USFWS Threatened and Endangered Species System Webpage (http://ecos.fws.gov/tess_public/TESSWebpage)
Coastal and marine fisheries[1]	Fisheries Management Plans	Mid-Atlantic Fisheries Management Council (http://www.mafmc.org) South-Atlantic Fisheries Management Council (http://www.safmc.net)

[1]See the Marine Systems section (Chapter 5C) for a listing of species for which Fisheries Management Plans are available.

Setting Priorities at Multiple Scales

Within the following sections (Chapters 5A, 5B, 5C) we detail threats, priority survey, monitoring and research needs, and broader conservation priorities, for terrestrial and aquatic systems alike. We have organized information in Chapters 5A and 5B such that individual sub-sections (e.g., a particular terrestrial habitat or a river basin) can, to a large extent, 'stand alone' as a resource to make conservation planning decisions at that particular scale. Within each section we have attempted to not only identify but also to prioritize implementation needs. Chapter 5C (Marine Systems) contains the same type of information, but the format of this section differs (based, to a large degree, on the extent and availability of existing information and resources). Nevertheless, it, too, lays out clear species and habitat conservation priorities in the marine environment along North Carolina's coast.

In order for the Plan to be a useful planning tool, priorities set at an individual habitat or basin scale must also fit within the context of priorities set at a broader level. For example, among all of the specific needs and activities identified in the Plan, how should priorities be set across habitats or basins, across activities, or at higher organizational levels (program or agency-wide)? And how do all of those priorities work to advance the goals of the Plan? In the following chapter (Chapter 6) we synthesize that type of information.

References

Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. U.S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W. C., J. Collazo, B. Noffsinger, B. Winn, D. Allen, B. Harrington, M. Epstein, and J. Saliva. 2000. Southeastern Coastal Plain – Carribean Regional Shorebird Plan, Version 1. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

North American Waterfowl Management Plan (NAWMP) Committee. 1998. North American waterfowl management plan 1998 update: Expanding the vision. US Fish & Wildlife Service.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2001. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

South Atlantic Migratory Bird Initiative (SAMBI). 2004 (DRAFT). Southeast U.S. region waterbird conservation plan. US Fish & Wildlife Service.

Watson, C., and K. McWilliams. 2004 (DRAFT). South Atlantic Migratory Bird Initiative implementation plan: an integrated approach to conservation of "all birds across all habitats." US Fish & Wildlife Service, Charleston, SC.

A. Terrestrial Systems

Biodiversity in Terrestrial Ecosystems

The southeast region of the United States contains some of the highest rates of faunal and floral biodiversity in the world (Ricketts et al. 1999). The Appalachian/Blue Ridge Forest (along with the adjacent Mixed Mesophytic Forest type) is one of the world's richest temperate broadleaf forest types. Two major forest types found in the southeast are 'globally outstanding' (meaning they are exceptional in species richness and endemism rates): Appalachian/Blue Ridge Forest and Southeastern Mixed Forest. Amphibian species richness and endemism rates are higher in the southern Appalachian region than anywhere else in the country; the pattern for land snails is the same. Finally, Mid-Atlantic Coastal Forests contain the most diverse assemblage of freshwater wetlands in all of North America (Ricketts et al. 1999).

Among southeastern states, North Carolina contains some of the highest species diversity rates—the state ranks fourth in the number of total vertebrate species, with more amphibians than any other state in the nation and more mammal species than any other state east of Texas.

Unfortunately, the southeast also contains some of the most endangered ecosystems in the country: southern Appalachian spruce-fir, longleaf pine forest and savanna, eastern grasslands, coastal communities, and forested wetlands (Noss et al. 1995). Threats to habitats across the region include fragmentation, conversion to other habitat types, suppression of fire, and outright loss due to development (Noss et al. 1995, Ricketts et al. 1999). Since 1990, forest cover in North Carolina has decreased by 5 percent. In 2002, forests covered 18.3 million acres, or 59 percent of the land area, compared with 19.3 million acres and 62 percent previously (Brown 2004).

Concerns over species imperilment are also great. Across the southeast, there are 132 terrestrial vertebrate species that are of conservation concern, as listed by state Natural Heritage Programs (Trani 2002). These are dominated by amphibians and reptiles. As of 2005, more than one-fifth of North Carolina's native mammal species are designated as rare and in need of special protection. The same applies to more than one-quarter of the bird species, more than one-third of all reptiles, and almost one-quarter of all amphibians.

Assessments of Terrestrial Conservation Priorities

Numerous state, regional, and national-scale efforts have provided a foundation on which to build the conservation priorities addressed within each of the individual habitat sections that follow. Some efforts have been focused on identifying species priorities, others have gone beyond this (or bypassed it) to propose strategies for long-term conservation. To the greatest extent possible and where applicable, the guidance provided by these important efforts has been incorporated into this Plan. The following is a brief review of some of the more influential literature that applies to terrestrial conservation priorities and strategies in North Carolina.

Species Priorities and Conservation Strategies

Information and literature regarding conservation priorities and strategies for birds far outweighs that of any other terrestrial species group in the nation. Many of the recommendations and priorities highlighted for birds within the following habitat sections have grown out of the efforts of the various North American Bird Conservation Initiative (NABCI) programs. These programs form a base from which to expand and improve bird conservation efforts in the state and the region. NABCI is made up of four principle bird conservation programs: Partners in Flight (PIF), the North American Waterfowl Management Plan (NAWMP), the US Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. The national, regional, and (in the case of Partners in Flight) state-based publications of each of these programs are useful in identifying species priorities, species and habitat objectives, and conservation strategies necessary to implement bird conservation for the group:

North American Bird Conservation Initiative

- US Shorebird Conservation Plan (Brown et al. 2001)
  - Southeastern Coastal Plains-Caribbean Regional Shorebird Plan (Hunter et al. 2000)
- North American Waterbird Conservation Plan (Kushlan et al. 2002)
  - Southeastern US Region Waterbird Conservation Plan (Hunter 2004, DRAFT)
- North American Waterfowl Management Plan (NAWMP Committee 2003)
  - Atlantic Coastal Joint Venture Strategic Plan (ACJV 2004)
- PIF North American Landbird Conservation Plan (Rich et al. 2001)
  - Southern Blue Ridge (Hunter et al. 1999)
  - Piedmont (Cooper and Demarest 1999)
  - South Atlantic Coastal Plain (Hunter et al. 2001)
  - North Carolina PIF Bird Conservation Plain (Johns et al. 2005)

The South Atlantic Migratory Bird Initiative (SAMBI) formed to provide a regional scale framework for the conservation of waterfowl, shorebirds, waterbirds, landbirds, and other high priority species (e.g., northern bobwhite and American woodcock) (Watson and McWilliams 2004, DRAFT). This framework utilizes existing national and regional plans of the NABCI programs to build a framework for regional bird conservation that integrates common goals and objectives of these national and regional plans.

The *Management of North Carolina's Colonial Waterbirds* (Parnell and Shields 1990) was completed well before the genesis of NABCI. This document provided much of the groundwork for the North American Waterbird Conservation Plan, as it pertains to North Carolina.

As previously mentioned, there are (as of yet) no comparable documents for mammals, amphibians, or reptiles. To the degree that priorities are implicit in federal and state protection and conservation lists, however, existing protected species lists and the efforts of the NC Natural Heritage Program in listing rare animal species of the state (LeGrand et al. 2004) are useful sources of prioritization information for these species groups, in addition to birds.

Other resources that serve as sources of broad conservation recommendations for various terrestrial species groups include:

North American Bat Conservation Partnership, Strategic plan – This plan is intended to provide a framework and direction for other local, state, and federal bat conservation and management plans. The plan provides broad goals and priority actions across research, education, and management activities.

Habitat management guidelines for amphibians and reptiles of the southeastern United States (Bailey et al. 2004) – This document provides habitat management and conservation guidelines and recommendations for land managers and private landowners that are practical to include with other management objectives on the landscape.

Species recovery plans – Recovery plans provide detailed conservation recommendations and management requirements for the recovery of listed-species. See Appendix I for a list of species with recovery plans in North Carolina.

By state statute, the Commission maintains a Nongame Wildlife Advisory Committee to help guide nongame wildlife management policies and actions. This body, in turn, relies on taxa-specific Scientific Advisory Councils to make recommendations for policies and actions. Specifically regarding terrestrial groups, these councils recommend bird, mammal, amphibian and reptile species for state listing as endangered, threatened, and species of concern, as well as potentially injurious non-native species. Publications, bulletins, and informal communications are periodically produced by these bodies that contain these and other recommendations for action by the Commission.

In anticipation of passage of the Conservation And Reinvestment Act, in 1999 the Commission prepared a draft Wildlife Diversity Plan that identified a number of general needs and objectives for wildlife management, conservation education, and recreation in the state (NCWRC 1999). That draft was generally a precursor of this Plan. Primary objectives stated in that document were to protect and enhance native wildlife populations and to enhance public awareness and appreciation

of wildlife through education, outreach, and recreation opportunities. A list of general priority actions to meet the general objectives was identified; however, no specific priorities or strategies were recognized.

Landscape Priorities and Conservation Strategies

In 1999, researchers with the World Wildlife Fund published *Terrestrial Ecoregions of North America: a conservation assessment* (Ricketts et al. 1999) to highlight the biological distinctiveness of North American ecoregions, assess the level of threats facing each ecoregion, and set forth recommendations for preserving and restoring biodiversity in those ecoregions. Their findings highlight the southeastern United States as supporting among the highest rates of biodiversity in the nation (and for some species groups, the world); Appalachian/Blue Ridge Forest and Southeastern Mixed Forest are 'globally outstanding' in their species richness and endemism rates. Mid-Atlantic Coastal Forests contain the most diverse assemblage of freshwater wetlands in North America. Many of the conservation recommendations made across the three ecoregions[1] that intersect North Carolina's boundaries are echoed within the individual habitat sections that follow. They include: *Appalachian/ Blue Ridge Forests* – identify and protect a regional system of large habitat blocks; restore linkage of appropriate habitat between large blocks; *Southeastern Mixed Forests* – enhance protection of Forest Service areas to increase biodiversity protection in the last remaining blocks; improve fire management regimes; inventory the last remaining sites to identify biodiversity priorities; *Mid-Atlantic Coastal Forests* – improve management for biodiversity conservation (particularly fire management) on federally owned lands; establish corridors among protected lands in the region; improve implementation of state programs for the protection of tidal and nontidal wetlands; enact and implement effective forest management programs at the state level, including economic incentives for good forest practices.

The Nature Conservancy operates on the principle of protecting biological diversity and functional landscapes through land conservation. Toward that end, their efforts to set ecoregional site conservation priorities represent some of the most directed land conservation work (Groves et al. 2003). Their process relies heavily on Natural Heritage Program data and expert feedback. Within the North Carolina portion of the Southern Blue Ridge, Piedmont, and Mid-Atlantic Coastal Plain ecoregions, The Nature Conservancy has identified a total of 464 sites that, if protected, would likely ensure the survival of the three ecoregion's native plants, animals, natural community types, and critical ecological processes (The Nature Conservancy 2000; The Nature Conservancy and NatureServe 2001; M. Bucher, pers. comm. 2004). The Nature Conservancy has also conducted a freshwater biodiversity assessment of the southeastern United States (Smith et al. 2002). That effort helped to identify critical areas for freshwater biodiversity conservation in the region, among them approximately 70 priority sites in North Carolina (Figure 5A.1).

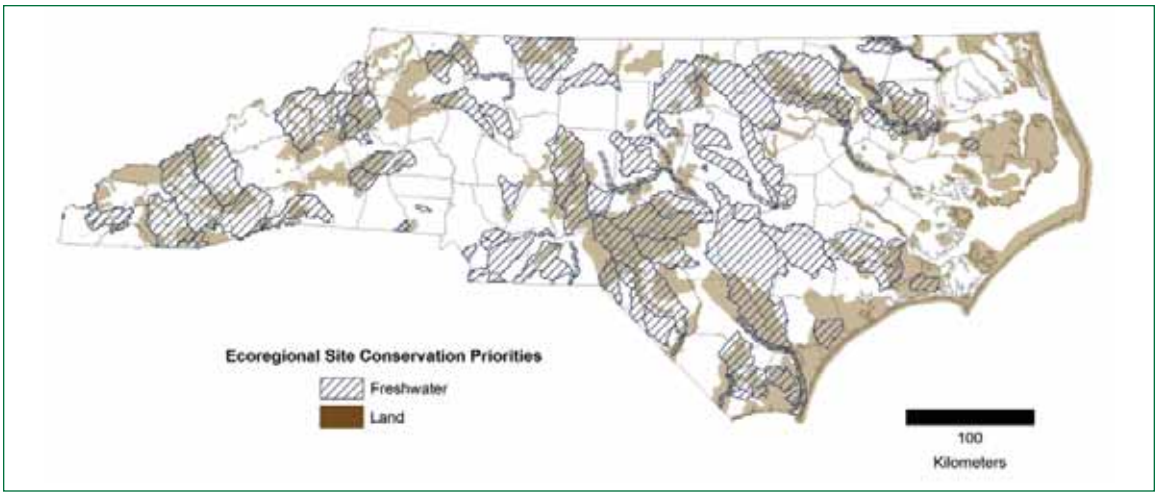


Figure 5A.1. Ecoregional site conservation priorities in North Carolina, as identified by The Nature Conservancy.

[1]These ecoregions, as defined by Ricketts et al. 1999, roughly coincide with the ecoregional designations used in the Plan (the Southern Blue Ridge, Piedmont, Mid-Atlantic Coastal Plain).

Ecoregion Descriptions

In the following sections, we address species and habitat conservation across the three distinct ecoregions of North Carolina, each typified by unique landscape and habitat features (Figure 5A.2)

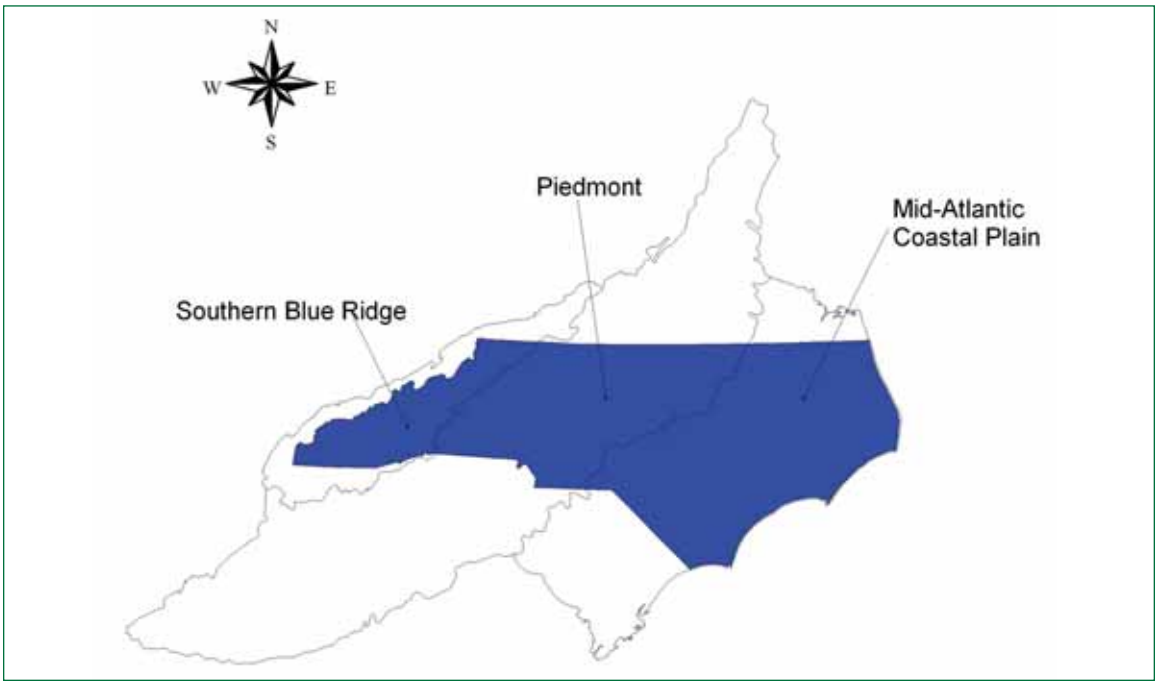


Figure 5A.2. Ecoregions of North Carolina, based on Bailey 1995 (source: NC GAP).

Southern Blue Ridge

The mountainous western portion of North Carolina makes up the majority of the Southern Blue Ridge ecoregion (Figure 5A.2). Elevations reach 6,684 feet (Mt. Mitchell) and habitats range from high peak spruce-fir forest to low floodplain valleys. The spatial heterogeneity of the ecoregion's topography (slope, aspect, and elevation) and its unique geologic history has resulted in a broad array of biodiversity. Moreover, the region receives the highest rainfall in the United States east of the Cascades, and is home to a range of climate types from warm temperate to boreal. The combination of these conditions, and the fact that this ecoregion escaped glaciation, has provided specialized habitat for the evolution and persistence of a vast and diverse floral and faunal assemblage, including over 400 endemic species—the most found in any ecoregion in North America (Ricketts et al. 1999).

The southern Appalachian region is the world's center for plethodontid salamander diversity (Ricketts et al. 1999). According to the Southern Appalachian Biodiversity Institute, nearly 10% of global salamander diversity and 10% of freshwater mussel diversity occur in this region. Why is species diversity so high in the region? For many typically "northern" species, the Southern Blue Ridge is the southern limit of their distribution. In addition, gradients in elevation, aspect, slope, and rainfall contribute to a range of available niches and habitats.

Many of the factors impacting species conservation in this region can be traced to larger habitat-level issues. The decline of high elevation forests is one of the most pressing habitat concerns in the region. The southern Appalachian spruce-fir forest is considered the second most endangered ecosystem in the United States (Noss et al. 1995). The major cause of the decline is attributed to an exotic insect pest, the balsam woolly adelgid. Timber harvest early in the twentieth century also contributed to the forest loss. Loss of spruce-fir forest has severely limited habitat availability for many bird species endemic to the region (Hunter et al. 1999). Other habitat loss issues include succession of high elevation heath and grass balds, homogeneous maturity of forested stands

(resulting in a lack of under-story and mid-story development), water quality concerns due to growth and development, wetland draining and filling for agriculture and development, and habitat fragmentation due to development in floodplains and on slopes.

Piedmont

The Piedmont ecoregion makes up the central portion of North Carolina (Figure 5A.2). Habitats range from mid-elevation forest and bogs at the edge of the Blue Ridge escarpment, to low floodplain valleys towards the east.

Species diversity for some animal groups is relatively high in the Piedmont. According to the World Wildlife Fund, Southern Mixed Forests (which encompasses the Piedmont ecoregion as defined by Bailey 1995) rank among the top 10 ecoregions in North America in richness of amphibians, reptiles, and birds, and among the top 10 ecoregions in number of endemic reptiles, amphibians, butterflies, and mammals (Ricketts et al. 1999). In the context of the eastern United States, many northern and southern species overlap their ranges in North Carolina and in the context of the state, examples of both predominantly montane and coastal fauna are found within the Piedmont region. However, many of the natural habitats within the Piedmont have been altered by human development and intensified forestry and agricultural practices. Less protected public land exists in the Piedmont compared to the Mountain and Coastal Plain regions of the state. Remaining hot spots of biodiversity include high quality stream, floodplain, and wetland habitats, in addition to well managed farm and forest lands.

Many of the factors impacting species conservation in this region can be traced to larger habitat-level issues. Species diversity and conservation in the Piedmont is heavily impacted by rapid development and growth throughout the region. Over the past two decades, North Carolina has been one of the most rapidly growing states in the nation, and the bulk of the population increases have occurred around Piedmont urban areas. Patterns of growth in the Piedmont have favored sprawling sub-divisions outside of city cores, putting even greater pressures on wildlife habitats and diminishing the quality of life for many urban residents. The US Forest Service has documented a sharp loss in forest land cover in counties surrounding the larger Piedmont urban areas (such as Charlotte and Raleigh) between 1990 and 2002 (Brown and Sheffield 2003).

In addition to the direct loss of habitat from human development, wildlife populations are also threatened by habitat degradation and fragmentation in the Piedmont. Habitat fragmentation limits area-sensitive species and isolates other species, making populations more vulnerable to disturbance, disease, and depredation. Increased road and transportation development projects have impacted populations in ecologically sensitive areas. Roads can separate amphibian breeding locations and provide substantial barriers to seasonal animal migration pathways. Increased human development also brings an increased risk of the introduction of exotic species.

Mid-Atlantic Coastal Plain

The Mid-Atlantic Coastal Plain ecoregion makes up the eastern portion of North Carolina (Figure 5A.2). This region is typified by flat land and low elevations, extending inland to the Piedmont fall-line and eastward to the coastal beach and dune systems on the Atlantic Ocean.

This ecoregion ranks among the top 10 in the continent in number of reptile, bird, and tree species (Ricketts et al. 1999). North Carolina's Coastal Plain is particularly diverse from an avifauna standpoint because it falls at the northern end of the range for many southeastern breeding species and the southern end for many northeastern breeding species. In fact, North Carolina is the only state where some species such as the piping plover are found all year (the state falls within the southern extremity of their breeding range and the northern extremity of their wintering range).

Many of the factors impacting species conservation in this region can be traced to larger habitat-level issues. Habitat loss is one of the most obvious threats. Longleaf pine was historically found in all but the wettest sites in coastal North Carolina. Today it exists across less than 3% of its former range (Frost 1993). Habitat fragmentation due to land conversion (e.g., agriculture, development, roads) and fire suppression also impact habitats in the Coastal Plain. As habitats become more dissected, fragments become smaller and more isolated, sometimes leading to a loss of ecological function.

Fragmentation disrupts dispersal of many species, especially those that migrate between wet lowlands and dry uplands, and can negatively affect population dynamics and reproductive success. Furthermore, prescribed burning becomes more difficult in fragmented areas, due to smoke management and liability issues. Fragmentation can be particularly destructive to species that do not move well across roads, such as many reptiles and amphibians.

North Carolina's coast is bordered by a system of barrier islands divided by inlets. Of the 316 miles of oceanfront coastline in the state, 150 miles (47%) of it is developed. Of the remaining portion, only 30 miles of coastline are not impacted by a roadway, beach driving or continued dredge material disposal. Beach renourishment is a common tool used to protect infrastructure as the barrier islands undergo regular patterns of erosion and accretion. Renourishment can have negative effects on turtle and bird nesting, and on the invertebrate food base of shorebirds. Other methods of beach stabilization, such as relocating inlets and preventing natural inlets from migrating, are also becoming more common. These activities can also have deleterious effects on early successional beach nesting birds by preventing spit formation and overwash and leading to increased vegetation. As development increase along the coastline, many non-native plants and animals proliferate and become problematic. Raccoons, foxes, and feral cats that were historically absent from most of the barrier islands are now taking advantage of trash dumps, fish bait and other food sources left behind by humans. These animals are particularly adept at finding and eating beach nesting bird chicks and eggs, and turtle hatchlings and eggs.

Water quality concerns stemming from local development, agriculture, livestock, and sources originating in upstream Piedmont cities, are impacting aquatic vertebrate and invertebrate species in the Coastal Plain. Direct impact to aquatic fauna can indirectly affect terrestrial vertebrates (e.g., insectivorous small mammals) that rely on aquatic species as their primary food source.

Biological Needs: Knowledge Gaps and Ubiquitous Concerns

In order to address species and habitat conservation needs, it is important to first acknowledge our current state of understanding about the species groups highlighted within this portion of the Plan.

Mammals

While we collect extensive data and information about managed mammalian game species (e.g., black bear, white-tailed deer), we are at the very earliest stages of understanding the life history and habitat needs of most of our native nongame mammals. A few select areas of the state have been the focus of much of the existing mammal work (e.g., the coast, the Sandhills); the majority of the state has yet to be extensively surveyed. Currently, the most critical information needs are basic surveys, inventories, research and monitoring, especially for bats and small mammals across the state. In addition, simply the compilation of pertinent mammalian studies from disparate sources would be useful in providing a solid foundation of work from which to build.

Amphibians and Reptiles

There is dire need for standardized statewide surveys and monitoring of our amphibians and reptiles. A North Carolina Partners in Amphibian and Reptile Conservation program was developed in 2004 to help facilitate efforts toward this need. As with mammals, we have only a very basic understanding of many of our amphibian and reptile species. Basic surveys, research, and monitoring are the most pressing concerns. Habitat-specific long-term monitoring data is severely needed in order to assess population trends.

Birds

Compared to most of the other taxonomic groups, we have better knowledge and understanding of many of our bird species. Waterfowl and other migratory birds are managed through support of cooperative agreements such as the Atlantic Coast Joint Ventures and the South Atlantic Migratory Bird Initiative. A Partners in Flight program has been underway since 1993 in North Carolina.

Monitoring through the Breeding Bird Survey, point counts, Migration Monitoring, and Monitoring Avian Productivity and Survivorship (MAPS) stations should be continued or increased because long-term trend data are critical to assess population changes. Additional monitoring and research related to breeding productivity and the migration periods are needed. The conservation needs of North Carolina birds center mainly on habitat management, restoration, and protection (especially of spruce-fir forest, bottomland hardwood forest, quality early successional habitats, longleaf pine communities and coastal beach and estuarine habitats). However, there are still basic survey and research needs associated with the following groups: montane hardwood and high elevation birds, marsh birds, bottomland hardwood birds, goatsuckers, raptors, inland colonial nesting waterbirds, and shorebirds.

Terrestrial Invertebrates

The NC Natural Heritage Program tracks species within all the aforementioned terrestrial taxa, in addition to rare species in the following invertebrate groups: terrestrial gastropods, arachnids, crustaceans, millipedes, mayflies, stoneflies, caddisflies, dragonflies, damselflies, flies, moths, butterflies, grasshoppers and katydids, beetles, true bugs, and annelids. However, the Commission does not have jurisdiction over most of these taxa, and there is a scarcity of biologists focused on these groups. Knowledge levels and data availability for insects, terrestrial gastropods, and arachnids are among the lowest of any animal group in the state. However, these taxa are an integral part of the ecosystems they share with other invertebrate and vertebrate species. Opportunities to expand our knowledge and understanding of these groups should be taken when possible, as should the establishment of habitat-based projects that are mutually beneficial to these groups and to higher taxa. For more information on invertebrate conservation needs, see Appendix D.

Other Needs

Filling all knowledge gaps for every taxonomic group is arguably not necessary to achieve effective conservation. Effective monitoring and management of terrestrial communities can generally be achieved through focused attention on key elements of those communities among the more well-known birds, mammals, amphibians, and reptiles. Even this, however, is a daunting challenge. Realistically, all necessary tasks cannot be accomplished by the Commission alone. Sharing and consolidation of data from various sources to more completely assess information gaps and help meet vital goals for inventory and monitoring must be improved. The NC Natural Heritage Program is an important partner in this effort. Improvements should be made in sharing data between the two organizations and broadening the scope of data captured between them. Other state and federal agencies (e.g., US Fish & Wildlife Service, US Forest Service), universities and museums (e.g., NC Museum of Nature Sciences), nonprofit organizations (e.g., The Nature Conservancy, NC Audubon), and certain industries (e.g., forestry) are engaged, to various degrees and purposes, in monitoring of terrestrial communities. These and other sources of data should be exploited to the greatest practical extent that their quantity and quality will allow.

Cooperation and coordination is also essential to fulfill research needs for basic life history and ecology, resolve taxonomic problems, vulnerability to specific threats, restoration techniques, etc. Opportunities to partner and leverage limited funds should be explored and pursued to the maximum extent possible.

Organization and Content

In the following sections, priority terrestrial and semi-aquatic species (mammals, birds, amphibians, and reptiles) are referred to within the context of their associated terrestrial habitats. The ecoregion (Section level) as defined by Bailey (1995) is the broadest level of organization. We identified a total of 23 habitat types (modified from NCNHP 2001), found across the three ecoregions as such (Table 5A.1):

Table 5A.1. Habitats, by ecoregion, across North Carolina.

		Ecoregion		
		Mid-Atlantic Coastal Plain	**Piedmont**	**Southern Blue Ridge**
Terrestrial habitats	Beach/dune	X		
	Estuarine communities	X		
	Maritime forest/shrub	X		
	Tidal swamp forest and wetlands	X		
	Nonalluvial mineral wetlands		X	
	Small wetland communities	X	X	
	Wet pine savanna	X		
	Pocosin	X		
	Dry longleaf pine forest[4]	X	*	
	Lakes and reservoirs	X	X	
	Riverine aquatic communities	X	X	X
	Floodplain forest	X	X	X
	Early successional	X	X	X
	Oak forest (& mixed hardwoods/pine)	X	X	X
	Dry coniferous woodlands	X	X	X
	Mesic forest	X	X	
	Low elevation cliffs/rock outcrops[4]		*	X
	High elevation rock outcrops			X
	Caves and mines			X
	Bogs and associated wetlands[4]		*	X
	Cove forest			X
	Northern hardwoods			X
	Spruce-fir forest			X

These habitats represent all of the major habitat types in the state. Each habitat section offers a more detailed view of the threats, needs, and conservation priorities of that particular habitat. Priority species associated with each habitat are listed in table form at the start of the section. Map Series 5A shows the location and extent of the habitat in the ecoregion (see *Note*). Supporting references are included to direct readers towards other information sources that might be useful to review for conservation planning in the habitat. See Appendix G for a complete list of habitat associations of priority species, by habitat and ecoregion.

It is important to point out that each habitat may not be of equal importance to every priority species listed therein (e.g., a particular habitat may be obligate breeding habitat for one species, but an over-wintering habitat for another). Details of these differences are highlighted within the text of each habitat section. We direct readers to use the species tables at the beginning of each habitat section as a resource to identify the broad range of priority species that may use the habitat (potentially at different times of the year).

[4]Some habitats are found at the periphery of or in scattered locations within a second ecoregion not designated in the table above. To reduce redundancy, we have simply made note of these instances within the text of the primary habitat section and we have indicated that recommendations therein would apply to the habitat, wherever it is found. A (*) indicates additional ecoregion(s) where the habitat can be found.

Note: The findings of the recently completed NC Gap Analysis Project (NC GAP) are applicable to the terrestrial portion of this Plan. NC GAP staff assisted us in developing habitat coverage maps using their 1992 landcover data, and in conducting analyses on our subset of priority terrestrial species (aquatic species were not included in NC GAP analyses). The habitat maps are referenced in each habitat section that follows (Map Series 5A). All NC GAP-based analyses, including predicted species distributions maps for the majority of our terrestrial priority species, are documented in Appendix K.

Data disclaimer: 1992 (30 meter pixel) satellite imagery data was used to create the habitat maps. This data, therefore, may not accurately represent the location and extent of the habitats as they currently exist. The scale of the data makes representation of narrow or scattered habitats difficult (e.g., Southern Blue Ridge floodplain forest). In addition, it should be noted that not all vegetation types represented in the maps (e.g., early successional and agricultural areas) are representative of quality *wildlife habitat*.

References

Atlantic Coast Joint Venture (ACJV). 2004. Atlantic Coast Joint Venture strategic plan. North American Waterfowl Management Plan.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Bailey, R. G. 1995. Descriptions of the ecoregions of the United States. Report #1391. U.S. Department of Agriculture, Forest Service.

Brown, M. J. 2004. Forest Statistics for North Carolina, 2002. Southern Research Station. U.S. Department of Agriculture, Forest Service, Asheville, NC.

Brown, M. J., and R. M. Sheffield. 2003. Forest statistics for the Piedmont of North Carolina, 2002. Southern Research Station. U.S. Department of Agriculture, Forest Service, Asheville, NC.

Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. U.S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Frost, C. C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. Pages 17-43 in S. H. Hermann, editor. Proceedings of the Tall Timbers fire ecology conference, No. 18. Tall Timbers Research Station, Tallahassee, FL.

Groves, C. R., M. W. Beck, J. V. Higgins, and E. C. Saxon. 2003. Drafting a conservation blueprint: a practitioner's guide to planning for biodiversity. Island Press, Washington, D.C.

Hunter, W. C. 2004 (DRAFT). Southeast U.S. region waterbird conservation plan. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W. C., J. Collazo, B. Noffsinger, B. Winn, D. Allen, B. Harrington, M. Epstein, and J. Saliva. 2000. Southeastern Coastal Plain – Carribean regional shorebird plan, Version 1. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E., M. Brooks, J. Gerwin, and K. O'Kane. 2005. A bird conservation plan for North Carolina. North Carolina Partners in Flight.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Division of Parks and Recreation, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 1999. North Carolina wildlife diversity plan. Raleigh, NC.

North American Bat Conservation Partnership – Strategic Plan. Accessed from the World Wide Web on March 22, 2004: http://www.batcon.org/nabcp/newsite/index.html

North American Waterfowl Management Plan Committee (NAWCP). 2003. North American waterfowl management plan strategic guidance. US Fish & Wildlife Service, Arlington, VA.

Noss, R. F., E. T. LaRoe, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. National Biological Service, U.S. Department of the Interior, Washington, D.C.

Parnell, J. F., and M. A. Shields. 1990. Management of North Carolina's colonial waterbirds. UNC Sea Grant Publication # UNC-SG-90-03.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2001. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial ecoregions of North America: a conservation assessment. Island Press, Washington, DC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

The Nature Conservancy. 2000. Conservation by design: a framework for mission success. The Nature Conservancy, Arlington, VA.

The Nature Conservancy and NatureServe. 2001. Mid-Atlantic Coastal Plain ecoregion plan. The Nature Conservancy, Durham, NC.

Trani (Griep), M. K. 2002. Terrestrial ecosystems. Pages 3–45 *in* D. N. Wear and J. G. Greis, editors. Southern forest resource assessment. Southern Research Station, US Department of Agriculture, Forest Service, Asheville, NC.

Watson, C., and K. McWilliams. 2004 (DRAFT). South Atlantic Migratory Bird Initiative implementation plan: an integrated approach to conservation of “all birds across all habitats.” US Fish & Wildlife Service, Charleston, SC.

Southern Blue Ridge Ecoregion

1. **Spruce-fir forest** – Spruce-fir forests occur on high mountaintops in western North Carolina, generally above 4,500 feet in elevation. These forests are considered Pleistocene relicts that have become isolated from boreal forests of the northern United States and Canada. Many of the species of plants and animals found in this community type are more common further north and have either evolved here, isolated from their northern cousins or remain in small areas where elevation provides similar conditions to more northern latitudes. Spruce-fir forests are often comprised of components of northern hardwood and northern red oak forests mixed with red spruce at elevations from about 4,500 feet to 5,500 feet, with spruce becoming dominant, followed by Fraser fir dominance above 6,000 feet.

   These forests have been, and remain threatened due to impacts from human activities (including residential development, recreational development, and historic land use for logging or grazing), non-native insects (especially the balsam woolly adelgid), air pollution, and natural factors such as insects, isolation, and climate. Indeed, this habitat is listed as the second most endangered ecosystem in the United States (Noss et al. 1995).

   Spruce-fir communities provide critical breeding habitat for many landbirds of conservation concern according to Partners in Flight (brown creeper, northern saw-whet owl, black-capped chickadee) that are likely endemic to these high peaks (Pashley et al. 2000, Rich et al. 2004, Johns 2004). Spruce-fir also provides critical habitat for a host of plant and animal species found nowhere else in North Carolina.

Priority species associated with spruce-fir forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter striatus*	Sharp-shinned Hawk	SR
	Aegolius acadicus	Northern Saw-whet Owl	T
	Carduelis pinus	Pine Siskin	
	Certhia americana	Brown Creeper	SC
	Dendroica magnolia	Magnolia Warbler	SR
	Dendroica pensylvanica	Chestnut-sided Warbler	
	Loxia curvirostra	Red Crossbill	SC
	Picoides villosus	Hairy Woodpecker	
	Poecile atricapilla	Black-capped Chickadee	SC
	Wilsonia canadensis	Canada Warbler	
Mammals	*Glaucomys sabrinus*	Northern Flying Squirrel	E (E)
	Microtus chrotorrhinus	Rock Vole	SC
	Mustela frenata	Long-tailed Weasel	
	Sorex cinereus	Masked Shrew	
	Sorex dispar	Rock Shrew	SC
	Sorex fumeus	Smoky Shrew	
Amphibians	*Desmognathus wrighti*	Pigmy Salamander	SR
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Plethodon welleri	Weller's Salamander	SC

A. Location and condition of habitat (see Map 5A.1):

There are currently 6 significant areas of spruce-fir habitat in Western North Carolina, including portions of Grandfather Mountain, Roan Mountain, the Black/Craggy mountains, the Great Balsam mountains, the Plott Balsam mountains, and the Great Smoky mountains. Red spruce habitats of lesser size or with somewhat different ecological community associates occur in a few other locations, including Long Hope Valley, Beech Mountain, and Alarka Laurel. Estimates of the amount of spruce-fir habitat are quite variable depending upon a number of factors including the estimation methods and habitat definition. The Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) identifies over 66,000 acres of spruce-fir forest in the southern Blue Ridge physiographic province and the Southern Appalachian Assessment (SAMAB 1996) identifies over 75,000 acres in North Carolina and Tennessee. The vast majority of these areas occur in North Carolina at the locations listed above.

Most of the spruce-fir habitat in North Carolina is located on public land, or private lands with permanent conservation easements, with estimates of 90-95% in conservation ownership in the southern Blue Ridge physiographic province including North Carolina, Tennessee, and Virginia (Hunter et al. 1999, SAMAB 1996). However significant private ownership of spruce-fir habitat occurs in the Plott Balsams and Black/Craggy mountains, and to lesser extents in several other ranges.

B. Problems affecting species and habitats:

Spruce-fir habitats in North Carolina are now found within a narrow range of suitable conditions, isolated from each other and the rest of their range. This condition alone makes them more susceptible to perturbation and catastrophic events that could significantly affect their availability into the future. In addition, much of the spruce-fir habitat in North Carolina and throughout the southern Appalachians has been significantly altered due to a number of factors including historic logging, fire, exotic insects, historic grazing, and recreational development. Much of the spruce was logged in the early 20th century and in some areas (notably the Great Balsams) slash fires burned not only the coarse woody debris, but also the organic soil, which has subsequently inhibited the re-development of spruce and fir forests over large areas (Schafale and Weakley 1990).

In the latter part of the 20th century, the balsam wooly adelgid (*Adelges piceae*) began to have severe negative impacts upon Fraser firs throughout the region, resulting in the death of most of the mature fir of the high elevation forests. While some Fraser fir remains in certain locations, the majority of late successional fir has been killed and often replaced by young fir, mixed northern hardwoods, and open, herbaceous habitats. The removal of mature Fraser fir from the canopy has profound implications for the spruce-fir ecosystem and the continued existence of several unique plants and animals (Nicholas et al. 1999).

In addition, during the latter part of the 20th century, the Blue Ridge Parkway was completed through western North Carolina. The Parkway traverses most of the high elevation islands of spruce-fir habitat. The Parkway and its associated development (the motor road, vistas, and visitor facilities) have had a significant impact on the amount of spruce-fir habitats available. More recent negative impacts upon spruce fir forests include insect outbreaks in several areas including Roan Mountain, the Black Mountains, and the Great Balsam mountains. Some research has shown that recent increases in acid precipitation in the mountains of western North Carolina may have impacts on forest health and productivity, particularly in the high mountains (Schafale and Weakley 1990, Hunter et al. 1999).

The wildlife species associated with spruce-fir forest have suffered losses due the impacts of all of these activities and events. Certainly the local relative abundance of many birds and mammals has decreased as the availability of spruce-fir habitats has declined (e.g., red crossbill, brown creeper, pine siskin, black-capped chickadee, northern saw-whet owl, northern flying squirrel). The fact that these habitats are so small and isolated from each other could have a negative impact upon genetic health of individual populations, as well as demographic effects upon populations.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to determine the distribution, relative abundance, and status of all wildlife species associated with spruce-fir forests.
  - Focus survey priorities on species believed to be declining, at risk, or exclusively dependent on the rare spruce-fir forest communities (e.g., red crossbill, brown creeper, black-capped chickadee, rock vole, rock shrew, northern flying squirrel, Weller's salamander, pigmy salamander).
  - Give secondary priority to surveys for species for which current distribution information is more available (e.g., northern saw-whet owl), or for species associated with additional, more extensive habitats (e.g., masked shrew, smoky shrew, hairy woodpecker, Canada warbler, sharp-shinned hawk, northern slimy salamander).
- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with spruce-fir forests. Priorities include:
  - Establish MAPS Stations, migration banding stations, or other means to monitor population status and trends for bird species not adequately sampled under existing monitoring protocols (i.e., BBS).
  - Establish monitoring systems and protocols for small mammal population status and trends including northern flying squirrel, rock shrew, and rock vole.
  - Establish monitoring systems and protocols for spruce-fir associated amphibians such as Weller's and pigmy salamanders.
  - Establish mechanisms for monitoring the distribution and condition of spruce-fir habitats through time.
- **Research** – Priority research needed for spruce-fir habitats and their associated species includes not only studies on the population biology of wildlife species, but also ecological relationships between the species, their habitats, and the biological, physical, and chemical habitat components. The following are currently recognized research needs.

  Genetics
  - Studies to explore the degree of endemism of Southern Appalachian populations (e.g., pine siskin, red crossbill, northern saw-whet owl, black-capped chickadee).
  - Studies to explore the degree of genetic isolation of species restricted to high elevations (e.g., northern flying squirrel, rock vole, rock shrew, Weller's salamander, northern saw-whet owl).

  Habitat
  - Studies to document ecological relationships between habitat use and availability for all taxonomic groups.
  - Studies to effectively map and/or model spruce-fir habitats both within and between habitat islands.
  - Studies on the impact of air pollution and climate change on the future availability of spruce-fir forests in North Carolina.
  - Studies to document forest management and restoration techniques that will benefit the habitat and associated species.

  Population demographics
  - Research on population demographics including trends, population structure, survivorship, reproduction, and population viability for all spruce-fir associated species/groups.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

While the vast majority of spruce-fir habitat in North Carolina is currently under conservation ownership by either state and federal government agencies or conservation groups (e.g., The Nature Conservancy), there remain areas of private ownership (particularly in the Plott Balsams and Black/Craggy Mountains), which, if developed in the future, could hasten the decline of the habitat as well as the species which depend upon it. In addition, the state and federal agencies which own/manage these habitats have goals and objectives which can conflict with conservation objectives for the habitat. For example state and federal parks have objectives to provide visitor services and developed recreational facilities that have, and could continue to decrease the availability or suitability of spruce-fir habitats under their jurisdiction. It is important to understand the influence of specific land uses within the landscape on ecological communities to avoid or mitigate associated impacts on wildlife species of concern (Rodewald 2003).

Many of the state and federal agencies take a passive role towards management of forest communities on their lands, particularly communities or habitats which support rare or endangered species, like spruce-fir forests do. While this management scenario may be beneficial in some instances for some habitats, it may not be appropriate to sustain habitats and associated species that are in decline and/or have very limited distribution to begin with. There are opportunities for active management of spruce-fir forests that could increase its distribution, health, and longevity that are not currently being pursued. Conservation actions that are appropriate and necessary to sustain spruce-fir forests and their inhabitants include both protection measures (acquisition/easement etc.) and management.

Protection Actions

- Assess, monitor, and mitigate impacts of existing management of state and federal holdings.
- Eliminate or minimize negative affects of future development of state and federal government holdings (state and federal parks, US Forest Service recreation developments).
- Acquire additional acreage of spruce-fir habitat through purchase, conservation easement, or other perpetual management agreements.

Habitat Management and Restoration Actions

- Continue efforts to study and develop management tools to ensure Fraser fir survival.
- Consider, implement, and evaluate effectiveness of spruce restoration in non-forested areas.
- Develop and/or implement techniques for managing pure spruce stands to include habitats components of the entire spruce-fir/northern hardwood community (i.e., thinning).
- Test silvicultural techniques to re-introduce spruce into formerly disturbed areas that have regenerated in northern hardwood or northern red oak communities (i.e., thinning and underplanting).

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy, The Plains, VA.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Nicholas, N.S., C. Eager and J.D Peine. 1999. Threatened ecosystem: high elevation spruce-fir forest. Pages 431–454 *in* J.D. Peine, editor. Ecosystem management for sustainability. CRC Press, Boca Raton, FL.

Noss, R. F., and R. L. Peters. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Defenders of Wildlife.

Pashley, D. N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Rodewald, A.D. 2003. The importance of land uses within the landscape matrix. Wildlife Society Bulletin 31(2):586–592.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

Southern Blue Ridge Ecoregion

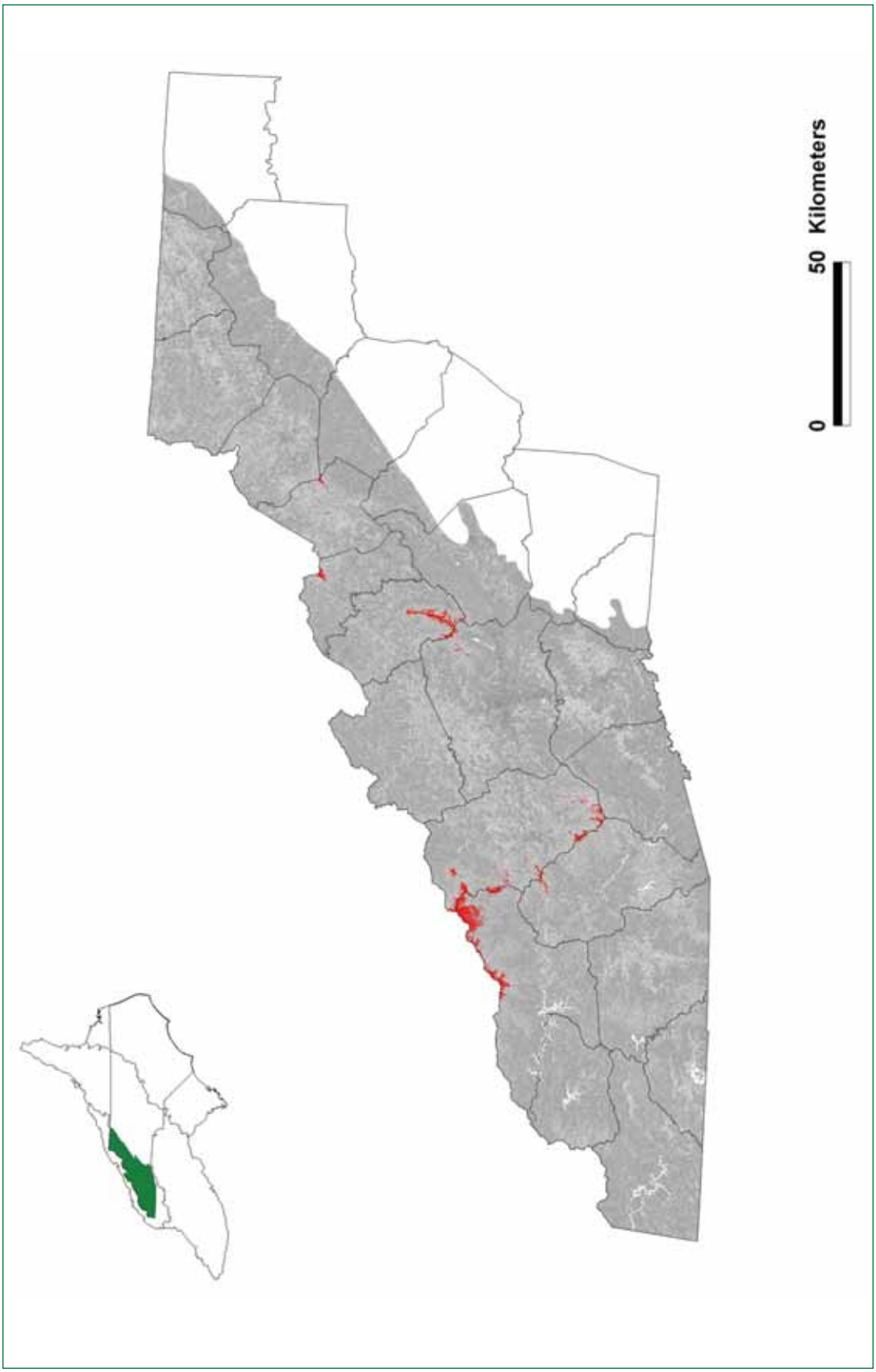


Figure 5A.1. Spruce-fir habitats in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

2. **Northern hardwoods** – Northern hardwood forests are found on high elevation sites (generally above 4000 feet, but more often above 4500 feet) throughout western North Carolina with abundant rainfall and a cool climate. High elevation climate, slope, aspect and past disturbance are critical ecological determinants of the distribution of northern hardwood forests today.

   These habitats can be quite variable and can include several ecological sub-types such as boulderfield forests and beech gaps. Dominant tree species include yellow birch, American beech, yellow buckeye, and sugar maple. Understory vegetation varies considerably from dense rhododendron to open sedge, with numerous potential combinations of herbaceous and shrub components (NCNHP 2001). Generally, the ecological boundaries of northern hardwood forest are not well defined, and therefore the ecotones are wide and contain a diverse mixture of components from the adjoining habitat(s). Northern hardwood forests share some ecological components with high elevation red oak forests. However, they are more likely to occur on northerly aspects, with more cool moist conditions. Often components of spruce-fir habitats are present in sub-dominant numbers within northern hardwood communities, and increase in dominance along the elevation gradient to a point where spruce-fir becomes the dominant community. Northern hardwoods grade to cove hardwoods at lower elevations and the distinction can be difficult to discern, with many species occurring in both types.

   Northern hardwood forests provide habitat for numerous wildlife species which also rely heavily on spruce-fir forests. Because of the spatial relationship between them, and the fact that they share many ecological components and plant species, northern hardwood forests are critical to maintaining many species of birds and mammals dependent upon spruce-fir habitats. In addition, northern hardwood plant species may be critical components of spruce-fir habitats even in their sub-dominant role. Consider, for example, the fact that many spruce-fir dependent wildlife species are cavity nesters. Yellow birch, beech, sugar maple and buckeye often provide more abundant natural cavities and decaying wood than spruce or fir for species such as northern flying squirrels, yellow-bellied sapsuckers, black-capped chickadees, northern saw-whet owls, and other wildlife. While the northern hardwood habitat can be defined in general terms, ecologically, it is and possibly should be considered in association with spruce-fir forest for the purposes of maintaining ecological relationships and sustainability.

A. Location and condition of habitat (see Map 5A.2):

Northern hardwood forests in western North Carolina are concentrated in many of the same high elevation areas as spruce-fir forests, however they are more widespread throughout the region owing to their respectively lower elevation range. Significant amounts of northern hardwood forest occur in the Great Smoky Mountains, Great Balsams, Plott Balsams, Black/Craggy Mountains, Unicoi Mountains, and in the vicinities of Roan Mountain, and Grandfather Mountain. While most of the available northern hardwood forest is associated with these high elevation mountain ranges, significant amounts are present in other areas of suitable elevation throughout the region, such as in the Amphilobite mountains in Ashe and Watauga counties and in the Nantahala mountains in Macon county.

In western North Carolina, estimates of the amount of northern hardwood forest have not been definitively made, however the Southern Appalachian Assessment estimated approximately 56,000 acres (SAMAB 1996), and the US Forest Service estimates 46,000–56,000 acres on the Pisgah and Nantahala National Forest (USFS 2001). Estimates range from 68–80% of the acreage of northern hardwood forest in older (60+) age classes (Hunter et al. 1999, USFS 2001). Regardless of the estimates used, most of the available northern hardwood forest in North Carolina can be found on federally owned lands including US Forest Service (Pisgah and Nantahala National Forests) and National Park Service (Blue Ridge Parkway and Great Smoky Mountains National Park). A small percentage does occur on state-owned lands, and other conservation ownerships (e.g., The Nature Conservancy, local land trusts, etc.).

Priority species associated with northern hardwoods:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Aegolius acadicus	Northern Saw-whet Owl	T
	Certhia americana	Brown Creeper	SC
	Coccyzus erythropthalmus	Black-billed Cuckoo	SR
	Dendroica pensylvanica	Chestnut-sided Warbler	
	Pheucticus ludovicianus	Rose-breasted Grosbeak	
	Picoides villosus	Hairy Woodpecker	
	Poecile atricapilla	Black-capped Chickadee	SC
	Sphyrapicus varius	Yellow-bellied Sapsucker	SC
	Vermivora chrysoptera	Golden-winged Warbler	SR
	Wilsonia canadensis	Canada Warbler	
Mammals	*Glaucomys sabrinus*	Northern Flying Squirrel	E (E)
	Lasionycteris noctivagans	Silver-haired Bat	SR
	Mustela frenata	Long-tailed Weasel	
	Napaeozapus insignis	Woodland Jumping Mouse	
	Parascalops breweri	Hairy-tailed Mole	
	Scalopus aquaticus	Eastern Mole	
	Sorex cinereus	Masked Shrew	
	Sorex dispar	Rock Shrew	SC
	Sorex fumeus	Smoky Shrew	
	Sorex hoyi winnemana	Southern Pygmy Shrew	
	Sorex palustris	Water Shrew	SC
	Sylvilagus obscurus	Appalachian Cottontail	SR
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Desmognathus wrighti	Pigmy Salamander	SR
	Plethodon aureolus	Tellico Salamander	SR
	Plethodon chattahoochee	Chattahoochee Slimy Salamander	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Plethodon richmondi	Southern Ravine Salamander	
	Plethodon welleri	Weller's Salamander	SC

Hunter et al. (1999) and Schafale and Weakley (1990) suggest that the available acreage of northern hardwood habitat is actually greater now than in the past, primarily due to expansion of northern hardwoods into areas formerly occupied by spruce-fir forests. In fact, there are places which may have been spruce or fir forests where previous disturbances (fires, grazing, etc.) have resulted in northern hardwood stands. It remains to be seen whether these places, under natural regimes will ultimately become mixed northern hardwood/spruce stands or whether spruce will eventually attain dominance. However, it must also be considered that significant development has and continues to occur in northern hardwood habitats on private lands throughout the region. Primarily this has been residential development and the rate of it has likely increased recently, making an estimate of current northern hardwood habitat availability relative to past availability difficult.

B. *Problems affecting species and habitats:*

The aging of many northern hardwood stands has resulted in closed canopy conditions and decreasing habitat for bird species that rely on diverse understory development, such as Canada warbler. Lack of disturbance has reduced available habitat for disturbance-dependent species such as golden-winged warbler and yellow-bellied sapsucker (Hunter et al. 2001). In turn, the impacts to other wildlife from stand level disturbance will need to be examined. For example, soricids such as masked and smoky shrews can respond favorably to forest disturbance in northern hardwoods (Ford et al. 2002), but this may not be true for other small mammals or salamanders. Many of the former fir forests and logged or grazed areas are regenerating into northern hardwood stands without a conifer component (spruce or fir). Development pressure includes threats from a large increase in second homes and recreation facilities. Many non-native pathogens are a potential problem for several tree species in this ecosystem, including hemlock woolly adlegid, balsam woolly adelgid, gypsy moth and beech scale. The isolated nature of several populations of wildlife, such as northern flying squirrel, northern saw-whet owl, black-capped chickadee and Weller's salamander, is likely detrimental to the genetic flow and overall long-range health of the species.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Initiate surveys for rare salamanders like Weller's, pygmy, seepage, and Tellico, as well as more common species such as ravine salamanders, to determine their actual distribution and better define their habitat associations.
  - Continue survey work on northern flying squirrel distributions within and between known populations. Questions remain, such as: *Are there additional populations? Within populations how much suitable habitat occurs? What are the spatial relationships between patches of suitable habitat?*
  - Conduct shrew surveys to determine the distribution of long-tailed, pygmy and water shrews and surveys to document the response of shrews to disturbance/management.
  - Conduct surveys for more common mammals such as Appalachian cottontails, bats (particularly silver-haired and hoary bats), woodland jumping mice.
  - Conduct bird surveys to document breeding distribution (e.g., black-billed cuckoo).
  - Conduct bird surveys for golden winged warbler, black-capped chickadees, brown creeper, yellow-bellied sapsucker, and other high elevation birds.
- **Monitoring** – Monitoring of population trends for all high elevation species, including those associated with northern hardwood forest, needs to be developed and implemented with top priority towards rare species and secondary priority towards all species occurring in this relatively rare community of the North Carolina landscape.
  - Establish more MAPS stations, point counts, and migration banding stations; montane birds are not adequately picked up in BBS routes.
  - Continue montane bird population monitoring (e.g., northern saw-whet owl, brown creeper, black-billed cuckoo, yellow-bellied sapsucker, rose-breasted grosbeak, and others that may be found at the upper or lower ranges of this habitat).
  - Establish monitoring systems and protocols for small mammal population status and trends including northern flying squirrel, rock shrew, water shrew.
  - Establish monitoring systems and protocols for bats (e.g., hoary, silver-haired and other bats) and other mammals (e.g., Appalachian cottontails) associated with northern hardwood communities.
  - Establish monitoring systems and protocols for northern hardwood associated amphibians such as Weller's and pigmy salamanders.

- **Research**

  Genetics

  – Conduct genetic studies across taxonomic groups to assess degree of population isolation/gene flow, and determine taxonomic status (primarily bird taxa thought to be southern Appalachian endemics).

  Habitat

  – Conduct species specific research needed for northern saw-whet owls, yellow-bellied sapsuckers, black-capped chickadees, golden-winged warbler to answer the question: *How are they using the available habitat?*
  – Initiate habitat use studies for many species to assess use of microhabitats, forest age classes and habitat spatial relationships.
  – Conduct research on habitat management techniques to successfully establish mixed spruce-northern hardwood stands in non-forested areas or appropriate pure/young northern hardwood stands.
  – Conduct research on habitat management techniques to maintain suitable habitat for disturbance tolerant species such as golden-winged warbler and yellow-bellied sapsucker.

  Population demographics

  – Initiate demographic studies of neotropical migrants through nest searching, spot mapping, telemetry.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

While much of the available northern hardwood forest in North Carolina occurs on conservation lands, that does not in and of itself ensure the continued existence of many of the species associated with it. Conservation actions necessary to conserve those species and the habitat itself include both protection and management of the community. Given the small proportion of the landscape occupied by northern hardwood forest, it and its associated species need to be protected from significant loss due to development or other factors. The current habitat and connectivity of isolated patches certainly needs to be protected through conservation ownership acquisition or easement. In addition, management of existing northern hardwood forests and adjacent habitats (particularly spruce-fir forests) needs to be expanded to ensure that we provide the complete mix of age class, composition, and conditions necessary to sustain populations of a wide range of species that utilize northern hardwood forests. The effects of edge and fragmentation need to be considered for forest interior wildlife in northern hardwood habitats (Manolis et al. 2000, Rosenberg et al. 2003).

Specific actions necessary include:

– Acquire additional acreage of northern hardwoods habitat through purchase, conservation easement, or other perpetual management agreements.
– Increased connectivity among habitat patches, both through acquisition or management of adjacent stands. Preservation of large tracts of minimally disturbed older forests may be key to maintaining forest litter amphibian populations.
– Consider and implement strategies to enhance the greater high elevation communities (particularly the spruce-fir/northern hardwood forest complex) by expanding the current distribution of mixed spruce/northern hardwood forest through appropriate means and at appropriate locations (e.g., establishing a subdominant spruce component in pure northern hardwood stands)
– Consider and implement silvicultural management at appropriate locations to enhance understory development, provide regeneration and habitat for disturbance dependent species or early successional species, and enhance mature forest conditions in young to middle-aged pure stands.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Ford, W.M., C.A. Dobony and J.W. Edwards. 2002. Shrews in managed northern hardwood stands in the Allegany mountains of West Virginia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 374–384.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2):440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Manolis, J.C., D.E. Anderson and F.J. Cuthbert. 2000. Paterns in clearcut edge and fragmentation effect studies in northern hardwood-conifer landscapes: retrospective power analysis and Minnesota results. Wildlife Society Bulletin 28(4):1088–1101.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Rosenberg, K.V., R.S. Hames, R.W. Rohrbaugh, Jr., S.Barker Swarthout, J.D. Lowe and A.A. Dhondt. 2003. A land manager's guide to improving habitat for forest thrushes. Cornell Lab of Ornithology, Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

U.S. Forest Service (USFS). 2001. Management indicator species habitat and population trends – Nantahala and Pisgah National Forests. Draft internal document, U.S. Department of Agriculture, Forest Service, National Forests in North Carolina, Asheville, NC.

Southern Blue Ridge Ecoregion

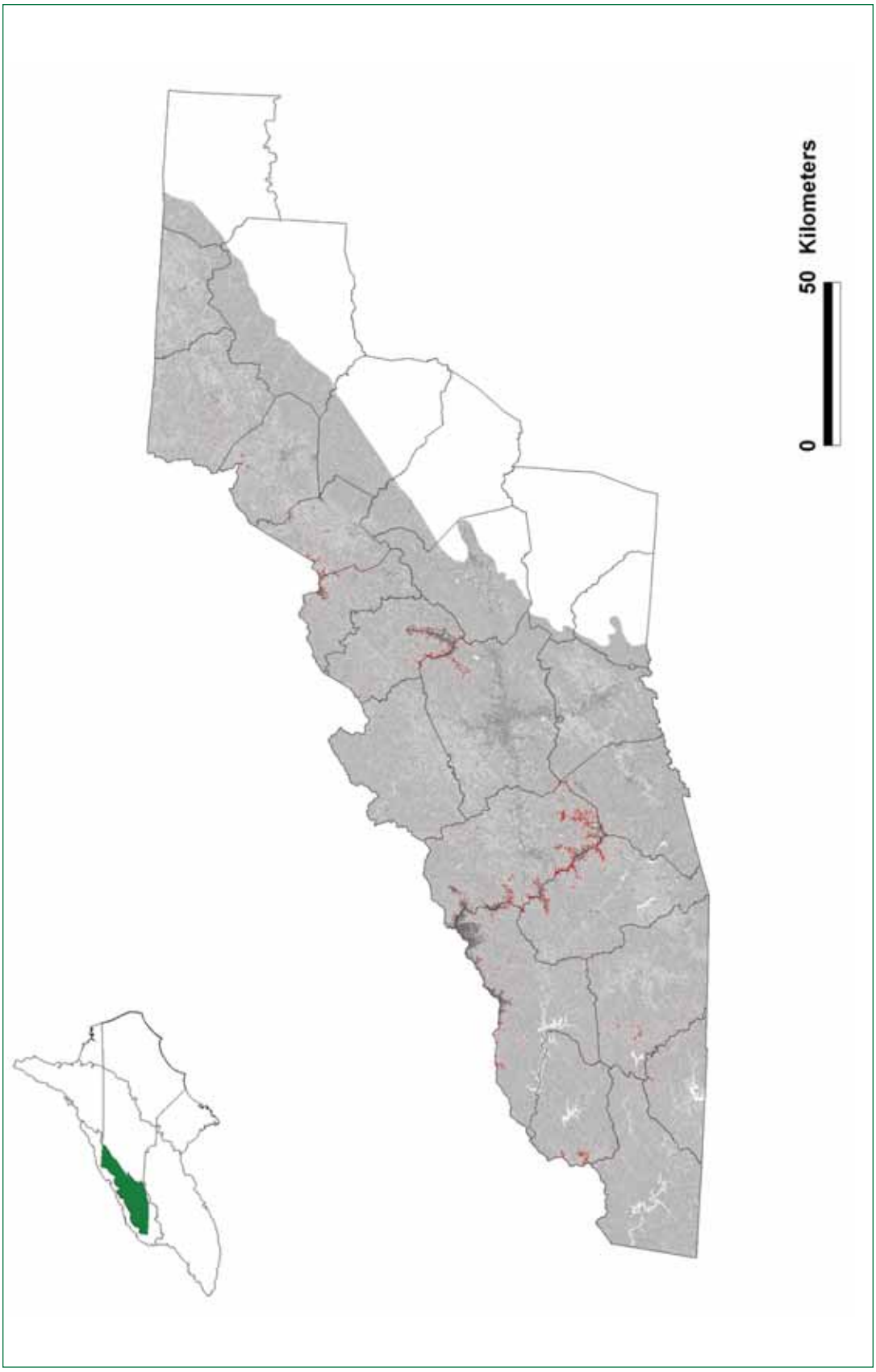


Figure 5A.2. Northern hardwood habitats in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

3. **Cove forest** – Montane cove forest occurs in low to mid-elevation sites in moist, protected areas. Coves are generally stable, uneven-aged climax forest, characterized by a dense tree canopy. Other plant community classification systems refer to cove forests as mixed mesophytic hardwoods (SAMAB 1996) or differentiate between acidic coves and rich (circumneutral soils) coves (Schafale and Weakley 1990). Common tree species may include: yellow poplar, sugar maple, yellow buckeye, basswood, beech, black cherry, white ash, red maple, hemlock, black birch, umbrella tree, fraser magnolia, and northern red oak. Generally, rich coves have a relatively open midstory with a dense herb layer of ferns and numerous herbaceous plants, and acidic coves have a dense midstory, often comprised of rhododendron and dog hobble, with a sparse herbaceous layer. Canopy gap dynamics play a large role in regeneration (NCNHP 2001).

   Appalachian cove hardwood forests represent some of the most diverse ecosystems in the world outside of tropical zones (Hunter et al. 1999). An amazing assortment of trees and herbaceous vegetation, coupled with topographic, microclimatic, and soil characteristics combine to provide an extremely productive habitat for numerous mammals, amphibians, and birds. High numbers of endemic salamanders are present (Petranka 1998), and population densities of these animal groups in cove hardwood forests make these extremely important habitats.

Priority species associated with cove forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Certhia americana	Brown Creeper	SC
	Coccyzus americanus	Yellow-billed Cuckoo	
	Coccyzus erythropthalmus	Black-billed Cuckoo	SR
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-Pewee	
	Dendroica cerulea	Cerulean Warbler	SR
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Limnothlypis swainsonii	Swainson's Warbler	
	Picoides villosus	Hairy Woodpecker	
	Sphyrapicus varius	Yellow-bellied Sapsucker	SC
	Wilsonia citrina	Hooded Warbler	
Mammals	*Mustela frenata*	Long-tailed Weasel	
	Napaeozapus insignis	Woodland Jumping Mouse	
	Scalopus aquaticus	Eastern Mole	
	Sorex cinereus	Masked Shrew	
	Sorex fumeus	Smoky Shrew	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Aneides aeneus	Green Salamander	E
	Desmognathus aeneus	Seepage Salamander	SR
	Desmognathus wrighti	Pigmy Salamander	SR
	Plethodon aureolus	Tellico Salamander	SR
	Plethodon chattahoochee	Chattahoochee Slimy Salamander	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Plethodon longicrus	Crevice Salamander	
	Plethodon richmondi	Southern Ravine Salamander	
	Plethodon ventralis	Southern Zigzag Salamander	
Reptiles	*Heterodon platirhinos*	Eastern Hog-nosed Snake	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

A. Location and condition of habitat (see Map 5A.3):

Cove hardwood habitat is well represented in the mountains of western North Carolina. The Southern Appalachian Assessment (SAMAB 1996) categorized over 3.1 million acres of their study area as mixed mesophytic hardwood forest. Hunter et al. (1999) estimated that within that total, the Southern Blue Ridge physiographic province (mostly NC, but with portions of TN, GA, and SC) contributed approximately 1 million acres of cove hardwoods. The US Forest Service (2001) estimated through ecological mapping that there was over 1.8 million acres of cove hardwood forest in the southern Appalachians of TN, NC, GA, and SC and approximately 300,000 acres of cove hardwood forest occurs on its lands in western North Carolina, on the Pisgah and Nantahala National Forests. Of course, direct measurement of the amount of cove hardwood habitat currently in North Carolina is not possible, so depending upon the methods used to estimate, and the data upon which estimates are based, the overall availability of cove hardwoods is, at best a crude estimate.

If estimating the amount of cove hardwood is difficult, defining its condition is impossible. Most would agree that the majority of cove hardwood forest in western North Carolina is currently in mid-late successional stages (SAMAB 1996, Hunter et al. 1999). Likewise, over 81% of the cove hardwood forest on the Pisgah and Nantahala National Forests is over 60 years old (USFS 2001).

B. Problems affecting species and habitats:

In general, the most significant problem affecting cove hardwood habitat is its conversion to other uses, primarily in the form of residential development, though estimates of the amount of cove hardwoods lost to development are unavailable. Residential development in mountain coves often differs from development in other habitats of the region, in that homes and associated spaces are often interspersed within the forest. The result may be that direct habitat loss as a result of the houses and associated structures may be more limited than other types of development. However, the reduction in quality of the habitat by virtue of being bisected by roads and driveways can certainly have significant impact upon the wildlife species of the forest (Rosenberg et al. 2003). Another potential problem affecting cove hardwood habitat is the advent of several exotic pest species which could have a significant impact upon the health of the forest, including the hemlock wooly adelgid, gypsy moth, and beech scale, as well as several non-native plants. And finally, timber harvesting and conversion to other forest types (white pine) or other uses on private lands in certain areas can also decrease the availability of this habitat in the future.

Problems of individual species associated with cove hardwood forests include isolation or extremely limited ranges of populations (e.g., cerulean warbler, crevice salamander). That could lead to increasing chances of genetic depression or stochastic events having negative consequences for the sustainability of populations. Some bird species which require a diverse understory may be impacted by the aging of stands, which can result in decreased plant diversity until the stand reaches age classes sufficient to produce canopy gaps (Hunter et al. 2001).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine current baseline distribution and status of species associated with cove hardwood forest for which that information is lacking. There are also numerous species associated with cove forests that are believed to be relatively common or have stable populations. However, in truth, we lack baseline information about actual distribution and status for most species that are considered common.

  - Focus initial survey efforts on state-listed species, and others that may be declining (e.g., Cooper's hawk, sharp-shinned hawk, brown creeper, black-billed cuckoo, cerulean warbler, yellow-bellied sapsucker, green salamander, seepage salamander, pigmy salamander, Tellico salamander, and zigzag salamander).
  - Next, conduct surveys to understand current status of species believed to be more common, from which we can measure future population changes. Examples of such species include: Swainson's warbler, silver-haired bat, long-tailed weasel, woodland jumping mouse, eastern mole, smoky shrew, masked shrew, spotted salamander, marbled salamander, ravine salamander, eastern hognose snake, and eastern smooth earthsnake.

- **Monitoring** – Protocols and procedures developed during surveys for these various taxa should subsequently provide a means to convert from a baseline survey mode, to a long-term population trend monitoring mode at all times of the year. Long-term population trend monitoring will be critical for planning conservation measures, setting goals, and measuring achievements. In addition, other monitoring systems and protocols for certain taxa (i.e., MAPS or BBS) may need to be enhanced such that species not covered by current efforts receive special attention.
- **Research** – In addition, priority research topics for cove hardwood associated species currently envisioned include:

  Genetics
  - Green salamander movement/habitat use and genetics studies.

  Habitat
  - Habitat use studies for certain bird species (especially cerulean warbler and yellow-bellied sapsuckers).
  - Studies of bird, amphibian, and vegetation responses to gap management or specific timber harvest regimes (e.g., cerulean warbler, Swainson's warbler, yellow-bellied sapsucker, and various plethodontid salamanders).

  Population demographics
  - Studies of neotropical migrant birds to get information on demographics through nest searching spot mapping, telemetry.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

As with all of our habitats, human population growth and its associated development is consuming or altering cove hardwood habitat rapidly. We must continue to add to our base of conservation ownership for future generations of the wildlife species associated with the habitat, as well as the use and enjoyment of them by future generations of North Carolinians.

Additional conservation measures that need to be considered will grow out of the research, survey, and monitoring mentioned above, however measures can be pursued now to help achieve both research and conservation goals regarding understory development and gap management. With the vast majority of cove hardwood habitat in mid successional stages, efforts should be directed towards increasing older age classes of cove hardwoods by both lengthening harvest rotation recommendations for timberland owners, and exploring whether we can mimic old growth gap dynamic conditions through selective harvesting techniques in mid-late successional cove hardwood stands. These and other measures to promote the development of diverse understory, particularly in acidic coves, should be pursued.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2):440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Petranka, James W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC.

Rosenberg, K.V., R.S. Hames, R.W. Rohrbaugh, Jr., S.Barker Swarthout, J.D. Lowe and A.A. Dhondt. 2003. A land manager's guide to improving habitat for forest thrushes. The Cornell Lab of Ornithology.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

U.S. Forest Service (USFS). 2001. Management indicator species habitat and population trends – Nantahala and Pisgah National Forests. Draft internal document. U.S. Department of Agriculture, Forest Service, National Forests in North Carolina, Asheville, NC.

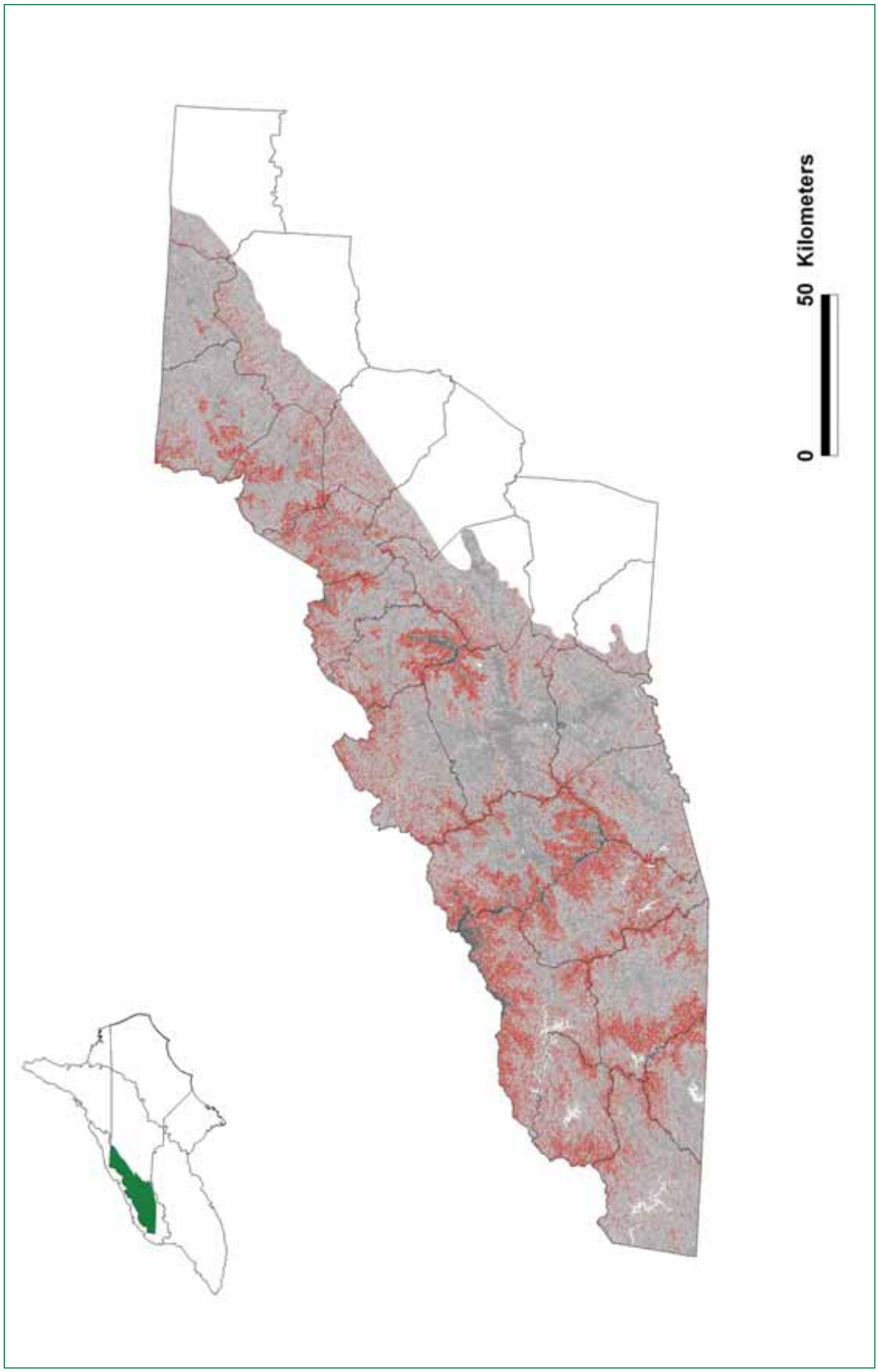


Figure 5A.3. Cove forests in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

Southern Blue Ridge Ecoregion

4. **Early successional habitats** – Early successional mountain habitats may range from relatively ancient grassy balds on or adjancent to broad ridgetops (containing a variety of unique grass and herb species) to shrub-dominated heath balds (alder, rhododendron and mountain laurel are common dominant species) to lower elevation fields, meadows, pastures, and clear cuts resulting from agriculture or forestry activities. Human influences, herbivore grazing, and environmental factors such as topographic position, climate, and natural fires have all played a role in the creation and maintenance of montane early successional areas. Grassy balds seem to have arisen in response to climatic and animal influences in the late Pleistocene and have been maintained by wild herbivores and, since the 1840s, by domestic livestock (Weigl and Knowles 1999). The balds support unique plant species and communities and many rare animal species (often with northern affinities) found nowhere else in the Southeast. They are also important stop-over habitats for migrating birds. Heath balds, resulting from fire, cutting, or other disturbances, are often invaded by forest and support only a few specialized vertebrates (e.g., alder flycatcher). The remaining open grassy areas are basically montane "old fields" which have occasionally been invaded by bald species but generally are either in agricultural use or have been abandoned to forest. All of these habitats have been modified by human activity and all are subject to natural succession once controlling mechanisms—such as grazing or cutting- have been eliminated. Without management—the return of the management factors—natural succession will limit the longevity of these habitats and their dependent plant and animal species.

   Though many montane early successional habitat types support species uniquely dependent on them, other types provide little benefit to plant and animal species, especially those patches of small size, and thus could only be considered marginal wildlife habitat at best. These kinds of places generally reflect human use and activity as the primary goals of their management and include a number of places such as large lawns, monoculture hayfields, golf courses, residential development and even urban development. While each of these areas may support a limited amount of food and other habitat requirements of certain wildlife species, the array of both plant and animal species utilizing them is quite limited, and therefore they are not considered high quality early successional wildlife habitats. They may, however, play a role in the overall landscape scale habitat selection process of certain early successional species, provide transitional habitats, or provide habitat for a limited number of other species. Therefore, in a general sense or at a large scale, they can be included as part of the overall early successional habitat matrix, though most of the priority early successional species require a more diverse plant community than is often provided at these kinds of sites.

A. Location and condition of habitat (see Map 5A.4):

Because early successional habitat can include many different kinds of areas, from grassy balds to agricultural areas and recently harvested forest stands, the amount and distribution of it is constantly changing. However, a recent estimate indicated that roughly 70% of the southern Appalachian landscape (Southern Appalachian Assessment data from SAMAB 1996) is covered in forest. Therefore, 30% is non-forest condition, including semi-permanent early successional habitat such as grassy balds, heath balds, and old fields. The majority portion (26%) of that estimate was types of early successional plant communities that may, but most often do not provide quality wildlife habitat such as developed areas, agricultural areas, and water. In fact, Hunter et al. (1999) estimate that the amount of semi-permanent early successional bird habitat in the Southern Blue Ridge region (which is mostly western North Carolina) is probably much less than in other parts of the Southern Appalachian Assessment area. Their estimate was that approximately 1% of the Southern Blue Ridge is comprised of semi-permanent early successional habitat like balds and old fields. Furthermore they estimate that less than 10% of the forests in the region are in early successional stages.

Regardless of how it is measured, high quality early successional wildlife habitat in the mountains of western North Carolina is limited and may be declining as a percentage of the landscape due to numerous factors. The declines of grassland bird species for example is attributed to not only actual loss of habitat but also degradation of remaining tracts because of improper or inadequate management and encroachment of exotic vegetation, as well as fragmentation of habitat patches into small isolated units (Johnson and Igl 2001).

Priority species associated with montane early successional/grass bald habitat:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Ammodramus savannarum*	Grasshopper Sparrow	
	Caprimulgus vociferus	Whip-poor-will	
	Chordeiles minor	Common Nighthawk	
	Colinus virginianus	Northern Bobwhite	
	Dendroica discolor	Prairie Warbler	
	Dendroica pensylvanica	Chestnut-sided Warbler	
	Dolichonyx oryzivorus	Bobolink	
	Empidonax alnorum	Alder Flycatcher	SR
	Empidonax traillii	Willow Flycatcher	
	Eremophila alpestris	Horned Lark	
	Falco sparverius	American Kestrel	
	Icterus spurius	Orchard Oriole	
	Passerculus sandwichensis	Savannah Sparrow	SR
	Pooecetes gramineus	Vesper Sparrow	SR
	Scolopax minor	American Woodcock	
	Spizella pusilla	Field Sparrow	
	Sturnella magna	Eastern Meadowlark	
	Tyrannus tyrannus	Eastern Kingbird	
	Tyto alba	Barn Owl	
	Vermivora chrysoptera	Golden-winged Warbler	SR
	Vermivora pinus	Blue-winged Warbler	SR
Mammals	*Microtus chrotorrhinus*	Rock Vole	SC
	Microtus pennsylvanicus	Meadow Vole	
	Mustela nivalis	Least Weasel	SR
	Sylvilagus obscurus	Appalachian Cottontail	SR
	Zapus hudsonius	Meadow Jumping Mouse	
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Eumeces anthracinus	Coal Skink	
	Opheodrys vernalis	Smooth Greensnake	SC
	Terrapene carolina	Eastern Box Turtle	

B. Problems affecting species and habitats:

There are a number of situations and conditions that have had, and continue to have a significant impact upon the availability, distribution, and quality of early successional habitat in the region. Some of them are natural processes such as succession, grazing (by native herbivores historically) and wildfire; others have been the result of gradual changes in human activities through history such as the progression from native American agriculture and land use practices, through early agricultural practices to modern agricultural practices. And finally, some of the conditions are the result of relatively rapid and large scale changes due to urban and rural development. Depending upon how the question is framed, each of these things can be a problem or challenge to the continued existence of quality early successional habitat in the region.

At least some grassy balds and heath balds are shrinking due to the effects of succession brought on by a lack of disturbance activities (NCNHP 2001). Agricultural practices have changed over time to favor "clean farming" practices including monoculture fields and pastures, limiting fallow field management, and minimal field borders and stream buffers. Invasive and exotic plan species also pose a major threat to early successional habitats, especially in riparian areas (e.g., tree of heaven, princess tree, Japanese stilt grass, oriental bittersweet, kudzu, privet). These species outcompete the native flora and ultimately reduce the quality and quantity of available early successional habitat. And finally, human development (residential, urban, etc.) in the region is essentially consuming and permanently removing wildlife habitat of all kinds. These and other political, social, and economic factors combine to pose a significant threat to the continued existence of early successional wildlife habitat in the region.

Besides problems associated with maintaining an adequate supply of quality early successional habitat in the region, there are a number of other problems faced by individual priority wildlife species including:

– Cowbirds present at low elevations (< 2500 feet) in disturbed areas (urban/suburban/agricultural) and potential impacts on songbird productivity
– Small isolated populations of some species (e.g., golden-winged warbler, alder flycatcher, rock vole), with greater potential for demographic, stochastic, and genetic impacts
– Appalachian cottontail displacement or dilution by eastern cottontails (Bunch, pers. comm.)

Many of the priority wildlife species are associated with particular landscape contexts, in addition to early successional habitats. In other words it is not enough to provide a small patch of early successional habitat surrounded by significant forested or developed areas. Populations of most bird species associated with grassland, shrub-scrub habitats and disturbed areas in forested habitats have declined steeply (Hunter et al. 2001). Most of the priority species of early successional habitat (e.g., grasshopper sparrow, vesper sparrow, orchard, prairie warbler, eastern meadowlark, meadow vole, meadow jumping mouse, etc.) are found in relatively open landscapes, or must have minimum amounts of early successional habitat in the area. This adds a level of complexity to the problem of maintaining an adequate supply of early successional habitat, in that the amount of habitat must be provided, but also in the proper sized patches and within the proper landscape context for it to be utilized by certain species.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Immediate efforts should be directed towards determination of the distribution and status of rare species or those believed to be declining (e.g., alder flycatcher, loggerhead shrike, savannah sparrow, vesper sparrow, golden-winged warbler, blue- winged warbler, rock vole, Appalachian cottontail, timber rattlesnake, and smooth greensnake). We currently lack baseline information on the distribution and status of most remaining priority species including whip-poor-will, willow flycatcher, American kestrel, common nighthawk, bobolink, horned lark (*breeding distribution*), dickcissel, least weasel, meadow jumping mouse, coal skink, and box turtle. Efforts to establish their current distribution and status are necessary to determine whether additional conservation measures will be necessary.

- **Monitoring** – After we have determined current distribution and baseline information on populations of the priority species, we must develop, adapt, or enhance long-term monitoring efforts for the entire suite of priority species associated with early successional habitats. For some taxonomic groups, monitoring efforts need to be expanded or enhanced. For example, additional Breeding Bird Survey routes or point counts may need to be established in selected areas or habitats and more attention paid to the migration period and wintering ecology of early succesional birds. Additional MAPS stations could also be beneficial, as well as migration banding stations. Monitoring protocols and procedures do not currently exist for mammals or reptiles on the priority list, so they will need to be developed.

- **Research** – Potential research questions abound regarding the numerous priority species in this habitat. Priority research includes the need to study golden-winged warbler population response to timber harvests of varying sizes and landscape contexts. For many bird species associated with early succession habitats (e.g., whip-poor-will, common nighthawk, prairie warbler, bobolink, willow flycatcher, loggerhead shrike, horned lark, vesper sparrow, dickcissel), we lack information about life history, breeding habits, and micro-habitat needs. Further research regarding the genetic status of Appalachian cottontails relative to eastern cottontails would also be important to shape conservation strategies for the species into the future.

  Research into the most effective and efficient measures to create, restore, and maintain quality early successional habitat (e.g., timber harvest, prescribed burning, mowing, herbicides, intermittent farming, grazing, etc.) needs to be emphasized, as well as understanding the differential impact that these strategies may have upon the wildlife species associated with early successional habitat. A final research recommendation concerns the study of rivercane (*Arundinaria gigantea*) in terms of its function and importance to wildlife as early successional habitat along floodplain areas.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

The highest priority conservation action for early successional habitats is to protect the sensitive grassy bald and heath bald habitat that are critical to numerous plant and animal species. However, most of those areas are now located upon conservation lands of state or federal agencies or conservation groups. Protection of those sites requires active management of them to ensure that they retain the characteristics necessary to sustain both the plants and animals they currently support. Secondarily, we must ensure an adequate sustained supply of quality early successional habitat through a combination of management strategies and appropriate practices including prescribed burning, timber harvest, grazing, herbicide use, or other practices) upon both public and private lands. Other important conservation measures to consider for early successional habitat include:

- Acquisition of conservation lands by management agencies/organizations (we need more *quality* early successional habitat, e.g., grass balds).
- Consider increasing the size of timber harvest areas where appropriate to support greater variety and density of early successional "area sensitive" species.
- Control of exotic species (e.g., red cedar, fescue, miscanthus, japanese spirea, tree of heaven, princess tree).
- Continue and enhance efforts to implement conservation measures upon private lands, through various programs and initiatives (e.g., Farm Bill programs, CURE, stewardship program, etc.).
- Additional monitoring of balds and bald edges, and increased management of balds (as is now going on in the Great Smoky Mountains, Roan Mountain, and Whitetop, Virginia).
- Protection of known rattlesnake dens.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2):440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Johnson, D.H., and L.D. Igl. 2001. Area requirements of grassland birds: a regional perspective. The Auk 118 (1): 24–34.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Pashley, D. N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the Land Birds of the United States. American Bird Conservancy, The Plains, VA.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

Weigl, P. D., and T. W. Knowles. 1999. Antiquity of southern Appalachian grass balds: the role of keystone megaherbivores. Pages 215–223 in R. P. Eckerlin, editor. Appalachian Biogeography Symposium. Virginia Museum of Natural History, special publication # 7.

Figure 5A.4. Early successional habitats (including agricultural areas)in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992). *Note: Due to the ephemeral nature of these habitats, this coveage may not be entirely accurate as of 2005. However, it should still give readers an indication of the extent of these habitats across the region.*

Southern Blue Ridge Ecoregion

5. **Dry coniferous woodlands** – This habitat type occurs on sites that are dryer than most mountain sites, including ridgetops, spur ridges, and along steep slopes, generally in the low to middle elevations below 3,500 feet on southern or western aspects. These sites contain shallow, often extremely acidic soils. Dry coniferous woodlands are variously referred to or include ecological communities such as pine-oak heath (Schafale and Weakley 1990) and southern yellow pine (Hunter et al. 1999, SAMAB 1996). Typically, lower elevation sites are dominated by Virginia or pitch pine, which is replaced near 3,000 feet with dominance by table mountain pine. Canopy species may include table mountain pine, pitch pine, Virginia pine, chestnut oak, Carolina hemlock, or white pine. In addition, a wide variety of hardwood trees are often dispersed throughout this habitat including scarlet and chestnut oak, hickories, sourwood, black gum, and sassafras. The understory is often very dense mountain laurel or rhododendron, though some sites, particularly those which have experienced recurring fires, support diverse understories of a wide variety of *Vaccinium* and other ericaceous shrubs and herbs (NCNHP 2001).

   Fire and other disturbances have played a critical role in the establishment, maintenance, composition and structure of dry coniferous woodlands. There is little doubt that frequent fires are necessary to sustain this habitat, and that in the absence of fire, these communities generally succeed into hardwood forest conditions (Hunter et al. 1999). Table mountain pine and table mountain/pitch pine stands in particular can only reproduce in a fire maintained system due to their serotinous cones and shade intolerance. The distribution and abundance of table mountain-pitch pine habitat will likely change with active management and restoration, the invasion of exotic organisms and the impact of forest decline agents (Williams 1998).

Priority species associated with montane dry coniferous woodlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Dendroica discolor	Prairie Warbler	
	Helmitheros vermivorous	Worm-eating Warbler	
	Loxia curvirostra	Red Crossbill	SC
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Sitta pusilla	Brown-headed Nuthatch	
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Eumeces anthracinus	Coal Skink	

A. Location and condition of habitat (see Map 5A.5):

Dry coniferous woodlands are widespread in the southern Appalachians as a whole, however they are more common in the ridge and valley and Cumberland Plateau physiographic regions than in the Southern Blue Ridge of western North Carolina. The Southern Appalachian Assessment reported over 3.7 million acres of southern yellow pine forest throughout the entire southern Appalachian region (SAMAB 1996). However, within the Southern Blue Ridge portion (mostly NC, with small amounts of TN, GA, and SC), Hunter et al. (1999) report only 650,000 acres. The US Forest Service estimates only 31,000 acres of southern yellow pine forest on the Pisgah and Nantahala National Forests of Western North Carolina (USFS 2001). Owing to the relatively low elevations occupied by dry coniferous forests in the region, significant ownership of this habitat occurs in western North Carolina upon state owned lands (Thurmond-Chatham, South Mountains, and Green River Game Lands; South Mountains State Park; Dupont State Forest). Most of the dry coniferous woodland habitat occurs in the foothills region, or in the far western counties (e.g., Cherokee and Clay counties).

With respect to the condition of dry coniferous forest in western North Carolina, it can only be characterized as quite variable. Because of the relationship between fire and other disturbances and the maintenance of this habitat, some sites are relatively open woodlands; others are densely packed with understory shrubs and succeeding into hardwood forest. In general, most are middle aged stands. There are examples of both older and younger age classes represented across the landscape, and there are also particular areas managed more intensively with prescribed fires though such areas are not common relative to the amount that is not actively managed.

B. *Problems affecting species and habitats:*

The most significant problem affecting dry coniferous forests in North Carolina is the lack of regular fires needed to maintain and reproduce this habitat type. Fire suppression, or the inability to use fire as a management tool, is resulting in a decline in both quantity and quality of this habitat. Not only will these forests not be able to reproduce themselves without fire, but those stands which are not regularly burned often develop dense mountain laurel/rhododendron understories that shade out other shrubs and herbaceous plants, thus lowering the habitat quality and diversity of wildlife which could utilize the area. Another general problem associated with dry coniferous forest is the southern pine beetle. Beetle outbreaks can have significant impacts upon this habitat type, killing the dominant pine overstory. However, southern pine beetles are a native insect and periodic outbreaks are a natural occurrence. What makes pine beetle outbreaks detrimental to the habitat is often the lack of fire after an outbreak leading to the development of dry hardwood habitats and thus the loss of the coniferous habitat.

Additional problems faced by individual species associated with dry coniferous forest include the lack of early successional habitat of this type or conversion of this habitat to other pine habitat (i.e. white pine) for species such as prairie warblers, woodpeckers, and nuthatches. Timber rattlesnake persecution in these habitats also remains a significant threat. And again, lack of management of the stands decreases the quality of habitat for woodland hawks by decreasing prey abundance and limiting their ability to hunt in dense understory growth.

As with all habitats, human development is rapidly decreasing the availability of this habitat across the region. Not only are we losing the habitat to development, but development in or adjacent to these sites leads to a significant problem with respect to managing these habitats with prescribed fire. Even where dry coniferous forest management could occur, we are often limited in our abilities to use fire as a management tool, due to the proximity of residential or other development.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – For all of the priority species associated with dry coniferous woodland, we need to intensify efforts to establish our knowledge of their distribution and status, particularly species for which broad scale monitoring (e.g., BBS for birds) has not provided adequate information, such as: brown-headed nuthatch, red-headed woodpecker, prairie warbler, Cooper's and sharp-shinned hawks, coal skinks, timber rattlesnakes..
- **Monitoring** – Monitoring protocols and procedures need to be developed or refined that will allow us to measure population trends of the priority wildlife species, as well as the health and distribution of this relatively rare habitat through time.
- **Research** – Research needs to continue on topics including efficient and effective means to manage and improve the quality and quantity of dry coniferous forest, with a particular eye towards techniques that are applicable in our developing landscape (e.g., *in the absence of fire, either as a natural event or as a management tool, what other means might be available to sustain this habitat across the landscape?*).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Besides research, surveys, and monitoring of the species and the habitat, two major conservation actions need to be pursued. First, we must protect as much of this habitat as possible from conversion to other habitats or from outright loss to human development. Acquisition for conservation ownership should be a high priority, as should the development and implementation of voluntary measures to conserve and manage dry coniferous forest on private lands. This can be pursued through existing or new programs to promote maintenance and appropriate management of this habitat on private lands (e.g., Farm Bill programs and other landowner incentive programs such as the Forest Landbird Legacy Program, or stewardship forestry). And second, we must do everything possible to promote appropriate management of dry coniferous forest on public land through increased use of prescribed fire as a management tool. Prescribed burning is necessary to promote understory development, as well as maintain overall habitat quality and function..

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

Williams, C.E. 1998. History and status of table mountain pine-pitch pine forests of the Southern Appalachian Mountains. Natural Areas Journal 18(1):81–88.

U.S. Forest Service (USFS). 2001. Management indicator species habitat and population trends – Nantahala and Pisgah National Forests. Draft internal document. U.S. Department of Agriculture, Forest Service, National Forests in North Carolina, Asheville, NC.

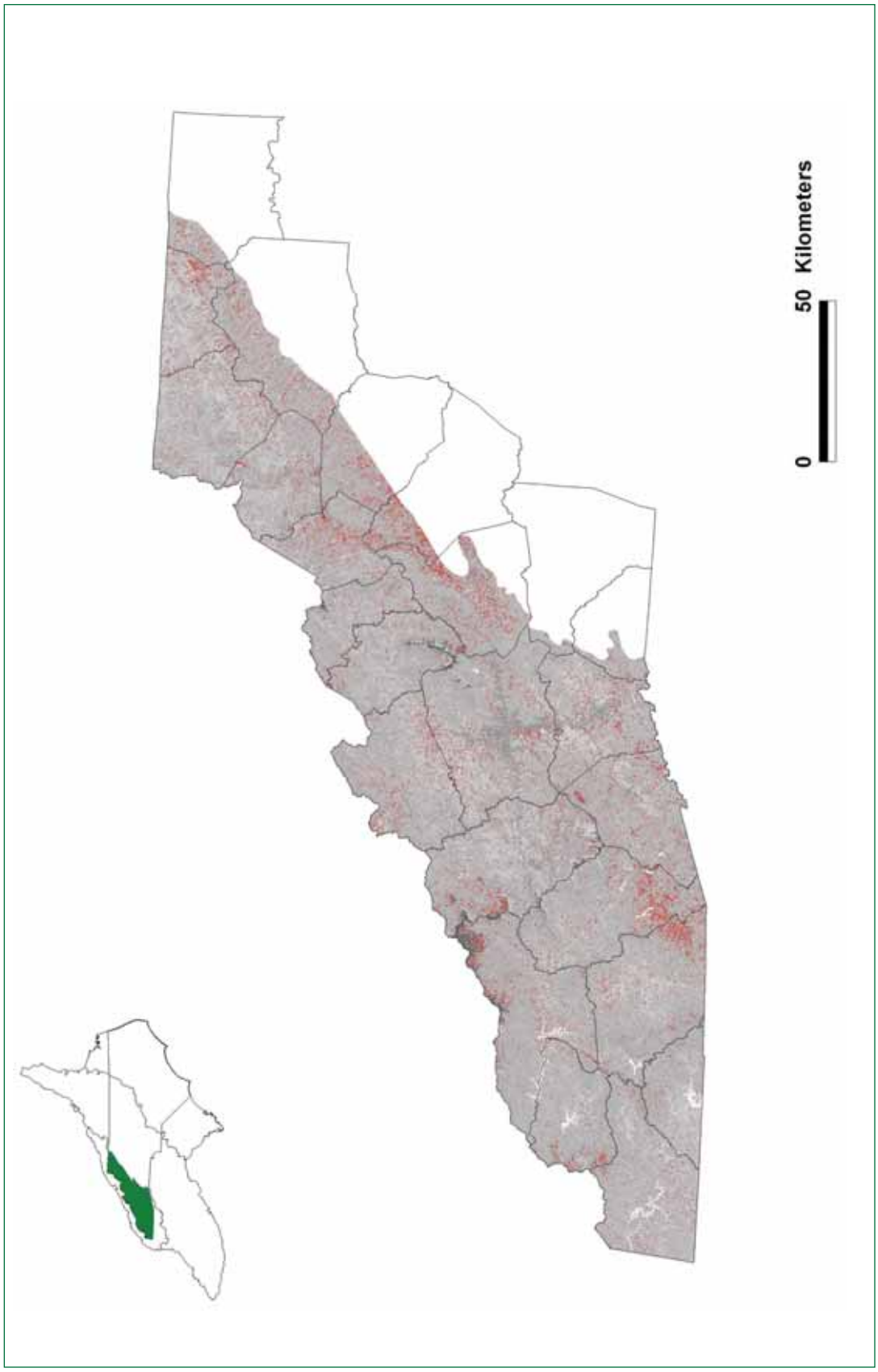


Figure 5A.5. Dry coniferous woodland habitats habitats in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

6. **Oak forest (including mixed hardwoods and pine)** – Oak dominated forest is the most widespread and heterogenous habitat of the Mountain Region of North Carolina, and throughout the Southern Blue Ridge ecoregion on relatively dry slopes and ridges. This habitat is a complex mix of numerous ecological community types including: high elevation red oak, montane white oak, chestnut oak, montane oak-hickory, dry oak-hickory, dry-mesic oak-hickory, basic oak-hickory, pine-oak heath, and mesic mixed hardwood (Schafale and Weakley 1990). Other classification systems differentiate this habitat into categories such as oak-dominated forests and mixed pine-hardwood forests (Hunter et al. 1999). This habitat includes a range of moisture and topographic gradients, from dry to mesic and from the Piedmont to some of the highest mountain ranges. The driest sites are dominated by chestnut oak and/or scarlet oak, often with an understory of sourwood, black gum, and red maple. Montane oak-hickory forests, one of the most abundant ecological community types of this habitat, contain a mixture of oak species (often white oak dominates). Hickories may be present, and the understory/shrub layer vegetation is often quite diverse, supporting species such as flowering dogwood, flame azalea, and huckleberries. Red oak forests may dominate at medium to high elevations (most common community on high mountains) and on ridgetops where spruce-fir and northern hardwoods are absent or adjacent (NCNHP 2001).

   The importance of oak forest to wildlife of the region cannot be overstated, due to the overwhelming predominance of the habitat across the landscape, the variety of conditions encompassed, and the mast production capacity of this habitat. By virtue of the production of vast quantities of acorns, hickory nuts, and a wide variety of soft mast associates, the wildlife food production capacity of oak forests is immense. Coupled with the sheer amount of this habitat available, these factors make oak forests one of the most important habitats of the region to a significant variety wildlife species.

A. Location and condition of habitat (see Map 5A.6):

As a result of the variety of ecological classifications of this habitat, it is difficult to accurately assess the availability of this habitat in the state or region. The Southern Appalachian Assessment ascribed over 17.5 million acres in the seven states covered by their assessment (VA, KY, TN, NC, SC, GA, AL) to oak or mixed oak-pine categories (SAMAB 1996). Hunter et al. (1999) went further in classifying over 5 million acres of the Southern Blue Ridge physiographic province (including parts of VA, TN, NC, and GA, though the majority in NC) as the combination of oak dominated forests and oak-pine mixed forests.

The US Forest Service has utilized several classification systems and techniques to assess availability of a variety of forest types on their holdings within western North Carolina. Out of approximately 1 million acres in Forest Service holdings on the Pisgah and Nantahala National Forests, utilizing Continuous Inventory of Stand Condition data, they have estimated over 500,000 acres of upland hardwood and mixed pine-hardwood habitat; and ecological modeling conducted by the Forest Service estimated over 600,000 acres of various oak and mixed oak-pine habitats on the same two national forests (USFS 2001). Regardless of the specific classification system or boundaries employed, it is clear that oak dominated forests are the predominant forest habitat of the mid- and lower elevation mountains of western North Carolina.

Information regarding the condition of oak forest in the region is less readily available. Because oak forest is so common on both public and private lands, coupled with a variety of other factors (geographic, topographic, micro-climatic, etc.), this habitat has been subjected to a wide variety of natural and anthropogenic stresses which have shaped its current distribution and condition. The loss of American chestnut as a component of the landscape, development patterns, historic demands for timber products, fire suppression and a variety of other conditions have brought us to the current condition of oak forests today. Hunter et al. (1999) indicate that over half of the available oak forest habitat is currently in mid-late successional stages, with a very small proportion in early successional stages. The US Forest Service estimates that on the Pisgah and Nantahala National Forests, over 89% of upland hardwood and mixed pine-oak stands are more than 60 years old (USFS 2001). Extrapolating from these figures, the vast majority of oak forest on public lands of western North Carolina is currently in older age classes, though the percentage of older age classes on private lands in the region is smaller due to more active timber management strategies on private lands, but remains a majority nonetheless.

Priority species associated with montane oak & mixed hardwoods/pine forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Caprimulgus vociferus	Whip-poor-will	
	Certhia americana	Brown Creeper	SC
	Coccyzus americanus	Yellow-billed Cuckoo	
	Coccyzus erythropthalmus	Black-billed Cuckoo	SR
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Dendroica cerulea	Cerulean Warbler	SR
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Oporornis formosus	Kentucky Warbler	
	Pheucticus ludovicianus	Rose-breasted Grosbeak	
	Picoides villosus	Hairy Woodpecker	
	Poecile atricapilla	Black-capped Chickadee	SC
	Sphyrapicus varius	Yellow-bellied Sapsucker	SC
	Vermivora chrysoptera	Golden-winged Warbler	SR
	Wilsonia canadensis	Canada Warbler	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Mustela frenata*	Long-tailed Weasel	
	Mustela nivalis	Least Weasel	SR
	Parascalops breweri	Hairy-tailed Mole	
	Scalopus aquaticus	Eastern Mole	
	Sciurus niger	Eastern Fox Squirrel	SR
	Sorex cinereus	Masked Shrew	
	Sorex fumeus	Smoky Shrew	
	Sorex hoyi winnemana	Southern Pygmy Shrew	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Aneides aeneus	Green Salamander	E
	Desmognathus aeneus	Seepage Salamander	SR
	Hemidactylium scutatum	Four-toed Salamander	SC
	Plethodon aureolus	Tellico Salamander	SR
	Plethodon chattahoochee	Chattahoochee Slimy Salamander	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Plethodon longicrus	Crevice Salamander	SC
	Plethodon richmondi	Southern Ravine Salamander	SC
	Plethodon ventralis	Southern Zigzag Salamander	E
	Plethodon wehrlei	Wehrle's Salamander	T
	Pseudacris brachyphona	Mountain Chorus Frog	SC
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Pituophis melanoleucus melanoleucus	Northern Pinesnake	SC
	Terrapene carolina	Eastern Box Turtle	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

B. Problems affecting species and habitats:

With regard to oak forest habitat, three main categories of problems currently recognized include habitat loss, insects and/or diseases, and inappropriate management. Specifically, these include the following historic and ongoing problems:

- Loss or conversion of habitats (e.g., due to human development, agriculture).
- Increased development leading to greater degrees of habitat fragmentation.
- Amphibian species impacted by loss of embedded ephemeral pool habitats.
- Chestnut blight, oak decline, gypsy moths, and other diseases/pests may significantly affect the composition and diversity of hardwood stands throughout the Southern Appalachians.
- Fire suppression is a major factor affecting species diversity and richness, also affecting the composition, structure and diversity of hardwood stands throughout the Southern Appalachians.
- Homogeneity of stand age has resulted in decreasing habitat for bird species that rely on diverse understory development (lack of understory development).

Individual species associated with oak forest habitats may be experiencing problems other than those listed above that are not necessarily associated with oak forest habitat. Timber rattlesnakes and other snake species are subjected to persecution. Many species (e.g., cerulean warbler, black-capped chickadee, green salamander, seepage salamander, crevice salamander, Wehrle's salamander, northern pine snake) have such a small range or clumped distribution within North Carolina that they are more susceptible to stochastic or genetic population declines or local extirpations. Many neotropical migrant birds may also be experiencing winter range habitat loss. And finally, since there is such abundance and diversity of species associated with oak forests, we may not know the exact habitat or life history requirements of individual species that are limiting factors to their population stability.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys**
  - Priority goes to gathering baseline information regarding the current distribution and status of oak forest associated species that are rare or declining (e.g., sharp-shinned hawk, cerulean warbler, black-capped chickadee, black-billed cuckoo, golden-winged warbler, eastern fox squirrel, green salamander, seepage salamander, four-toed salamander, Tellico salamander, crevice salamander, southern zigzag salamander, Wehrle's salamander, mountain chorus frog, timber rattlesnake, northern pine snake).
  - Next, expand surveys to include species for which we know very little about current status and distribution (e.g., whip-poor-will, Cooper's hawk, weasels, moles, shrews, bats, certain salamanders, and reptile species such as the box turtle).
  - Finally, compile, store and synthesize information about the status and distribution of more common species, developed through those approaches or other efforts.

- **Monitoring** – Monitoring efforts need to be established for numerous species groups for which no current framework exists. For many species groups (e.g., amphibians, reptiles, mammals), no current efforts are focused upon determination of population trends. Procedures and protocols must be developed that will allow us to determine whether populations of all of these animal groups are increasing or decreasing as a result of habitat changes through time. In addition to establishment or expansion of monitoring efforts at all times of the year for wildlife species associated with oak forest, we must work towards a consistent, comprehensive approach to monitoring the health, distribution, and availability of oak forests themselves. Knowing what the trends are for the habitat will be critical to understanding the dynamics of wildlife populations which depend upon them.

  - Expand monitoring frameworks to account for species that are not suited to traditional long-term monitoring protocols (e.g., hawks, goatsuckers, owls), or for species missed under systematic monitoring due to small population sizes or limited ranges in North Carolina (e.g., brown creeper, cerulean warbler, black-capped chickadee).

– Track oak habitat trends (e.g., rate of loss or conversion of the habitat and disease or pest affects) and consider trends in the development of long-term monitoring strategies for oak forests of the region.

- **Research** – Because the list of species associated with oak forest habitat is so broad, the potential research topics are innumerable. However, priority research efforts include:

Genetics

– Initiate genetic and morphological studies to clarify taxonomic status of numerous birds and amphibians (e.g., high elevation birds, plethodontid salamanders)

Habitat

– Conduct life history and habitat use research on northern pinesnake.
– Conduct habitat use studies of neotropical migrants (e.g., cerulean warbler, black-capped chickadee, many others) using telemetry.
– Conduct habitat use and life history studies for bat species that may potentially use this habitat (e.g., hoary, silver-haired, eastern small-footed, northern bats)
– Study population responses of plant and wildlife species to habitat manipulations (e.g., large scale prescribed burning, oak savannah creation, canopy gap creation, etc.)
– Conduct green salamander movement studies either around embedded rock outcrops or between rock outcrops

Other

– Establish studies to determine both direct and indirect impacts of pest control measures upon oak forest dependent species (e.g., *What is the impact of gypsy moth control strategies upon local and landscape scale wildlife populations? Upon invertebrates that serve as food for vertebrates?*)

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Because oak forest habitat remains abundant and widespread, the most critical conservation activities revolve around gathering information about the wildlife species that utilize it and the habitat itself. We do not face the imminent threat of loss of the habitat as a whole, and therefore we must learn as much as possible about the species, the habitat, and their inter-relationships in order to develop concentrated strategies to both protect the most critical areas, and properly manage those under conservation protection. We cannot protect all oak forest in western North Carolina from loss or perturbation. We must understand what the most critical components are both ecologically and with respect to wildlife groups or species, and develop strategies to conserve and manage them. We must also recognize opportunities to act as soon as possible to protect landscape scale oak forests through both acquisition and other protection measures (voluntary incentives, cooperative agreements, easement programs) focused upon large tracts that will preclude future fragmentation or promote connectivity between existing conservation ownerships.

Within the land management realm, we must foster efforts to understand and implement appropriate management techniques (e.g., prescribed fire or thinning) for the benefit of the broadest array of oak forest dependent wildlife, while taking into account specific needs of wildlife with more restrictive requirements (Artman and Downhower 2003, Ford et al. 2000). We must encourage both study and dissemination of information about the impacts (both positive and negative) of various management strategies upon oak forest wildlife species. We must continue to pursue appropriate management of existing conservation lands including the use of prescribed burning to diversify structure and composition of forest understory, and other silvicultural techniques to promote regeneration, provide an array of age class and structural composition, and promote long-term economic sustainability of Appalachian oak forests. Changes in the Southern Appalachian landscape have reduced populations of some early successional birds that require disturbance and proper management in largely forested areas may be required to meet the needs of the wide array of wildlife (Marzluff et al. 2000, Klaus and Buehler 2001).

Supporting References

Artman, V.L., and J.F. Downhower. 2003. Wood thrush (Hylocichla mustelina) nesting ecology in relation to prescribed burning of mixed-oak forest in Ohio. The Auk 120(3):874–882.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Ford, W.M., M.A. Menzel, T.S. McCay, J. W. Gassett and J. Laerm. 2000. Woodland salamander and small mammal responses to alternative silvicultural practices in the Southern Appalachians of North Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 54:241–250.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Klaus, N.A. and D.A. Buehler. 2001. Golden-winged warbler breeding habitat characteristics and nest success in clearcuts in the Southern Appalachian Mountains. Wilson Bulletin 113(3):297–301.

Marzluff, J.M., M.G. Raphael and R. Sallabanks. 2000. Understanding the effects of forest management on avian species. Wildlife Society Bulletin 28(4):1132–1143.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

U.S. Forest Service (USFS). 2001. Management indicator species habitat and population trends – Nantahala and Pisgah National Forests. Draft internal document, U.S. Department of Agriculture, Forest Service, National Forests in North Carolina, Asheville, NC.

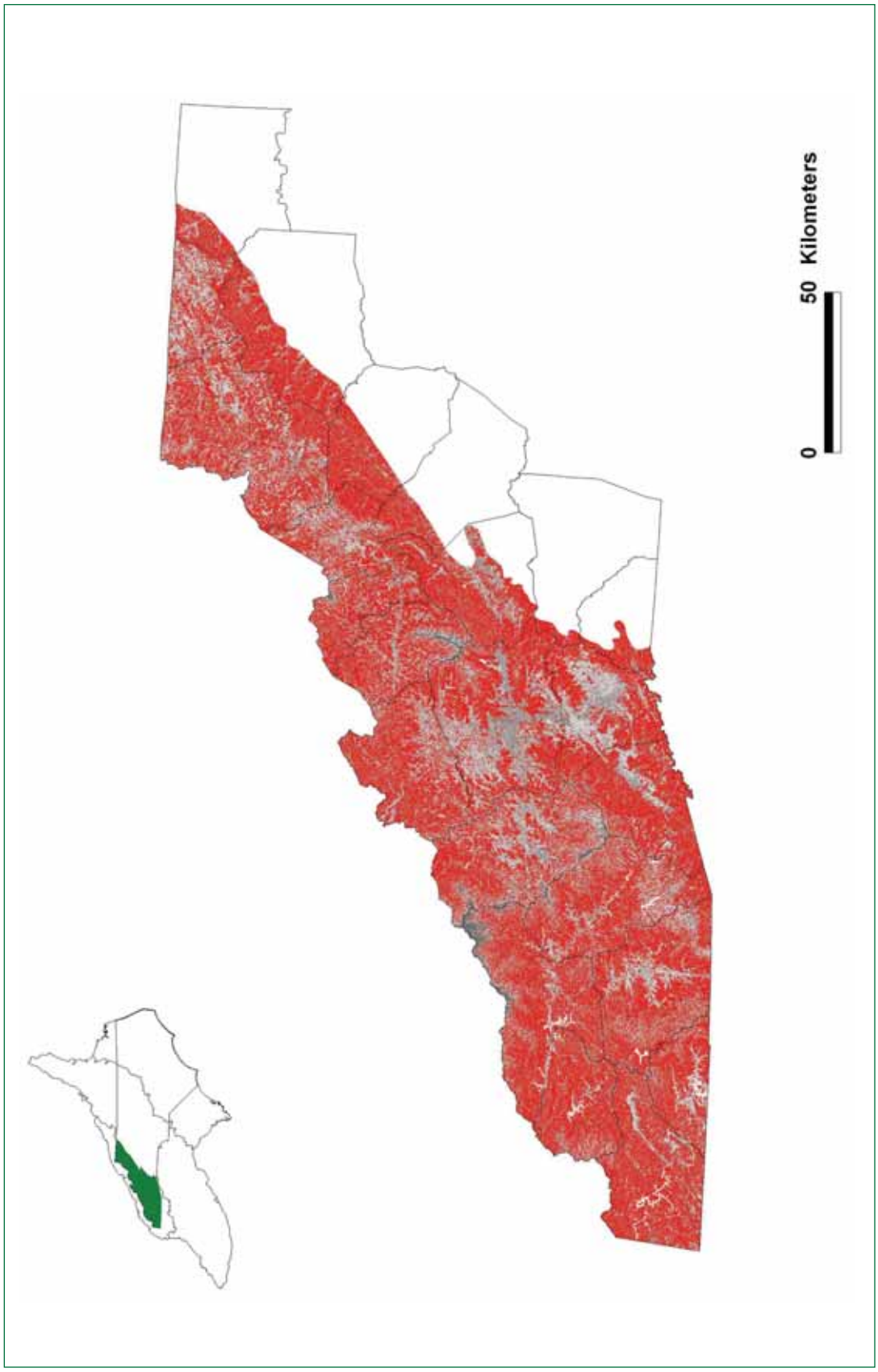


Figure 5A.6. Oak forest and mix hardwoods/pine habitats in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

Southern Blue Ridge Ecoregion

7. **High elevation rock outcrops** – High elevation rock outcrops are quite limited across the North Carolina landscape, however they are quite variable in terms of both geological and ecological condition. This habitat includes many distinct natural communities defined by Schafale and Weakley (1990) including boulderfield, rocky summit, granitic dome, acidic cliff, and mafic cliff, as well as some specific habitats less well defined or occurring within the context of other forest types including rock outcrops and talus slopes. In general they are found on ridgetops, peaks, and upper slopes where soils are thin and rock dominates the surface. We have not defined a lower elevation limit for this habitat type because there is extensive overlap between the plant community, animal community, and the physical condition of this habitat and the low elevation cliff/rock outcrop habitat. While high elevation rock outcrop habitat and low elevation cliffs/rock outcrops support many of the same animals and plants, there are species of both plants and animals that are found exclusively at high elevation rock communities (e.g., rock vole, long-tailed shrew, Allegheny woodrat, and several rare plant species), and others found only in low elevation cliffs/rock outcrop habitat (e.g., southern Appalachian woodrat, spotted skunk, crevice and Southern zigzag salamanders). The elevation limit for each of these species varies, but clearly there is a distinction between the animal assemblage at rock habitats that is dependent upon elevation.

   In general high elevation rock outcrops are open canopy communities with patchy vegetation due to variability in soil depth. Lichens and mosses occur on bare rock and other vegetation may develop in deep moss mats or crevices (oatgrass species, sedges, mountain dandelion). Woody plants or trees such as mountain laurel, Catawba rhododendron, table mountain pine, red spruce, and yellow birch may occur in the deepest soil mats, rock crevices, and at the edge of these habitats. Many rare plant species are associated with high elevation rock outcrop habitats. Certain high elevation rock outcrop habitats can occur within a forested setting (e.g., boulderfields within northern hardwood forests or small rock outcrops within any forest habitat) (NCNHP 2001).

Priority species associated with high elevation rock outcrops:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Falco peregrinus*	Peregrine Falcon	E
Mammals	*Microtus chrotorrhinus*	Rock Vole	SC
	Neotoma magister	Allegheny Woodrat	SC
	Sorex dispar	Rock Shrew	SC
Amphibians	*Aneides aeneus*	Green Salamander	E
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Eumeces anthracinus	Coal Skink	

A. Location and condition of habitat[1]:

There is no current assessment available which characterizes the availability or distribution of the high elevation rock outcrop habitat. Owing to the small size, the dispersed nature, and the variability of types of this habitat, we have no means to determine the amount of it available, nor map where it occurs. However, it is certainly one of the most limited habitats in the state in terms of area, and also widely distributed throughout the mountains. High elevation rock outcrops obviously occur only in the highest mountain ranges of western North Carolina, notably in the Great Smokies, Plott Balsams, Great Balsams, Black/Craggy Mountains, Grandfather Mountain, Roan Mountain, and in the Amphibolite mountains of Ashe County. However, depending upon elevation, they can be found scattered just about anywhere that elevations allow. As with its distribution and abundance, we have no current means to assess the current condition of high elevation rock outcrop habitat across the region.

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

Conditions vary, and each site can have a unique set of problems depending upon land ownership, historic uses, and a host of other potential variables that can affect the availability and use of a particular site by various animals. Many, but by no means all of the high elevation rock outcrop sites are found on conservation lands owned by the US Forest Service, National Park Service, and or The Nature Conservancy.

B. *Problems affecting species and habitats:*

High elevation rock outcrop habitats can be affected by numerous activities and situations, the exact nature of which remain specifically undetermined. Recreational activities such as hiking and rock climbing can have deleterious effects upon the plants and animals associated with the habitat as a result of trampling, habitat alteration, or even presence of people or human activities at or near the sites. Development (primarily housing) can and certainly has had an impact upon both the habitat as well as the species utilizing it. There has been suggestion that air pollution could be having an impact upon the high elevation rock communities of western North Carolina (TNC and SAFC 2000), however there has not been definitive evidence of air pollution impacts upon wildlife species associated with high elevation rock outcrops. However, each site can have a somewhat unique set of problems particular to it, ranging from almost no impact to a high degree of impact. Common threats across the range of high elevation rock outcrops include:

– Recreational activities (climbing and trampling) can have significant impacts upon both the physical characteristics of the site, as well as disrupting behavior patterns of particular wildlife species.
– Development (both recreational development and housing development in particular locations have, and continue to cause direct habitat loss and indirect impacts upon wildlife species dependent upon them).
– Intrusion by alder, rhododendron and other woody plants causing rock outcrops to become overgrown.

Individual wildlife and plant species can be affected by the problems mentioned above, however they may also face additional threats specific to either their particular location or the species itself. For example, timber rattlesnakes face threats in addition to habitat loss including being subject to collection, disturbance of hibernacula/gestation sites, and persecution. There has been considerable effort undertaken in the northeastern United States to determine the impact upon Allegheny woodrat populations from a roundworm parasite that may have impacted populations in that region (McGowan 1993, Stone et al. 1993), though no studies have been conducted within North Carolina to assess the level of threat posed to North Carolina woodrat populations. The decline of peregrine falcons during the last half of the 20th century has been widely attributed to the use of DDT and its concomitant effects on bird reproduction. The use of DDT was banned and peregrine restoration efforts occurred in the late 1980's and 1990's, however peregrine falcons still face threats due to habitat loss to development and recreation impacts at individual cliff sites. Furthermore, the North Carolina population remains at fairly low density, thereby increasing the threat of stochastic events having significant population impacts.

For many plant and animal species associated with high elevation rock outcrops we may not currently know the entire spectrum of threats that are affecting populations due to inadequate levels of study or knowledge. For example, green salamander populations in North Carolina may have experienced dramatic declines during the late 1970's and early 1980's (Wilson 2001). Various theories were promulgated to explain the apparent decline including impacts of air pollution, deforestation, development, disease, and over-collection (see Wilson 2001 for discussion), however there is no definitive cause for the apparent decline, and in fact, we do not really know if an overall population decline occurred or whether isolated impacts upon particular sites caused local declines. There remain many unknown problems which can and will impact high elevation rock outcrop communities and their fauna.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**

– Prioritize surveys for rock shrew, rock vole, coal skink, and timber rattlesnake.

- **Monitoring** .
  - Continue monitoring for green salamander, Allegheny woodrat, and peregrine falcon populations.
  - Initiate long-term monitoring (when baseline surveys permit) for the species mentioned above (rock shrew, rock vole, coal skink, timber rattlesnake).
- **Research**
  - Examine peregrine falcon productivity, contaminant effects (per US Fish & Wildlife Service monitoring plan, 2003), and juvenile dispersal (using satellite telemetry).
  - Examine green salamander habitat use/movements and genetic relationships within/between populations.
  - Examine parasite (*Baylisascaris*) prevalence in Allegheny woodrats.
  - Explore better ways to identify the distribution and characteristics of this habitat across the landscape.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

High elevation rock outcrops are extremely rare, have a very restricted range, and are subject to extreme environmental conditions. All existing habitats of this type should be high priorities for conservation action including:

- Habitat protection site management – closure of sensitive areas at certain times or permanently to stop direct (trampling, loss of habitat to recreation developments (trails, vistas, etc.) and indirect human impacts (disturbance).
- Maintenance of biologically significant areas, including peregrine falcon nesting areas, reptile den sites and significant salamander occurrences.
- Easements and land acquisition (potential for partnerships with NC Natural Heritage Program, The Nature Conservancy, and the NC Plant Conservation Program) to protect from long term impacts such as housing development.
- Management of outcrops to reduce intrusion by alder, rhododendron, and other species, which contributes to the disappearance of some vertebrates.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

McGowan, E. M. 1993. Experimental release and fate study of the Allegheny woodrat (*Neotoma magister*). New York Department of Environmental Protection. Federal Aid Project W-166-E; E-1, Job No. VIII-7.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Stone, W. B. , E. M. McGowan, and A. P. Hicks. 1993. The parasites and disease of the woodrat in New York State with special emphasis on the nematode *Baylisascaris procyonis*. Unpublished abstract from the report presented at the Allegheny Woodrat Conference. Dickenson College, PA.

The Nature Conservancy and Southern Appalachian Forest Coalition (TNC and SAFC). 2000. Southern Blue Ridge ecoregion conservation plan. The Nature Conservancy, Durham, NC.

US Fish & Wildlife Service (USFWS). 2003. Monitoring plan for the American peregrine falcon, a species recovered under the Endangered Species Act. US Fish & Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Pacific Region, Portland, OR.

Wilson, C. R. 2001. Status of the green salamander (*Aneides aeneus*) in the Blue Ridge mountains. Masters Thesis. Appalachian State University. Boone, NC.

8. **Low elevation cliffs/rock outcrops** – This habitat category includes areas that are characterized by exposed rock, sometimes supporting forest canopy, but often these areas are too steep or rocky to support a closed canopy. These habitats can be found in the Southern Blue Ridge, but also in some areas of the Piedmont. Often these areas contain patchy vegetation, reflecting the variability in soil depth and moisture content. Seepage may provide some moisture for mosses, lichens, and wetland vegetation. This habitat type contains many different types of communities defined by Schafale and Weakley (1990) including low elevation granitic domes and rocky summits, acidic cliffs, mafic cliffs, and some boulderfields. In addition, many of the wildlife species associated with low elevation cliffs and rock outcrops occur in association with rock outcrops dispersed throughout other forest or habitat types in patches too small to be considered discreet communities of their own.

   Many wildlife species utilize rock outcrop habitat without regard to arbitrary elevational distinction (e.g., peregrine falcon), and others will utilize only high elevation rock outcrop habitats (at least according to what we currently know, e.g., rock voles and rock shrews). However, many wildlife species and even more plant species (Schafale and Weakley 1990) are either associated with high elevation rock communities or low elevation rock communities. The elevation limits for each species, however, are quite variable. Many low elevation rock outcrop species of plants and animals are restricted to ranges outside high elevation areas (e.g., crevice salamanders are only found in and around the relatively low elevation Hickorynut Gorge). Still other wildlife may occur in both high and low elevation rock communities, but for various reasons may reach higher densities or have wider distribution in low elevation rock outcrops (e.g., timber rattlesnakes).

   Some wildlife species may occupy/use low elevation rock outcrop communities, but may not necessarily be restricted to them (e.g., eastern woodrat). Finally, several species are often associated with low elevation rock outcrops, however we may not know the full extent of their range and distribution, nor specific factors that result in their selection of low elevation rock outcrops. The result is a wide array of animal species associated with low elevation rock outcrop communities, with varying degrees of exclusive use. Nonetheless, there are several wildlife species often associated with our generalized low elevation rock outcrop habitat.

Priority species associated with low elevation cliffs/rock outcrops:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Falco peregrinus*	Peregrine Falcon	E
Mammals	*Myotis leibii*	Small-footed Bat	SC
	Myotis septentrionalis	Northern Long-eared Bat	SC
	Neotoma floridana haematoreia	Eastern Woodrat	SC
	Spilogale putorius	Eastern Spotted Skunk	
Amphibians	*Aneides aeneus*	Green Salamander	E
	Plethodon longicrus	Crevice Salamander	SC
	Plethodon ventralis	Southern Zigzag Salamander	SC
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Eumeces anthracinus	Coal Skink	

A. Location and condition of habitat[1]:

As with high elevation rock outcrop habitats, there is not currently a standardized definition of this habitat, nor capability to map and assess condition at each of these relatively small and dispersed habitats throughout western North Carolina. This habitat type is spread throughout the Mountains and upper Piedmont Region of the state (Piedmont examples include Sauratown Mountains inclusive of Pilot Mountain, the Crowders, the Uwharries, and South Mountains). Some specific sites have been characterized and studied, but many more have not, owing to their not being restricted to specific elevation or mountain ranges. They can and do occur just about anywhere in western North Carolina. Conditions also vary considerably within this habitat type, with a significant number having been impacted and/or lost due to numerous factors, while others remain functional "natural sites" and others yet specifically managed to minimize human impacts..

B. Problems affecting species and habitats:

As with high elevation rock outcrops, the two major problems most associated with the low elevation rock outcrops include development and recreational impacts. However, many more low elevation rock outcrops are subjected to short term habitat alterations (e.g., forestry operations) than high elevation rock outcrops due to land ownership patterns, proximity to markets, accessibility, and other factors. The extent and degree of impact associated with such temporary habitat alterations is unclear for most species. Regardless of the impacts or problems associated with short-term habitat modifications, the relative scarcity of low elevation rock outcrop habitat across the landscape of North Carolina, and reliance upon it by numerous wildlife species lends greater significance to the need to identify and manage these habitats appropriately to conserve wildlife.

Individual wildlife species associated with low elevation rock outcrops are subject to specific conditions of their habitats or their life histories and biology, which could be considered problems, depending upon the scale, location, extent, and duration. Many of the problems identified for high elevation rock outcrops and their associated species can impact species inhabiting low elevation rock outcrops (see discussion under "high elevation rock outcrops").

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys**
  - Conduct surveys for the southern zigzag salamander, crevice salamander, green salamander.
  - Conduct bat surveys (survey appropriate habitats for hibernacula or summer roosts).
  - Intensify efforts to determine eastern spotted skunk range and status.
  - Survey/develop baseline status and distribution information for coal skink, timber rattlesnake, peregrine falcon.
- **Monitoring** .
  - Continue annual monitoring of peregrine falcon nest cliffs to assess population status.
  - Establish protocols and regularly monitor green salamander and eastern woodrat.
  - Establish protocols and monitoring system for all priority wildlife species associated with low elevation rock outcrops upon completion of baseline inventories/surveys.
- **Research**
  - *See green salamander and peregrine falcon research needs under "High elevation rock outcrop" section.*
  - Study the impact of various management scenarios on the habitat and associated species.
  - Explore ways to identify the distribution and characteristics of this habitat across the landscape.

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Given the relative rarity of low elevation rock outcrops across the state, measures need to be taken to conserve as much of this habitat as possible. This includes preservation measures, as well as conservation/management measures to ensure that species which rely upon these outcrops continue to be afforded the variety of habitat conditions desired into the future. Certainly a high priority should be placed upon acquisition or easement of land tracts which support low elevation rock outcrops due to the fact that they are not abundant, they have numerous rare plant and animal associates, and remaining sites are subject to significant threats associated with both recreational and other development pressures.

In addition, conservation actions that are necessary include assigning appropriate management schemes to rock outcrops upon conservation lands to minimize negative impacts from human activities including recreational use and development. Appropriate restrictions upon use of the areas need to be developed where none currently exist to minimize the direct impact upon the habitat and its occupants. The results of studies on the impact to low elevation rock outcrops from surrounding habitat modification should be incorporated into appropriate management recommendations to minimize impacts upon wildlife species utilizing the rock outcrop. Mapping of these sites in a GIS format would facilitate tracking changes over time in both the habitat, as well as the associated species; and facilitate landscape scale management of this rare habitat. Maintenance of biologically significant areas, including peregrine falcon nesting areas, reptile den sites and significant salamander occurrences, is critical.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

N.C. Natural Heritage Program. 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

9. **Caves and mines** – Caves are found scattered across the Southern Blue Ridge physiographic province, and some do occur in other regions of the state as well. There are several different types of caves, however the most common types of caves are solution caves, fissure caves, and rock shelter/boulder caves. These types differ primarily in the way they are formed. Solution caves are created by the action of water, dissolving the underlying rock to form tunnels. Over time, solution caves get larger and larger and are generally the most extensive (size and length of passage). There are a few areas of North Carolina with underlying limestone geology which lend themselves to solution cave formations. Most notably the Nantahala Gorge and North Fork Catawba River/Linville Mountain area of western North Carolina and parts of the coastal plain are underlain with limestone (marble, dolomite, and marl respectively).

   Fissure caves are formed by movement of the earth's surface which results in cracks of the rock layers. Depending upon the actual events which spawn the development, fissure caves have varying sizes and configuration. Fissure caves occur in many places in North Carolina, though one of the most well known (in fact one of the largest known fissure cave systems in the world) occurs in Hickorynut Gorge in Rutherford County (Cato Holler, pers. comm.).

   Rock shelter/boulder caves are formed by erosive forces, weather events, earth surface movements and other factors, which essentially leave spaces underneath/behind surface rock. The vast majority of caves in North Carolina are rock shelter/boulder caves. Owing to their diversity of formation, differing geology, and range in the state, caves in North Carolina are quite variable in terms of both the plant and animal communities adapted to, and found in them.

   In addition, an extensive mining history in North Carolina has provided numerous subterranean excavations which can and do mimic environmental conditions of natural caves. Like caves, mines come in many shapes and forms, depending upon numerous factors. There are many mines which do not provide conditions similar to those found in caves such as open pit mines, strip mines, and quarries. Our definition of the caves and mines habitat type is intended to include only mines which include subterranean excavations such that conditions inside the mine shafts and tunnels resemble conditions in caves. That being said, the range of variability of those conditions is extensive.

Priority species associated with caves and mines:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mammals	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	T
	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	E (E)
	Myotis grisescens	Gray Bat	E (E)
	Myotis leibii	Small-footed Bat	SC
	Myotis septentrionalis	Northern Long-eared Bat	SC
	Myotis sodalis	Indiana Bat	E (E)
	Neotoma magister	Allegheny Woodrat	SC
Amphibians	*Eurycea longicauda*	Longtail Salamander	SC

A. Location and condition of habitat[1]:

As mentioned previously, caves and mines are found throughout North Carolina. The majority of documented caves occur understandably in the Mountain Region of western North Carolina, though there are some caves present in all regions of the state, including the coastal plain. The North Carolina Cave Survey has documented over 1,300 caves in the state (Cato Holler, pers. comm.). We have no accurate assessment of the availability of abandoned mines in North Carolina, and certainly have no idea as to their individual suitability for use by cave dwelling animals or plants. Certainly, some portion of the mines do function similarly to caves in

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

providing the range of microhabitat conditions which cave obligate species need. Usually, the larger the mine excavations and the air volume within are important correlates of use by cave dwelling animals. Many smaller mines do support minor levels of use, or use by small numbers of individuals, however the bigger the mine, the bigger the chances for it to be used by wildlife (particularly bats of various species).

Given the variability in cave types, mine types, and a host of different substrates, orientations, positions on the landscape, etc., the condition of caves and mines in North Carolina is quite variable. Caves and mines occur across all land ownership types. Several of the most significant sites have received attention in the past to protect resources (wildlife or geological in most cases). At least three caves and two mine complexes currently have bat friendly gates installed to prohibit or regulate human entry and subsequent impacts upon cave resources. Various surveys and investigations have been conducted in many caves and mines in attempts to document significant wildlife or geological resources, though no comprehensive evaluation has ever occurred. Certain wildlife groups (i.e. bats) have been surveyed in a portion of the caves on an irregular schedule over the past couple of decades. Therefore, not only is the condition of caves and mines quite variable in North Carolina, but our state of knowledge about the use of caves and mines by plants and animals is extremely variable.

B. *Problems affecting species and habitats:*

In many states, and throughout the world, many caves have been developed into tourist attractions, often with lighting, tours, gates, etc. All of these activities have resulted in both habitat conditions for cave dwelling animals, as well as disrupted normal behavior patterns, effectively eliminating habitat for many cave animals. In the Southern Blue Ridge Ecoregional Conservation Plan, recreation is the greatest threat to cave and cave species conservation (TNC and SAFC 2000). That would include both developed tourist caves, as well as recreational caving/exploration. Thus far, only one cave complex has been developed as a recreational destination in North Carolina, however you would be hard-pressed to find a cave or mine that doesn't experience some level of human visitation. Many of the wildlife species that use caves, if not the caves themselves have been and continue to be impacted by human activities including both direct impacts (e.g., repeated disturbance during bat hibernation), as well as indirect impacts (e.g., habitat changes that make microhabitat conditions inside the cave or mine unsuitable).

In addition to the recreational impacts, certainly many smaller caves and mines have most assuredly been impacted by development. However, there is little to no documentation of this actually having occurred. Nonetheless, given the amount of development that has occurred in North Carolina over the last century, it seems very likely that at least some cave habitat has been impacted.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Conduct bat surveys in caves and mines that have not been previously evaluated.
  - Survey for potential nesting birds in caves such as turkey vulture, black vulture and common raven..
- **Monitoring**
  - Establish and implement long term monitoring protocol to document bat use of significant cave/mine roosts.
  - Develop protocols and procedures for long-term bat banding study and data storage throughout the state.
  - Establish protocol for periodic monitoring and assessment of Allegheny woodrat populations.

- **Research**
  - Longtail salamander research: in some areas of its range, the longtail salamander occurs often associated with caves, or portions of caves. No investigation of its habitat use has ever occurred in North Carolina, and could be undertaken in conjunction with more generalized research on this species distribution, status and habitat in the state.
  - Consider studies to document maternity sites used by bats from specific hibernacula (e.g., find maternity colonies utilizing radio telemetry of individual Virginia big-eared bats that hibernate in known caves/mines, or track any Indiana or gray bats captured to their maternity sites or hibernacula).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

We must develop a comprehensive, prioritized list of significant caves including the factors which add significance (e.g., roost of endangered bats, rare geologic formations, other rare plants or animal use). We must also acquire additional cave habitat through purchase, conservation easement, or other perpetual management agreements (potential for partnerships with NC Natural Heritage Program, The Nature Conservancy). Lastly, we must pursue the development of plans for protection of caves where necessary to protect roosting bats or other cave resources, where feasible, and where cost effective (e.g., gating like at Cranberry Mine, limiting access).

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

The Nature Conservancy and Southern Appalachian Forest Coalition (TNC and SAFC). 2000. Southern Blue Ridge ecoregion conservation plan. The Nature Conservancy, Durham, NC.

10. **Bogs and associated wetlands** – This habitat type is a complex of multiple natural communities found throughout the western portion of the state. These include: swamp forest-bog complex, Southern Appalachian bog, Southern Appalachian fen, Hillside seepage bog, high elevation seep, and meadow bogs. In addition, these wetlands can be contained in landscapes of montane/piedmont alluvial forest and contain floodplain pool communities (Schafale and Weakley 1990). In some areas, beavers play a significant role in shaping the hydrologic and vegetative characteristics of these wetlands. Various ecologists, botanists, biologists and others can and do distinguish among these various communities, depending upon the species composition, hydrology, soils, or structure of the vegetation. Because of the complex nature of these communities, the interspersion of them, and the fact that they support many wildlife species in common, they are treated similarly under the habitat category of bogs and associated wetlands, and will be henceforth commonly referred to as "mountain bogs," regardless of whether they occur in the Southern Blue Ridge or upper Piedmont physiographic provinces.

    Mountain bogs are among the rarest communities in the Southern Appalachians and in North Carolina. Unlike northern bogs of glacial origin, mountain bogs form in poorly drained depressions or on gentle slopes, generally in relatively flat valley bottoms that are not subject to flooding. They are often small (less than 2 acres), dispersed, and hydrologic regimes are quite varied from site to site. Most often they are fed by seepage or springs, however some are associated with beaver activity and thus impoundment of surface waters. Small remnant bog communities can also be found in the headwater areas of some artificial impoundments as well. Some are permanently wet, some intermittently dry, and still others contain both wetter and dryer areas. Generally, they are underlain by wet organic or mucky mineral soils, which are very acidic, though a few can be relatively basic (NCNHP 2001).

    Vegetation is quite variable in mountain bogs. True Southern Appalachian bogs contain a very diverse mix of herbaceous and woody vegetation. Other types of mountain bogs are dominated by herbaceous vegetation only. The exact composition of vegetation is dependent upon numerous factors including, but not limited to: hydrology, soils, geographic location, disturbance history, current land use activities, and other factors. In fact, the hydrology and current land use of particular sites may be the most important factors that determine the current vegetation composition and structure of mountain bogs. For some, natural hydrologic factors result in what appears to be a relatively stable plant community (at least in the short term) dominated by herbaceous vegetation and sphagnum. Others seem to be more subject to natural successional processes that may, over time, shift the communities from open, herbaceous dominated areas towards more wooded communities like swamp forests or alluvial forests. Beavers have played a significant role in the formation and maintenance of many mountain bogs (Somers et al. 2000). While the role of beavers in creating and maintaining wetlands across the regional landscape can be debated in terms of its historical extent and impact, it is certain that they have had a role in shaping the availability of various wetland types across the Southern Appalachian landscape. Human activities such as livestock grazing play a major role in the current vegetation makeup of mountain bogs.

    The variability of the sites, their hydrology, and their current condition make a listing of plant species difficult, and potentially misleading, since each site can be quite different. However many species of plants, in various combinations, are associated with mountain bogs. Shrub species common to many mountain bogs include rhododendron, alder, rose, and poison sumac. Tree species may include red maple, white pine, hemlock, pitch pine, river birch, and occasionally red spruce. Herbaceous vegetation commonly includes many species of *Juncus* and sedge along with numerous herb species, and sphagnum mats. At least four federally endangered plants are associated with mountain bogs. Numerous other herbaceous plants and several animal species that are state-listed or rare are also associated with mountain bogs, including the bog turtle, mole salamander, four-toed salamander, and alder flycatcher. Mountain bogs, though very limited in their distribution and availability across the landscape are one of the most significant habitat types of the state for rare plants and animals (TNC and SAFC 2000), and they support a disproportionate amount of the overall composition of plants and animals found here as well.

Priority species associated with mountain bogs and wetlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Empidonax alnorum*	Alder Flycatcher	SR
	Empidonax traillii	Willow Flycatcher	
	Vermivora chrysoptera	Golden-winged Warbler	SR
Mammals	*Microtus pennsylvanicus*	Meadow Vole	
	Zapus hudsonius	Meadow Jumping Mouse	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma talpoideum	Mole Salamander	
	Eurycea guttolineata	Three-lined Salamander	
	Hemidactylium scutatum	Four-toed Salamander	
Reptiles	*Clemmys muhlenbergii*	Bog Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat[1]:

As defined, mountain bogs encompass many diverse habitats throughout the western portion of the state. Historically, more attention has been paid to bogs and wetlands of the Mountain Region than those of the Piedmont, with a few exceptions. Many of the bogs (of various types) within the mountains have been identified and studied, owing to the number of rare plants and animals associated with them. However several upper Piedmont bogs and wetlands have been identified and studied as well. Perhaps less well studied have been Piedmont region wetlands that fall outside the known range of rare species, or in other wetland habitats found more commonly throughout the Piedmont, such as Piedmont alluvial forests, swamps, and upland pools. Within the Southern Blue Ridge province, the Southern Appalachian Assessment (SAMAB 1996) identified over 72,000 acres of wetlands. This figure represents less than 1% of the Southern Appalachian landscape. Certainly, not all of these wetlands can be considered mountain bogs, however, depending upon numerous factors and processes, much of that acreage could support similar suites of plants and animals most often associated with mountain bogs. In addition, many mountain bogs were not included in the Southern Appalachian Assessment due to their small size and their inability to be detected through the remote sensing tools applied in the assessment (Landsat imagery). The US Fish & Wildlife Service (2002) estimates that at one time there were 5,000 acres of bogs in North Carolina. Depending upon the classification methods used for wetlands or bogs, estimates of mountain bog habitat availability are quite variable. Nevertheless, mountain bogs comprise a small fraction of the landscape of the region.

Mountain bogs (and 'meadow' bogs) are distributed throughout the Mountain and upper Piedmont of North Carolina, with examples as far east as Forsyth and Gaston Counties. Most of the known occurrences of them are situated along (both above and below) the Blue Ridge escarpment, or in the northwestern (Ashe and Alleghany) and southwestern (Cherokee, Macon, Clay) counties. Over 60% of the SAA wetlands identified (SAMAB 1996) occurred on privately owned lands. It is likely that overall, the percentage of mountain bog habitat in private ownership is even greater than that.

The condition of mountain bogs is quite variable. What is clear, however, is that significant amounts of mountain bog habitat have been converted to other uses, primarily through draining, filling, or impoundment. Some estimates indicate that fewer than 500 acres of mountain bogs in North Carolina remain (USFWS 2002). Again, regardless of how they are

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

defined, mountain bogs have suffered dramatic declines at the hand of humans. There are examples of various types of mountain bogs remaining that provide a reference for the "natural" condition of these habitats, however there is much debate as to what constitutes natural conditions due to both anthropogenic and other forces involved. Situations such as beaver control and fire suppression by humans may not have occurred at all mountain bog sites, but their indirect impact upon mountain bog habitats through facilitation of secondary succession certainly has occurred at some sites. In general, some bogs support a mix of open and closed canopy, maintained by hydrology, elevation, and other natural factors. Others may be open canopied (dominated by herbaceous vegetation) due to active management of vegetation or other land uses (grazing). Many are certainly affected by hydrologic changes (i.e. ditches or drains), but retain some of the functional qualities and wildlife habitat of their former states.

B. Problems affecting species and habitats:

Many things have had an impact upon the availability of mountain bogs. Certainly, a significant number of bogs have been destroyed to make way for industrial, commercial and residential development. Agriculture in North Carolina, both historically and currently, plays a significant role in the availability and condition of mountain bogs. Numerous bogs have been destroyed by agricultural practices including draining, filling, or pond creation. However, many of the remaining mountain bogs are located on agricultural lands dominated by livestock grazing. In fact, most of the more productive bog turtle sites that remain today are found upon grazed lands. This could be due to many factors, though certainly grazing by livestock retards or even stops the successional process in some wetlands, therefore maintaining the open conditions that bog turtles and other bog species require. Mowing and prescribed burning of certain bogs has had similar effects in some cases. This is not to suggest that agricultural management should be prescribed for all mountain bogs. Clearly some activities are detrimental, though agricultural practices can be helpful tools in managing mountain bog habitats in some situations.

The largest scale problem affecting mountain bogs and wetlands in general has been and continues to be the conversion of these habitats to other land uses. Whether for agriculture or other types of development (roads, housing, or other development), significant amounts of mountain bog habitat have been destroyed. In some cases destruction has been complete removal of the habitat from an area. In other cases, it has been focused on altering the hydrology through ditches or pipes, or even conversion to small ponds. In addition to the direct impact of habitat loss on the species occupying sites that are destroyed, there are secondary impacts upon populations of such species associated with them becoming more isolated from each other. Many mountain bogs are small in size, though often situated upon the landscape in such a manner as to be hydrologically connected. These connections support important movement corridors for wildlife from one small site to another, thus creating local populations of particular species not associated with a single site, but a larger complex of sites within the drainage. Therefore, loss of even small sites within a local population can have an impact, which in turn can affect the overall population of the particular species.

A significant problem for some mountain bogs, or at least for some species associated with them (i.e. bog turtle), is secondary succession of the plant communities at particular sites. This is not a problem at all sites, however succession does change community composition of certain sites, in terms of both the plants and animals found there. Some of the wildlife species associated with mountain bogs require open, herbaceous habitat (bog turtle, golden-winged warbler, meadow vole, meadow jumping mouse, bog lemming) while others prefer closed canopy wetlands (salamanders). Many species are found in mountain bogs with mixtures of open areas and shrubby areas, with a few trees. When succession is allowed to proceed open areas often become shrubby, followed over time by the development of closed canopy swamp forests. Regardless of the factors responsible for allowing succession to proceed (fire suppression, hydrologic diversion, or other disturbance factors), many bogs that formerly provided either open or mixed open/shrub habitat are becoming closed canopy swamps, thus becoming unsuitable for many mountain bog dependent species of wildlife.

The priority amphibians associated with mountain bogs are all salamanders, though there certainly are a much larger number of amphibians found in mountain bogs. These salamanders, for the most part (mole, four-toed, marbled, three-lined, and spotted salamanders) require pools of water for breeding purposes. They are associated with mountain bogs, to the extent that mountain bogs (as defined here) often contain pools of water that are utilized as breeding habitat. Their association with mountain bogs is less related to the bog being spring fed, muddy, or with specific plant associations than many of the other priority mountain bog species. These species are more suited to treatment of their threats/problems within the depression communities habitat type. Nevertheless, loss of wetland habitat in general is a significant problem for these species.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – For many of the priority species associated with mountain bogs, we do not have a clear understanding of their current distribution within the state. We must undertake surveys to gather baseline information on the distribution and status of most of these species.
  - Prioritize species that are state or federally listed as endangered, threatened, or special concern (bog turtle, mole salamander, four-toed salamander), or those often utilizing mountain bog habitats (Alder flycatcher).
  - Secondarily prioritize species facing significant threat, thought to be declining, or those for which we have limited information on their distribution and status (golden-winged warbler, willow flycatcher, American woodcock, rails, meadow jumping mouse, spotted salamander, marbled salamander, three-lined salamander, common ribbonsnake).
  - Work to develop a model to predict habitat for bog turtles, based on characteristics at known localities; this could lead to additional survey sites for other bog herpetofauna.
- **Monitoring** – Once we have completed surveys to determine the distribution and status of these priority species, efforts must shift immediately towards long term monitoring of their populations. In some instances it may take years of study to determine the complete distribution and status of a given species. Given the limited availability and threats facing mountain bog habitat, considerable effort needs to be expended to determine if populations are increasing, decreasing, or remaining stable. Particularly for species that are state or federally listed or thought to be declining, we must establish long-term monitoring efforts to learn what is happening not only within local populations, but on a regional or range-wide basis. It will be imperative to have this information both for planning conservation measures as well as gauging the success of measures undertaken.
- **Research** – Specific research needs are innumerable regarding these species and their habitat relationships.

  Genetics
  - Genetic studies to determine degree of gene flow between populations and to assess overall population health for species restricted to this habitat (i.e. bog turtle), given the isolated nature of mountain bogs.
  - Genetic studies of other priority species to examine degree of isolation.

  Habitat
  - Document the habitat relationships of priority species; for most species, we do not know how dependent they are upon mountain bog habitats, relative to other habitat types.
  - Determine of the microhabitat preferences and requirements of species utilizing mountain bogs. We must document whether specific hydrological and biological requirements of these priority species are being met under current management regimes, and to do that we must understand how these species are utilizing the habitat.

Management practices

- Examine the effects of different management strategies upon various taxa to document effective measures to manage these habitats into the future (e.g., determine the impact of various controlled grazing regimes or physical removal of woody vegetation).
- Investigate the potential of beavers to create bogs and associated wetlands when previously none occurred; or where beavers were removed, research the possibility of reintroducing the species to these habitats to create wetland habitat.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

First and foremost we must establish frameworks for gathering the information required to substantiate all conservation actions that we might undertake. The baseline surveys, population trend data, and habitat relationships are the foundation of knowledge upon which all future conservation actions must be undertaken. That does not mean that other conservation measures are not needed immediately. On the contrary, given what we do know about the limited availability and threats facing mountain bogs, we need to begin now with both information gathering as well as habitat protection measures. Habitat protection measures necessary throughout the planning horizon need to focus upon utilizing existing regulatory frameworks to protect both the habitat and these species (e.g., state and federal endangered species laws, wetland protection laws, etc.). Government conservation programs and incentives (e.g., Farm Bill programs) and partnerships with private landowners need to be fully utilized to stem the conversion of suitable bogs to other uses. Since those measures are not available or effective for all species or situations, aggressive steps to acquire conservation ownership of mountain bogs should be actively pursued in concert with state and federal agency partners (e.g., US Fish & Wildlife Service, US Forest Service, National Parks Service, Natural Resources Conservation Service, NC Division of Parks, NC Natural Heritage Program, local governments, etc.) as well as private conservation partners (e.g., The Nature Conservancy, land trusts). Recently completed soil survey mapping efforts may assist partners in identifying wetland soils, to prioritize potential restoration sites (considering size, adjacency, and other factors).

As conservation ownership of mountain bogs increases, we must devise programs or processes to facilitate the dissemination of information and guidance, as well as implementation of actual land management practices upon such lands to effectively maintain suitable habitat for the species dependent upon mountain bogs. Specific bog management needs include the control of woody encroachment and succession, the maintenance (and where necessary, restoration) of natural surface water and groundwater hydrology (using ditch plugs, temporary dams, level spreaders, or other engineering devices), the restoration of herbaceous vegetation, and the prohibition of take of rare bog-related species (e.g., bog turtle). We already know that passive management of these sites can lead to their loss through succession. We must establish the framework and means to ensure that management of these sites takes into account all the habitat needs of the species, and focuses upon providing for those needs in a cost effective, sustainable manner into the future. In some cases, habitat protection and management may not be sufficient to sustain populations or re-establish them. Measures necessary to re-introduce species at specific locations, under proper management scenarios may need to be examined and implemented to ensure healthy geographic and genetic populations are sustained.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Somers, A. B., K. A. Bridle, D. W. Herman, and A. B. Nelson. 2000. The restoration and management of small wetlands of the mountains and piedmont in the Southeast: a manual emphasizing endangered and threatened species habitat with focus on bog turtles. The Watershed Science and Wetland Science Institutes of the Natural Resources Conservation Service, the University of North Carolina at Greensboro, and Pilot View Resource Conservation and Development, Inc.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

The Nature Conservancy and Southern Appalachian Forest Coalition (TNC and SAFC). 2000. Southern Blue Ridge ecoregion conservation plan. The Nature Conservancy, Durham, NC.

US Fish & Wildlife Service (USFWS). 2002. Appalachian mountain bogs. Informational Pamphlet. Asheville Field Office, Asheville, NC.

11. **Floodplain forest** – Floodplain forests of the Southern Blue Ridge physiographic province in western North Carolina are ecologically rich and diverse. Montane floodplain forests are relatively narrow and do not contain well-developed levees, sloughs and ridges. They are generally restricted to larger streams and rivers with relatively low gradients, since smaller, high gradient streams often do not have representative floodplains, but instead have riparian zones embedded within other habitat types. They are subject to sporadic high-intensity flood events of short duration. The most common ecological communities associated with floodplain forest in the Mountain Region are montane alluvial forest and piedmont/low mountain alluvial forest. However, floodplain forests of the mountains often contain small amounts or isolated patches of swamp forest, swamp forest-bog, floodplain pools and semipermanent impoundments (Schafale and Weakley 1990).

    In these floodplains, the forest canopy contains a mixture of bottomland and mesophytic (moderately moisture tolerant) species including eastern hemlock, yellow poplar, yellow birch red maple, and others. In areas where floodplain landforms are apparent, levees may contain sycamore, river birch and box elder. Common shrub layer components include rhododendron, dog-hobble and alder. Herb layers can be quite different from site to site. Floodplain pools that occur in small depressions and are flooded for a portion of the year are important sites for breeding amphibians.

Priority species associated with montane floodplain forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Coccyzus americanus*	Yellow-billed Cuckoo	
	Limnothlypis swainsonii	Swainson's Warbler	
	Oporornis formosus	Kentucky Warbler	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Myotis sodalis*	Indiana Bat	E (E)
	Sorex fumeus	Smoky Shrew	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma talpoideum	Mole Salamander	SC
	Desmognathus aeneus	Seepage Salamander	SR
	Eurycea guttolineata	Three-lined Salamander	
	Eurycea junaluska	Junaluska Salamander	T
	Eurycea longicauda	Longtail Salamander	SC
	Hemidactylium scutatum	Four-toed Salamander	SC
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Pseudacris brachyphona	Mountain Chorus Frog	SC
Reptiles	*Clemmys muhlenbergii*	Bog Turtle	T (T)
	Crotalus horridus	Timber Rattlesnake	SC
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Lampropeltis getula getula	Eastern Kingsnake	
	Terrapene carolina	Eastern Box Turtle	

A. Location and condition of habitat (see Map 5A.11):

Floodplain forest is a difficult habitat to characterize and quantify, owing to the terminology used by different individuals to identify this habitat type. Often, floodplain forest, riparian forest, and bottomland forest are used interchangeably to describe habitats associated with mountain waterways. While they can refer to the same habitat, they do not necessarily refer to the same habitat. Furthermore, many of the wildlife species associated with mountain floodplain forest are not restricted to floodplains, but will utilize them and a variety of other mountain habitats. Therefore, floodplain forest habitat for the purposes of this plan should be broadly interpreted to include a range of ecological communities defined by Schafale and Weakley (1990), but generally occurring on floodplains or immediately adjacent to waterways.

There is no single estimate of the amount, nor an assessment of the condition of floodplain forest condition in the mountains. Estimates of bottomland hardwood forest for the Southern Appalachian Assessment exceed 450,000 acres (SAMAB 1996), and Partners in Flight estimates 65,000 acres of lowland riparian woodlands in the southern blue ridge (Hunter et al. 1999). However, these estimates were for habitats defined differently, that encompassed different regions of the Southern Appalachians. The fact is, we do not know how much floodplain forest we truly have in western North Carolina. What we do know is that historic development patterns and land uses have taken a disproportionate toll on the availability of floodplain forest in the region, for the simple fact that it is the flattest land around, and therefore most amenable to both agricultural uses as well as development for transportation, housing, and urban development. No matter how it is characterized, floodplain forest is currently in short supply in western North Carolina. There remain a few examples of functional floodplain forest along major rivers in the region primarily upon private lands, and a greater amount of more generalized riparian forest associated with smaller streams upon conservation lands, such as those owned by state and federal government agencies.

B. Problems affecting species and habitats:

In a word, the biggest factor that has had a negative impact upon floodplain forest habitat and consequently the wildlife associated with it is development. There is no question that the river and stream valleys of the Mountain Region have historically supported the bulk of agricultural activities, transportation development, hydroelectric facility development, commerce, and urban development. That has led to a number of different effects upon the habitat that include direct loss, habit fragmentation, altered hydrology, and others. Each of these has affected the entire assemblage of species that utilize floodplain forest to one degree or another. However, most of the species associated with floodplain forest will utilize other habitat types, and have been able to survive even in the face of dramatic loss of habitat.

Floodplain forests, are particularly important habitats for breeding amphibians in the region, mainly due to the inclusion of floodplain pools, and semi-permanent impoundments (i.e. beaver ponds), in our definition of the habitat. These temporarily flooded areas are critical breeding habitat for species such as marbled, mole, four-toed, and spotted salamanders. Likewise they can be critical for breeding to other amphibians such as chorus frogs, wood frogs, etc. Floodplain pools within floodplain forests have been directly impacted by conversion to other land uses, but also indirectly lost due to our development of water control structures (mostly combined with hydroelectric facilities) which have reduced the frequency, duration, and magnitude of flood events. That, in turn has had a number of direct impacts upon the habitat: pools don't get filled or get filled less frequently, vegetation structure and composition changes as a result of lost flood events as well. All of these have impacts upon the entire suite of species which formerly occupied or used floodplain forests.

Often, our approach to managing habitats within floodplains or riparian zones is dictated by other factors which are critically important, such as water quality considerations. However, this combination of management strategies can lead to such situations as floodplain forests becoming homogenous in structure/and composition, partly due to a lack of water quality protection, partly due to historic land use/clearing, and partly due to the diminution of flood regimes.

The result can be a lessening of microhabitat diversity within floodplains, and the concomitant impact on the assemblage of species utilizing floodplain forests.

Other problems affecting particular species that utilize floodplain forests include geographic and genetic isolation (e.g., mole and four-toed salamanders, bog turtles) and small ranges of particular species such as Junaluska and longtail salamanders and mountain chorus frogs. These factors, the limited availability of existing floodplain forest, and others constitute a significant conservation concern for many floodplain forest species.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – The first priority towards developing conservation strategies for floodplain forest wildlife is to enhance our current understanding of the distribution and status of the species which utilize this habitat, as well as the availability of the habitat itself. Status surveys are needed to gather current baseline information on all species, though priority should be given to species that are considered rare, or thought to be declining (e.g., Indiana bat, mole salamander, seepage salamander, Junaluska salamander, longtail salamander, four-toed salamander, mountain chorus frog, bog turtle, timber rattlesnake). Secondary priority for surveys should be concentrated upon species for which we have little current information about status and distribution, though they are thought to be more common (e.g., Swainson's warbler, Kentucky warbler, hooded warbler, Louisiana waterthrush, Baltimore oriole, warbling vireo, smoky shrew, spotted salamander, marbled salamander, three-lined salamander, slimy salamander, eastern hognose snake, eastern kingsnake).
- **Monitoring** – We must begin gathering information about population trends for all priority species associated with floodplain forests (considering new techniques for those that are not adequately sampled through existing methods). Again, we must initially concentrate on perceived rare or declining species, but eventually include all priority species. These forests are often heavily used by migrant birds and should be targeted for establishment of both MAPS and migration banding stations, as well as regular monitoring efforts (e.g., cover boards, egg mass counts, etc) for other priority species groups, such as amphibians. .
- **Research** – Research priorities include many potential topics/questions related to the species themselves, as well as species-habitat relationships. There remain many questions about the genetic status of species ascribed to floodplain forest habitats that need to be addressed such as degree of isolation of populations (e.g., longtail salamanders, mountain chorus frogs, mole and four-toed salamanders). For most of the priority species we do not have a clear understanding of species/habitat relationships to determine how critical maintenance of floodplain forest habitat or its management is to population or species sustainability. The relative importance of floodplain forest habitat compared to other habitats is generally lacking for many of the priority species and needs to be studied, such that conservation measures can be targeted for the species with the most specific requirements for floodplain forest habitat, as opposed to more generalized habitats. Investigations of the impacts and effects of beaver ponds on various floodplain forest species may also be warranted.

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Conservation actions that are necessary for both the species and the habitat include more detailed study of status, trends and species specific habitat use, as well as general protection and management measures for floodplain forest habitats. As with most wildlife habitats today, the level of threat to remaining floodplain forests from development or conversion to other land uses remains a significant factor in the future sustainability of wildlife species and populations. Contiguous, unfragmented gradients between floodplain forest and adjacent upland sites are essential to many amphibian and reptile species in providing foraging habitat, hibernation sites, and refugia during high water events (Bailey et al. 2004).

Protection and restoration of the remaining floodplain forest in the region needs to be a high priority for conservation agencies and organizations from numerous perspectives, including both maintenance of water quality, as well as aquatic and floodplain forest wildlife. These priority protection measures include, but are not limited to acquisition of floodplains (through purchase, easement, or other legal means such as management contracts), restoration of floodplain systems, or other legal measures (e.g., buffer rules). The Little Tennessee River valley has good restoration potential in the region, especially with the recent protection of the Needmore Tract (an acquisition made possible through a partnership of the Ecosystem Enhancement Program, the Clean Water Management Trust Fund, the Natural Heritage Trust Fund, the US Fish & Wildlife Service, The Nature Conservancy, the Land Trust for the Little Tennessee, and the Commission).

In addition, we need to place a high priority upon understanding the habitat relationships of floodplain wildlife, such that an active role can be pursued by conservation agencies and organizations in provision of technical guidance related to management of floodplain systems over space and time. We need to better understand the relationships such that we can develop and implement management strategies to mimic natural processes of flooding, which have been altered due to human activities or land use. For example, in the absence of periodic flooding, due to upstream water control, coupled with historic land use and current water quality regulations and recommendations, are we developing homogenous floodplain forests that are not as diverse floristically or spatially to accommodate use by the full array of wildlife that once occurred across the landscape. We need to study both the situation, and the potential remedies, including both our management of the water and surrounding forest to ensure that floodplain forests of the future do in fact provide the full range of requirements to conserve floodplain forest wildlife.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment terrestrial technical report. Report 5 of 5. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA.

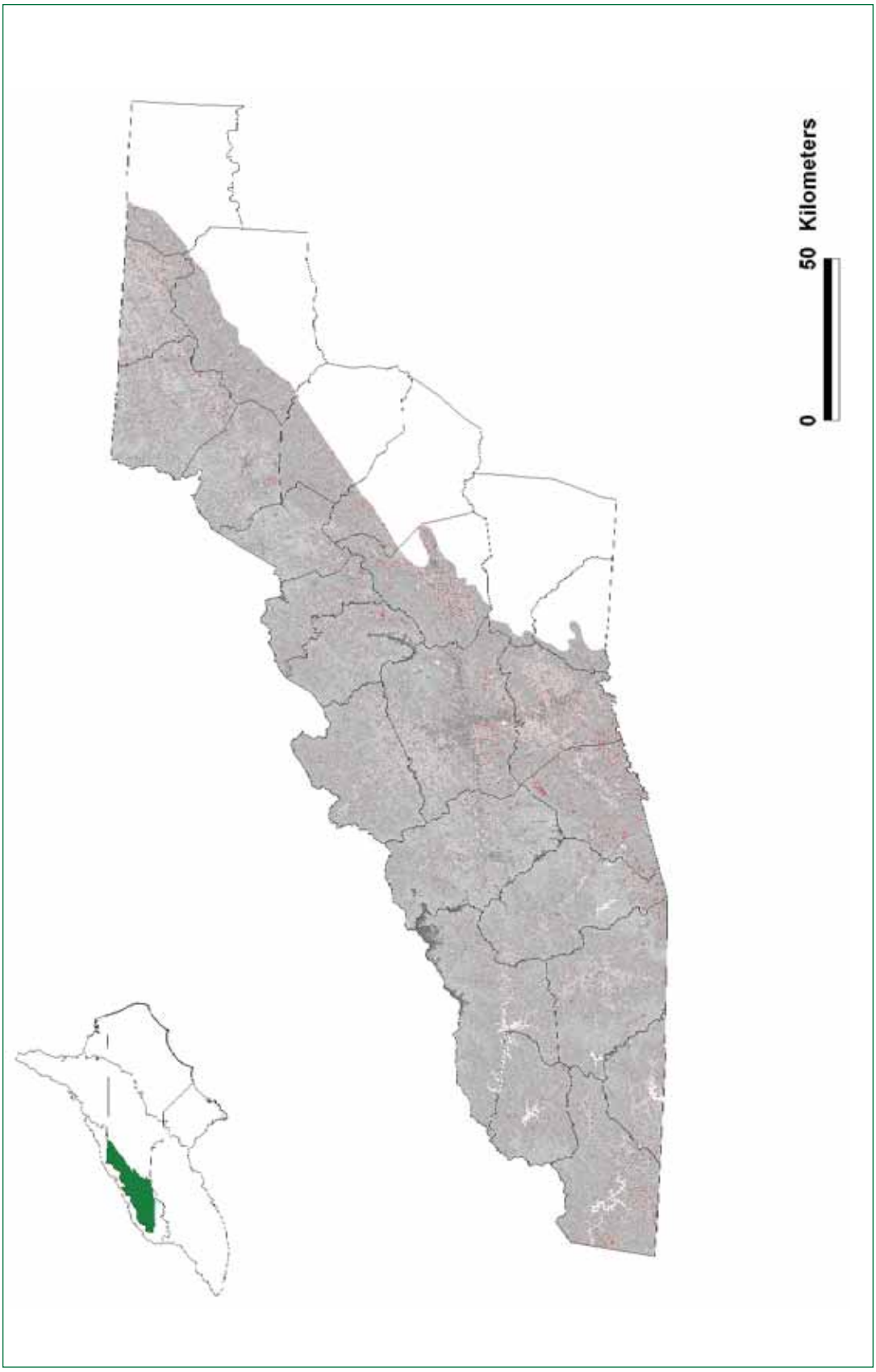


Figure 5A.11. Floodplain forest habitats in the Southern Blue Ridge ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

Southern Blue Ridge Ecoregion

12. **Riverine aquatic communities** – Riverine aquatic habitat for our purposes encompasses the vast array of mountain rivers and streams from headwater seeps and springs through major waterways, including impoundments upon those waterways. Montane riverine habitats are important for a number of reptiles and amphibians including certain turtles, frogs, and salamanders that utilize aquatic habitats during part or all of their life cycle. These habitats are also important for a variety of mammals that are semi-aquatic and/or that have an aquatic food base (e.g., water shrews, muskrats, beavers, river otters, and certain bats). Selected bird species also rely upon aquatic habitats including rivers and streams to provide habitat or a food base, such as various waterfowl, wading birds, and certain songbirds like the Louisiana waterthrush. Mountain rivers and streams provide a number of important habitat, life cycle, or prey components to a vast assemblage of terrestrial, semi-aquatic, and aquatic wildlife. In addition, the importance of maintaining water quality of riverine habitats cannot be overstated, both in terms of the species that rely upon rivers and streams for habitat, as well as those species which rely indirectly upon the habitat by virtue of provision of habitat for their prey.

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basins portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

Priority species associated with montane riverine aquatic habitat:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mammals	*Sorex palustris*	Water Shrew	SC
Amphibians	*Cryptobranchus alleganiensis*	Hellbender	SC
	Desmognathus marmoratus	Shovel-nosed Salamander	
	Eurycea guttolineata	Three-lined Salamander	
	Eurycea junaluska	Junaluska Salamander	T
	Eurycea longicauda	Longtail Salamander	SC
	Necturus maculosus	Common Mudpuppy	SC
Reptiles	*Apalone spinifera spinifera*	Eastern Spiny Softshell	SC
	Sternotherus minor	Loggerhead Musk Turtle	SC
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat[1]:

Human-influenced alterations have affected much of the Mountain Region riverine and floodplain habitats. Water quality and quantity have been impacted by run-off from municipalities and slope development. Dam construction has altered flows and river hydrology and morphology. Removing woody debris from streams after storm events has influenced in-stream habitat structure. The ecological condition of some mountain rivers is greatly reduced due to these impacts. However, some sections of rivers are designated High Quality Water and Outstanding Resource Water Management Zones and provide excellent opportunities for maintaining relatively pristine waterways. Each of the river basins in North Carolina are described in detail within the 'Aquatics' section of the report, which follows. See the Hiwassee, Little Tennessee, French Broad, Watauga, and New River basin sections in particular.

[1]See the basin maps associated with the Hiwassee, Little Tennessee, Savannah, French Broad, Watauga, New, Catawba, and Broad River basins.

B. *Problems affecting species and habitats:*

Water quality deterioration and loss of habitat are two of the most serious problems affecting wildlife that utilize riverine habitat. Water quality concerns, originating from both point and non-point sources have had, and continue to pose a threat directly to species that occur in riverine habitat, and indirectly through alteration of the food base or habitat. Direct and indirect impacts of decreased water quality upon wildlife associated with riverine habitat are difficult to quantify, and have not been as fully explored as have impacts upon fully aquatic species. However, there is little doubt that clean water is critical to a host of species that live in rivers and streams for a portion of their lives, and that sedimentation, channel scour, and other alterations of the physical habitat can lead to both deterioration of the habitat quality and negative impacts upon aquatic flora and fauna, which form the base of the food web for numerous wildlife species.

A condition with historic roots that still affects riverine habitat and its wildlife is the impoundment of rivers and streams for a variety of purposes including hydroelectric power generation, flood control, water supply, and recreation/aesthetics. There are miles and miles, or acres and acres of lakes and ponds that have converted lentic habitat to lotic. Again, the resultant effects have been both direct and indirect, in that habitat has been lost, and the food web has shifted, at least in portions of former riverine habitat, to species that do not depend upon flowing water. Other than measuring the direct impact of this habitat conversion, we do not know the overall impact upon the wildlife species present from the indirect effects of river or stream impoundment.

Another impact upon riverine habitat that can be construed as habitat loss, at least for some species, is through development of floodplains or riparian areas. River or stream-front development may or may not have a direct negative impact upon water or habitat quality in the stream or river, however in most instances it certainly can and does. The impacts of development adjacent to rivers and streams includes potential problems associated with direct input of contaminants and sediment, alteration of hydrologic patterns and temperature regimes, and loss of critical habitat adjacent to aquatic habitat that may be of equal importance to species that only spend a portion of their lives in the water (e.g., many amphibians).

Several of the priority species associated with riverine habitat face potential problems associated with having very limited distributions, or widely dispersed but small populations (e.g., eastern spiny softshell turtle, loggerhead musk turtle, Junaluska and longtail salamanders). Isolation or fragmentation of particular habitat stretches occupied by those species could have significant long-term affects upon the sustainability of those populations in North Carolina.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – In order to begin to plan conservation strategies for these species, we must have a better understanding of their distribution and status currently. Several of the priority species associated with riverine habitat in western North Carolina are known from only a few localities, and are considered rare or declining. Priority needs to be placed upon the conduct of baseline surveys to determine their current range and distribution (e.g., water shrew, hellbender, Junaluska and longtail salamander, mudpuppy, eastern spiny softshell, and loggerhead musk turtle). Secondary priority should be directed towards gathering better information about the status and distribution of more common species associated with riverine habitats (e.g., shovel-nosed, and three-lined salamanders).
- **Monitoring** – When we have a better understanding of the current distribution of these species, survey efforts should be re-directed into development of long-term monitoring strategies to document population trends, from which conservation strategies can be specifically designed to target those species which are experiencing declines.

- **Research** – Priority research topics related to these species and riverine habitats include investigations into the relationships between water quality and hydrologic regimes and population change of selected species. In particular, research needs to be conducted which will establish whether water quality declines are having a negative impact upon hellbender populations. Potential studies also include efforts to determine specific flow regimes necessary to support microhabitat for particular species (e.g., Junaluska salamander) and investigations to determine the effect that beaver ponds have on downstream movement of toxins and sediment. And finally, better information is needed regarding the specific microhabitat requirements for most of the priority species in order to develop long-term conservation strategies.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

In general the most critical conservation actions necessary to sustain populations of riverine habitat species involve protection of water quality and aquatic habitats. Immediate and continuing efforts need to be undertaken to limit water quality deterioration from point sources of pollution as well as non-point sources. Toxic chemicals and sediment are entering our waterways and having a direct negative impact upon the species in the rivers and streams, but also having significant negative impacts upon the quality of the habitat itself.

Measures to address these issues, some of which are in practice currently, such as regulation of point and non-point sources of pollution, need to be enacted and enforced. Mandatory and incentive based practices to improve water quality need to be actively pursued with cooperation from agencies and organizations at local, state and federal levels. Programs to promote vegetated buffers along rivers and streams need to be supported and intensified. River and stream ecosystem enhancement and restoration efforts and programs need to be enhanced and supported as well. Management of riverine habitats should promote the natural evolution and movement of woody and rocky structures and natural processes like bank dynamics, channel meanders, and flood regimes. And finally, within the frameworks afforded by state, local, federal, and private initiatives, riverine habitats need to be permanently protected from the negative impacts of development through conservation ownership (fee title or easement) of as much habitat as possible, both for long-term water quality protection in our state, as well as the sustainability of wildlife populations dependent upon our rivers and streams. *Also see the appropriate river basin sections for more detailed conservation recommendations by basin.*

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Piedmont Ecoregion

13. **Dry coniferous woodlands** – This habitat type occurs on extremely dry Piedmont sites, including ridgetops and steep slopes. These sites contain rocky, shallow, often extremely acidic soil. Canopy tree species may include table mountain and pitch pine (uncommon), Virginia pine, shortleaf pine, chestnut oak, scarlet oak, post oak, blackjack oak, and some hickories. Hemlocks (especially Carolina hemlock) occur on some rocky areas and exposed bluff slopes in the western Piedmont.

    Piedmont Monadnock Forest is a specific community type (distinguished from other dry oak-pine communities by the dominance of chestnut oak) that can include pine species such as Virginia and shortleaf pine in the canopy, a patchy shrub layer and a sparse herb layer (Schafale and Weakley 1990). Monadnocks are exposed and subject to disturbance by high winds and lightning and can contain old trees. Because of the dryness and disturbance, pines were likely a more important component of Piedmont Monadnock Forests than of other piedmont forests (Schafale and Weakley 1990).

    Piedmont Acidic Cliff communities occur on very steep to vertical slopes on acid soils, stream bluffs, and other slopes. They typically lack a closed tree or shrub canopy due to the rocky, dry sites, but may occur in areas with softer substrate that has been exposed by stream undercutting (Schafale and Weakley 1990). Pine species include Virginia and shortleaf pine, and hemlocks may occur on sites that are more sheltered along with rhododendron. Cliff communities are distinguished from forest communities by having an absent or open canopy and abundant bare substrate due to steepness and rockiness (Schafale and Weakley 1990).

    Pine-Oak Heaths are more typical of the Mountain Region but Piedmont examples occur on high ridges and monadnocks in the western Piedmont (Schafale and Weakley 1990). The typical pines found include Virginia, pitch and table mountain pine. These communities depend on periodic fires, which allow for seeding by shade-intolerant species such as pines, but the natural fire regime that is needed to maintain these areas is not clearly understood.

Priority species associated with piedmont dry coniferous woodlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Falco sparverius	American Kestrel	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides villosus	Hairy Woodpecker	
	Sitta pusilla	Brown-headed Nuthatch	
Mammals	*Lasiurus seminolus*	Seminole Bat	
Reptiles	*Crotalus horridus*	Timber Rattlesnake	SC
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Tantilla coronata	Southeastern Crowned Snake	

A. Location and condition of habitat (see Map 5A.13):

Dry coniferous woodlands along ridgetops and steep slopes are relatively rare in the Piedmont, occurring mostly in counties that border the mountains. In a 2002 forest inventory (Brown and Sheffield 2003), 8,300 acres were classified as pitch-pine dominated and 1,400 acres as table-mountain pine dominated in the Piedmont. A reduction in fire events in these habitats is impacting species composition. The overall condition of this habitat, however, is comparatively stable but this will change unless fire is used to manage these areas.

Piedmont Monadnock Forests with conifers present occur throughout the Piedmont, but are most common in the western Piedmont and in the Uwharrie Mountains. These areas grade into oak-hickory forests downslope, may grade into Piedmont Acidic Cliff, and may grade into pine-oak heath on sharp high ridges (Schafale and Weakley 1990). Piedmont Acidic Cliff communities occur throughout the Piedmont and generally border floodplain forests or stream channels. There is tremendous variation in plant composition among these sites based on elevation, aspect, and geographic location and in the amount and quality of the conifers present. Pine-Oak Heath occurs mainly in the upper Piedmont. Pilot Mountain, Hanging Rock and Crowders Mountain State Parks all have examples of this community.

B. Problems affecting species and habitats:

- *Fire suppression* – The location of dry coniferous woodlands along ridgetops and well-drained slopes makes this habitat more prone to fire, including occasional catastrophic fires, than more mesic or sheltered habitats. Many of the climax tree species in this habitat depend at least in part upon fire for regeneration.
- *Human disturbance leading to erosion and mass movement of soil* – Construction activities, clear cutting, and other causes of the removal of plant cover can make steep slopes prone to "slides" of mud and/or rock, causing loss of topsoil and potentially causing property damage and threatening human safety, as seen during the hurricanes of 2004.
- *Tree pests and diseases* – There are numerous native and exotic pests that can impact coniferous trees in this habitat (e.g., southern pine beetle, tip moths, pine webworm, Schweinitzii root and bud disease, red heart of pine disease). Localized and non-lethal infestations can be beneficial for wildlife by creating snags, a food source, and habitat diversity. However, extensive lethal outbreaks can dramatically shift the composition of the tree community, with implications for conifer-specialists like brown-headed nuthatch.
- *Development causing habitat loss and fragmentation* – Development projects are impacting dry coniferous woodlands, as with many other habitat types, in the Piedmont. As slopes are a prime location for new housing, development in this habitat can lead to fragmentation and disrupts connectivity between patches for most wildlife except birds. Road crossings can lead to mortalities, especially for reptiles and amphibians.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine the current baseline distribution and status of species mainly associated with dry coniferous forest (especially those that are state-listed or believed to be declining). Data is most severely lacking for reptiles, small mammals, and nocturnal birds. Since we lack baseline information about even common species and their distribution and status in this habitat type, we need to direct secondary efforts to conduct surveys to understand current status from which we can then measure future population changes over time.
  - Determine the distribution and status for pigmy rattlesnake, timber rattlesnake, southeastern crowned snake, and other reptiles (especially lizards).
  - Determine the distribution and status for small mammals and bats (e.g., seminole bat).
  - Conduct population status surveys for chuck-will's-widow, whip-poor-will (nocturnal), brown-headed nuthatch and woodpeckers.

- **Monitoring** – Protocols and procedures developed from baseline surveys should then provide a means to convert from a baseline survey mode to a long-term population monitoring mode. Current monitoring systems and protocols (e.g., MAPS and BBS) may need to be enhanced to better cover species not well covered by current monitoring efforts.
  - Establish MAPS and migration banding stations (although less of a priority than in Piedmont mesic forest, floodplain forest, oak forest and early successional communities).
  - Establish long-term monitoring efforts for small mammals and reptiles in the habitat.
- **Research**

  Population demographics
  - Conduct Seminole bat life history research, as little is known about the life history of this species in the Piedmont.

  Management practices
  - Determine impacts of prescribed fire on these communities and the resulting effects on wildlife communities.
  - Develop logistically and economically effective control strategies for controlling outbreaks of the most damaging insect pests and diseases.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

The highest priority for protecting dry coniferous forest and associated species is to identify the best remaining examples of this habitat in the western Piedmont and then to pursue easements or acquisition. The efforts of land trusts and government agencies should be coordinated to target the highest priority sites. At a larger scale, land use planning is needed to minimize development within large, unfragmented tracts of all woodland types in the western Piedmont.

The greatest habitat management need is the reintroduction of controlled fire on dry ridges to encourage pine regeneration, understory development, and structural diversity. Steep topography and smoke management concerns can make controlled burning a challenge. The NC Forest Service will be a critical partner for promoting an increase in controlled burning in this habitat. Another priority is regulation of human activities on steep slopes that may cause excessive erosion or mud slides, and the development and implementation of best management practices to mitigate erosion. Where feasible, efforts should be made to control large outbreaks of tree-killing insects and diseases.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Brown, M.J. and R.M. Sheffield. 2003. Forest statistics for the Piedmont of North Carolina, 2002. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. Resource Bulletin SRS-86.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Piedmont Ecoregion

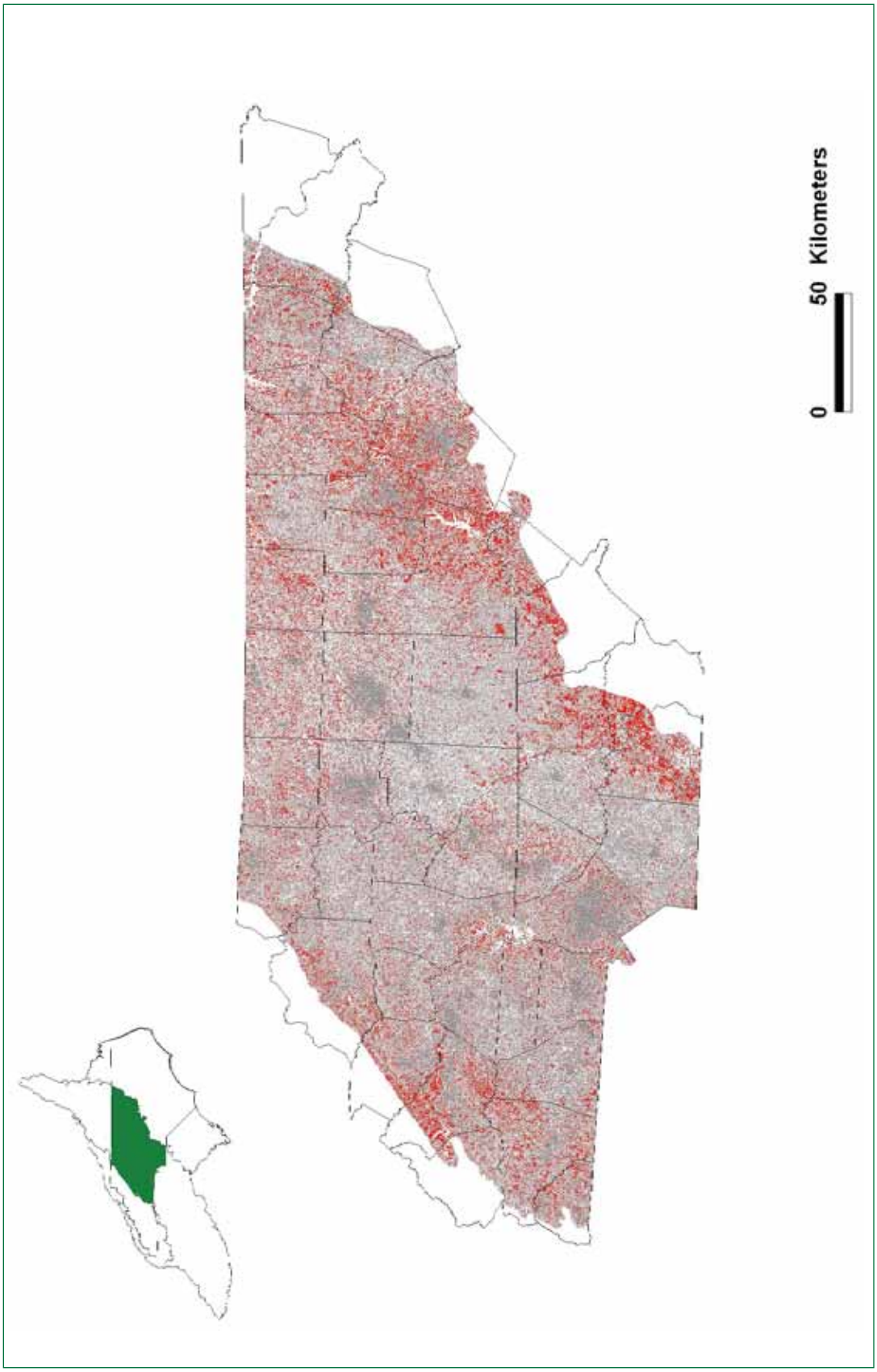


Figure 5A.13. Dry coniferous woodland habitat in the Piedmont ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

14. **Oak forest (including mixed hardwoods and pine)** – This habitat includes all mature Piedmont forests found upslope, or on drier sites, than Mesic Forest and downslope, or on wetter sites, than Dry Coniferous Woodland. Immature forests will be discussed in the Early Succession habitat section. Within this moisture gradient, there is a wide range of composition of the plant community, ranging from pine-dominated to hardwood-dominated forests, depending primarily upon soils and management history.

    According to Brown and Sheffield (2003) about 52% (5.4 million acres) of the Piedmont was forested in 2002 (all forest types combined). Seventy four percent (4.0 million acres) of Piedmont forests were classified as hardwood. Within hardwood forests, oak-hickory was the most widespread (2.7 million acres), followed by oak-pine (1.1 million acres) and oak-gum-cypress (151,000 acres). Pine forests accounted for 1.4 million acres, dominated by loblolly pine (798,000 acres), Virginia pine (404,000 acres) and shortleaf pine (132,000 acres). Planted stands comprised 12 percent (640,000 acres) of the total area of timberland in the Piedmont with 473,000 acres in pine plantations and 167,000 acres classified as planted oak-pine stands.

    A variety of natural communities recognized by the NC Natural Heritage program have an oak-hickory or mixed hardwood/pine component and occur in the Piedmont on both xeric and mesic sites. The communities with the largest or best examples include Dry Oak-Hickory Forest, Dry-Mesic Oak-Hickory Forest, Basic Oak-Hickory Forest, Xeric Hardpan Forest and Piedmont Monadnock Forest (Schafale and Weakley 1990).

    Dry-Mesic Oak-Hickory Forests and Dry Oak-Hickory are the most natural community types of the Piedmont landscape, occurring on ridgetops, upper slopes, south-facing slopes and other dry to mesic upland areas with acidic soils. They are dominated by a variety of oak and hickory tree species, but pines may also be an important component of both communities. Shrub layers are variable in density, but herbs are usually sparse (Schafale and Weakley 1990). Both of these forests are naturally uneven-aged forests with some old trees present. Reproduction typically occurs in canopy gaps and although the historical fire regime is largely unknown, fires (mostly of low intensity) certainly occurred periodically (Schafale and Weakley 1990).

    Piedmont Monadnock Forests occur on monadnocks or high ridges and have a canopy dominated by chestnut oak, although other oaks are also present. The Xeric Hardpan community is found at scattered locations throughout the Piedmont, and the canopy is often dominated by post oak and blackjack oak. Basic Oak-Hickory Forest is also found scattered throughout the Piedmont on slopes, ridges and uplands with basic or circumneutral soils (Schafale and Weakley 1990).

    In addition to these natural communities, there are a growing number of acres of pine plantations in the Piedmont, primarily of loblolly pine (Brown and Sheffield 2003). While there can be significant variation in the structure and composition of these pine plantations, particularly in the mid-story, the vast majority are even-aged stands with exclusively loblolly pine in the canopy.

A. Location and condition of habitat (see Map 5A.14):

Mature hardwood and pine forests are found throughout the Piedmont, though the total acreage has been declining in recent years. The total forested acres in the Piedmont declined 7%, or by about 400,000 acres, between 1990 and 2002, primarily due to urban development, and secondarily due to agriculture (Brown and Sheffield 2003).

Most Piedmont forests have been logged or cleared at least once within the past 300 years, and many have been cut multiple times. The quality of existing tracts ranges widely across the Piedmont and depends primarily upon the age of the canopy trees, management history, and size of the tract (Godfrey 1997). Some tracts are too small to support viable populations of area-sensitive species or species with large home ranges or dispersal movements. In 2002, only 5.6% of the area of private forests occurred in tracts larger than 500 acres (Brown and Sheffield 2003). Land use conversions in the Piedmont (primarily to suburban and exurban development)

Priority species associated with piedmont oak forests and mixed hardwood/pine stands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds[1]	*Accipiter cooperii*	Cooper's Hawk	SC
	Caprimulgus vociferus	Whip-poor-will	
	Coccyzus americanus	Yellow-billed Cuckoo	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides villosus	Hairy Woodpecker	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Mustela frenata*	Long-tailed Weasel	
	Scalopus aquaticus	Eastern Mole	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla versicolor	Northern Gray Treefrog	SR
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Cemophora coccinea copei*	Northern Scarletsnake	
	Crotalus horridus	Timber Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Terrapene carolina	Eastern Box Turtle	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

contribute significantly to the reduced condition of some tracts. Fire suppression and conversion to pine plantations are two management activities that have most extensively impacted these natural communities.

Disturbed areas in Dry Oak-Hickory and Dry Mesic Oak-Hickory Forests have varying amounts of pines, red maple, tulip poplar and sweetgum depending on the degree of canopy opening and disturbance history. Heavily logged areas or high-graded sites have a mixture of pines and hardwoods and there are several variants present in the Piedmont. Usually these forests are uneven-aged with old tress occasionally present. Disturbances of many types, exotic plants, and fire suppression have undoubtedly changed the species composition and structure of the oak-dominated forests. The best examples of oak forests are found in the central Piedmont and often near rivers or streams (Schafale and Weakley 1990) and several small examples are protected on public lands (e.g., Caswell Game Land, Umstead State Park, Uwharrie National Forest).

[1]In pine-dominated systems under this heading, the brown-headed nuthatch and Chuck-wills-widow could also be included in the list of associated priority species.

B. *Problems affecting species and habitats:*

Many of the problems impacting oak and mixed hardwood/pine forests, including fire suppression and even-aged forest management, result in a loss of habitat complexity and associated wildlife niches (Hunter et al. 2001).

- *Development causing habitat fragmentation* – Development causes direct loss of forest habitat and also fragments remaining forested patches. Fragmentation of forests into smaller contiguous blocks is a concern for forest interior birds (like wood thrush, Cooper's hawk, and worm-eating warbler), which may occur in lower densities or suffer lower productivity or survival in small habitat patches. Animals with large home ranges or dispersal needs may become isolated or absent in small tracts. Fragmentation by roads and development can be particularly problematic for reptiles (particularly timber rattlesnake and box turtle), amphibians, and small mammals that suffer high mortality on roads when traveling between forest patches.
- *Diseases* – Sudden Oak Death disease, which was detected at plant nurseries within North Carolina in 2004, could potentially have devastating impacts on oak forests across the state.
- *Short rotation forestry* – Shorter rotation forestry limits the creation of old-growth forest dynamics, such as creation of canopy gaps, hollow trees, snags, and woody debris. In 2002, less than 1% of both hardwood and pine trees in the Piedmont measured >19 inches diameter at breast height (Brown and Sheffield 2003), indicating that there are few old, large trees that help provide these old growth conditions[2]. Older stands will be more likely to be established and maintained on public land than on commercial forestland, though niche markets for larger timber may entice some landowners to extend cutting rotations.
- *Conversion to pine plantations* – Some native forest stands are being replaced by even-aged pine plantations, resulting in decreased habitat value for forest species that rely on diverse forest composition and structure, such as Kentucky warbler and wood thrush. Pine plantations do, however, provide increased opportunity to provide habitat for brown-headed nuthatch and bobwhite quail, with proper management.
- *Fire suppression leading to reduced or altered understory community and shifting tree species composition* – Historical data suggests that oak communities benefited from periodic fires (Abrams 1992, Close 1996), and many oak species are fire tolerant. In pine stands, fire can play a very important role in reducing the midstory while enhancing structure in the understory. Fire helps to create snags, woody debris, and canopy gaps, and prepares a fertile seed bed, while also improving vegetative structure. The benefit of fire to understory plant development is highly dependent upon the density of canopy trees, with closed-canopy stands suppressing the growth of grasses and forbs following fire. Cavity nesting birds, arboreal mammals, and some frogs, lizards and snakes are impacted by the lack of snags, while reptiles, amphibians and small mammals are impacted by lack of woody debris. Many bird species, such as hooded warbler, red-headed woodpecker, eastern wood-pewee, northern flicker, nightjars, and many post-fledging juvenile birds utilize canopy gaps for cover, or for foraging habitat, as do some bat species. Lack of fire has also allowed some fire-intolerant mesophytic plant species to become quite common in oak dominated communities including American beech (Franklin and Kupfer 2004). The resulting loss of acorn production may be limiting for some wildlife in the future.
- *Exotics* – There are many potential and realized impacts by imported gypsy moths (*Lymantria dispar*) and other non-native insects, kudzu, and other non-native pathogens, plants, and animals. Gypsy moths are the most destructive defoliating insect attacking northern red oak, chestnut oak, and white oak. This insect repeatedly defoliates trees and has killed oaks in a wide area of the northeastern United States. The Asiatic oak weevil (*Cyrtepistomus castaneus*) attacks northern red oak seedlings and has the potential to seriously affect seedling growth because the larvae feed on the fine roots while the adults feed on the foliage.

[1]It should be noted, however, that tree diameter does not always correlate with tree age.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with oak or mixed hardwood/pine forests. In general, inventory and trend information is most severely lacking for reptiles, amphibians, and small mammals (bats in particular), while diurnal birds are relatively well surveyed in Piedmont upland forests. Priorities for conducting surveys need to focus on species believed to be declining, at risk, or mainly dependent on oak dominated communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are generalists in terms of habitat usage.
  - Document the distribution and status of forest bats. Several priority bat species, including Seminole bat, southeastern bat, hoary bat, northern yellow bat, silver-haired bat, and northern long-eared bat may occur in upland Piedmont forests, but very little work has been done to document these species.
  - Document the distribution and status of priority amphibians (e.g., eastern spadefoot toad, four-toed salamanders) and document non-breeding use of oak forests by spotted and marbled salamanders.
  - Document distribution and status of timber and pigmy rattlesnakes.
  - Conduct nocturnal surveys to determine the status and distribution for whip-poor-will and Chuck-will's widow.
  - Determine the breeding status and distribution of Cooper's hawks.
  - Document status and distribution of priority reptiles (e.g., northern scarlet snake, mole kingsnake, scarlet kingsnake, corn snake, eastern smooth earth snake) and document the extent of eastern box turtle use of oak or hardwood/pine dominated forests.
  - Document the distribution and rate of spread for the most detrimental invasive exotic insects, plants, and diseases.
- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with oak or hardwood/pine forests. Again, the best trend information is available for many birds, while little long-term trend data are available for amphibians, reptiles, and mammals.
  - Monitor tree infestations and diseases to document potentially destructive organisms shortly after they show up, while there is still a chance to contain or eradicate the pest. This effort should include monitoring of potential vectors for the introduction of new pests and diseases, including nursery and forest products.
  - Monitor for exotic species spread; control may be required locally.
  - Develop standardized monitoring programs analogous to the Breeding Bird Survey for reptiles, amphibians and small mammals. Of particular interest is trend information for those species dependent upon snags and woody debris.
  - Establish mist-netting stations for long-term forest bat monitoring.
  - Establish MAPS and migration bird banding stations to monitor population status and trends for birds not adequately sampled under existing monitoring protocols.
  - Establish Migration Monitoring routes and winter surveys for birds in oak dominated forests.
- **Research** – There is a need to develop a greater understanding of the ecological relationships between wildlife species and their habitats, as well as the biological, physical and chemical habitat components, to help better guide management and conservation efforts.

  Predator effects
  - Study predator impacts on nest productivity, especially for ground nesting birds.
  - Examine cowbird parasitism impacts on bird productivity in small versus large habitat patches.
  - Determine the interactions between fire ants and ground nesting birds, small mammals and reptiles in disturbed forests, along edges of forest, and at road/forest interfaces.

Population demographics

– Establish long-term bird nest searching and spot mapping studies on neotropical migrants like worm-eating warbler, wood thrush, hooded warbler and eastern wood-pewee.
– Determine the impacts on native wildlife populations of large-scale applications of pesticides for gypsy moths and other pests.

Habitat use

– Determine the minimum forest patch size needed to support stable populations of forest-interior birds (e.g., wood thrush and scarlet tanager), as well as basic studies of nest success and productivity in habitat patches of different sizes, similar to studies conducted with citizen science volunteers by the Cornell Lab of Ornithology.
– Conduct productivity studies of open woodland woodpeckers (i.e. northern flicker and red-headed woodpecker).

Management practices

– Examine the feasibility of using forestry practices that mimic old growth forest dynamics (e.g., canopy gap, snag, and woody debris creation) in a manner that is compatible with economic goals of private landowners.
– Study the efficacy and wildlife impacts of thinning mature oak stands to encourage understory development.
– Compare oak forests that are managed via prescribed fire and those that are not burned at all, tracking differences in plant, wildlife and invertebrate communities.
– Study the efficacy of wildlife underpasses where habitat is highly fragmented by high volume roads.
– Develop new management techniques that control invasive exotic species while minimizing impacts on non-target species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

About 5 million acres, or 93%, of the forested land in the Piedmont is owned by non-industrial private landowners (Brown and Sheffield 2003), and thus any effort to conserve species in Piedmont forests must focus on impacting private lands. Privately-owned Piedmont forests are under tremendous developmental pressure, and the highest priority for conservation of this habitat is land use planning and protection of large tracts of land. A secondary priority is controlling the impacts of introduced pests that have the potential to dramatically alter forests, with Sudden Oak Death a very high priority. The third-level conservation priority is promoting management practices that enhance habitat conditions, including selective thinnings and controlled burning.

Policy–based actions

County and state-level land use planning is needed to minimize development within large, unfragmented tracts of forests. Where development will occur, cluster development and other lower impact development approaches are urged. This would be most appropriate and effective in the regions that are, as yet, not heavily developed, including Anson, Montgomery, Stanly, Randolph and Richmond counties in the southern Piedmont, and the northern tier counties of Surry, Stokes, Rockingham, Caswell, Person, and Granville. Planning for future infrastructure (roads, water lines, etc.) should be concentrated closer to existing development and should avoid dissecting larger tracks of unfragmented forest.

Protection actions

The next highest priority for this habitat is direct land protection through easements and land acquisition. Attempts should be made to provide large core areas of forest and to connect isolated patches of forests. As this is the dominant vegetation type in the Piedmont, protection of large tracts (>500 acres) is recommended. Cooper and Demarest (1999) recommend that core areas be at least 16,000 acres in size to produce viable populations of forest-interior birds, like scarlet tanager. Large core areas will be important for reptiles like box turtle and timber

rattlesnake, which suffer high mortality when crossing roads. State and county parks departments, the Commission, the Ecosystem Enhancement Program, The Nature Conservancy, the Piedmont Land Conservancy, the Land Trust for Central North Carolina, and other regional land trusts are all important players in land protection. The Nature Conservancy's Piedmont ecoregional plan (when completed) and the One NC Naturally Initiative will help to prioritize land protection efforts in the Piedmont.

Habitat management and restoration actions

Controlled burning is a beneficial habitat management practice, and should be encouraged in almost all Piedmont forest types, especially those with a pine component or a more open overstory. The greatest limitation on controlled burning is the presence of well-traveled roads, developments and sensitive agriculture operations (like chicken houses) which raise concerns over smoke management and liability. The NC Forest Service is the most important partner in promoting controlled burning. The Forest Service offers a free fire line program for private landowners, helping to dramatically defray the cost of implementing controlled burning.

Invasive and exotic species control should be targeted at ecologically sensitive areas and at new and potentially manageable outbreaks. Rapid response to new outbreaks will be critical.

There are a number of management practices that can be implemented on commercial pine plantations to enhance their habitat value. Many forest managers attempt to control hardwoods in pine stands with chemicals or other means, to reduce competition with pines. Morrison and Meslow (1983) and Santillo et al. (1989 *a, b*) found that retaining even small patches of deciduous trees with pine stands maintains a similar songbird community as in stands where hardwoods are not controlled. They recommend retaining these in areas of unstable soil, along roads, and as stream buffer strips. Banded or spot applications of herbicides can be used to maintain vegetation diversity and cover (Isaacson 1999). When selecting herbicides for pine release, Thomas (n.d.) recommends using Arsenal alone because legumes and blackberries are not damaged.

On large timber holdings it will be beneficial to maintain a diversity of habitat types and stand ages across the landscape and to restrict clearcut size, if benefit for forest interior species is the goal. Thinning prior to crown closure (Isaacson 1999), prescribed burning (Perkins 1962), and mid-rotation pine release using Arsenal (Thomas 1993) improve the quality and diversity of plant communities important to many wildlife species. Landowner incentives, technical assistance, and markets that promote extending rotation lengths should also be supported.

Supporting References

Abrams, M.D. 1992. Fire and the development of oak forests. Bioscience 42: 346–353.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Brown, M.J. and R.M. Sheffield. 2003. Forest statistics for the Piedmont of North Carolina, 2002. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. Resource Bulletin SRS-86.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Close, D.D. 1996. Evaluation of herbaceous diversity and differential species in mature forest stands at land Between the Lakes, Kentucky and Tennessee. Masters Thesis, Dept. of Forestry, Southern Illinois Univ., Carbondale, Illinois.

Franklin, S.B., and J.A. Kupfer. 2004. Forest communities of Natchez Trace State Forest, Western Tennessee Coastal Plain. Castanea 69(1): 15–29.

Godfrey, M.A. 1997. Field guide to the Piedmont. University of North Carolina Press, Chapel Hill, NC.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2): 440–455.

Isaacson, C. 1999. Intensive Forest Management: Impacts on Wildlife. Preceda Education and Training. Auburn, AL.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Morrison, M.L. and E.C. Meslow. 1983. Impacts of forest herbicides on wildlife: Toxicity and habitat alteration. North American Wildlife Conference 48: 175–185.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Perkins, C.J. 1962. Quail management in southern pine forests. Forest Research Notes, Southlands Experiment Forest. Bainbridge, GA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Rosenberg, K.V., R.S. Hames, R.W. Rohrbaugh, Jr., S.Barker Swarthout, J.D. Lowe and A.A. Dhondt. 2003. A land manager's guide to improving habitat for forest thrushes. The Cornell Lab of Ornithology.

Santillo, D.J., P.W. Brown, and D.M. Leslie, Jr. 1989a. Response of songbirds to glyposate-induced habitat changes on clearcuts. Journal of Wildlife Management 53(1): 64–71.

Santillo, D.J., D.M. Leslie, Jr., and P.W. Brown. 1989b. Response of small mammals and habitat to glyposate application on clearcuts. Journal of Wildlife Management 53: 164–172.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Thomas, M.W. n.d. Improve white-tail deer habitat, hunter visibility and hunter safety with arsenal herbicide applicators concentrate for site preparation and pine release. Proceedings of the Southern Weed Science Society.

Thomas, M.W. 1993. Arsenal herbicide benefits wildlife habitat. Weyerhaeuser Making Tracks. Spring: 9–19.

Piedmont Ecoregion

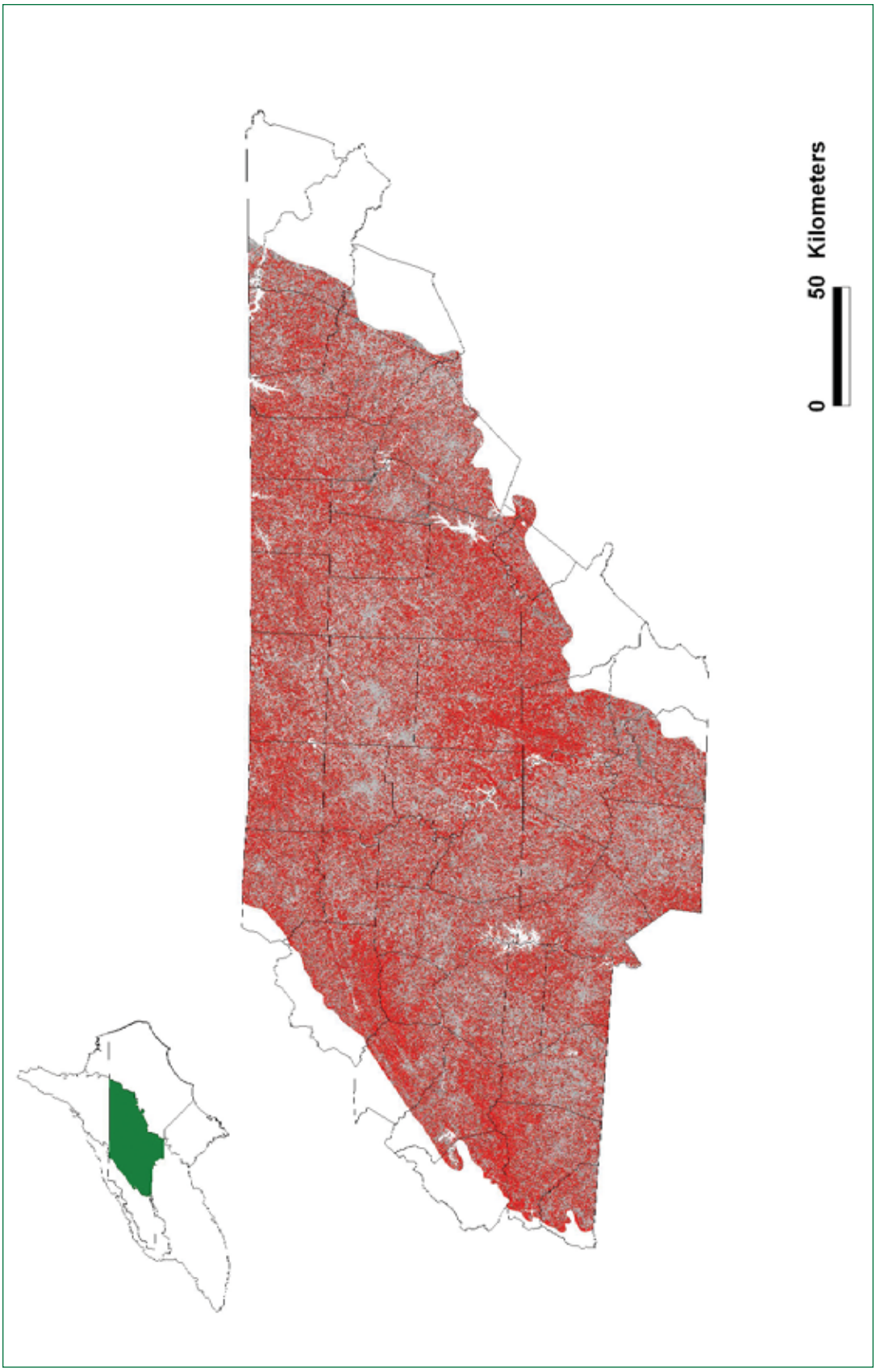


Figure 5A.14. Oak forest and mixed hardwoods/pine habitat in the Piedmont ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

15. **Mesic forest** – Piedmont mesic forests occur on moist portions of upland habitat, steep north-facing slopes, lower slopes, along ravines, high sections of outer floodplains and stream bottoms. The most common subtypes in the Piedmont are Mesic Mixed Hardwood Forest and Basic Mesic Forest (Schafale and Weakley 1990). These habitats have well-developed understory and shrub layers and are characterized by canopy species such as American beech, tulip poplar and red oak, and in the western Piedmont, eastern hemlock.

    Under natural conditions these forests are uneven-aged and often have some old, large trees present. Reproduction occurs mainly in canopy gaps (Schafale and Weakley 1990) and disturbed areas have increased amounts of pines, tulip poplar and sweetgum. Fires most likely occurred periodically but because of the moist and sheltered nature of the sites, they likely did not burn often or with great intensity. Mesic Mixed Hardwood Forests grade into alluvial or bottomland forest or into various upland forest types and can be distinguished from Basic Mesic Forest by more acidic soils, an absence of base-loving plants and lower vegetative diversity in the understory.

    In general, Mesic Mixed Hardwood Forests are quite common and their occurrence on steeper topography has allowed some to escape extensive disturbance until recently. Due to a scarcity of basic rocks in the piedmont, the Basic Mesic Forest subtype is rare. Mesic forests can be distinguished from upland hardwood forests by the canopy composition and from floodplain forests by the lack of bottomland tree species and presence of flood-intolerant trees (Schafale and Weakley 1990).

Priority species associated with piedmont mesic forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Accipiter striatus	Sharp-shinned Hawk	SR
	Coccyzus americanus	Yellow-billed Cuckoo	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Helmitheros vermivorus	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Oporornis formosus	Kentucky Warbler	
	Picoides villosus	Hairy Woodpecker	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Lasionycteris noctivagans*	Silver-haired Bat	SR
	Mustela frenata	Long-tailed Weasel	
	Scalopus aquaticus	Eastern Mole	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma talpoideum	Mole Salamander	SC
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla gratiosa	Barking Treefrog	
	Hyla versicolor	Northern Gray Treefrog	SR
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
Reptiles	*Clemmys guttata*	Spotted Turtle	
	Crotalus horridus	Timber Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broadhead Skink	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Terrapene carolina	Eastern Box Turtle	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

A. Location and condition of habitat (see Map 5A.15):

Mesic habitats in the Piedmont have experienced less direct habitat destruction and fragmentation as compared to other upland habitats, but more recent logging has reduced the extent of old growth canopy in most places. Also, the extent of intact natural landscapes with a mesic forest component (often amidst other upland forest types and bottomland communities) has been reduced by development and forest clearing for agriculture, especially in oak forest types immediately above the mesic forest slopes.

There are still good examples of this mesic forest in the Piedmont at Umstead State Park, Duke Forest, Hill Demonstration Forest, Raven Rock State Park and at Eno River State Park in the central Piedmont, and also examples in parts of Uwharrie National Forest. The Basic Mesic Forest subtype often has rare and disjunct plant species.

B. Problems affecting species and habitats:

- *Development causing habitat fragmentation* – Housing subdivisions are often built adjacent to mesic slopes and floodplain forests in central North Carolina. As with all Piedmont forested habitats, fragmentation of mesic forests into smaller or narrower contiguous blocks is a concern for forest interior birds (like wood thrush, Cooper's hawk, and worm-eating warbler), which may occur in lower densities or suffer lower productivity or survival in small habitat patches. Fragmentation by roads and development can be particularly problematic for reptiles (particularly timber rattlesnake and box turtle), amphibians, and small mammals (particularly eastern mole) that suffer high mortality on roads when traveling between forest patches or between mesic forest and other habitats.
- *Conversion to loblolly pine monoculture* – After logging, some mesic forest habitats are replanted to even-aged loblolly pine plantations, reducing species and structural diversity.
- *Shorter rotation logging* – When forests are cut for timber as soon as they are economically viable, they are not able to develop old-growth structural characteristics such as canopy gaps and standing and fallen snags. A lack of canopy gaps in this habitat type has probably lead to a reduced number of some avifauna such as the eastern wood-pewee, red-headed woodpecker, northern flicker, hooded warbler and Kentucky warbler. This reduction in canopy gaps has also caused a decline in midstory and understory vegetation, which has impacted species such as the Swainson's warbler, Kentucky warbler, hooded warbler and wood thrush. The reduction in standing snags negatively impacts primary and secondary cavity nesting species, and the lack of dead wood on the forest floor impacts herpetofauna and small mammals.
- *Exotic plants* – Plants such as autumn olive, Japanese grass, Japanese honeysuckle, and privet have taken resources from native vegetation and altered habitat structure and species composition. The extent of negative (and positive) impacts of exotic species on populations of native fauna is largely unknown.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine the current baseline distribution and status of species mainly associated with mesic forests (especially those that are state-listed or believed to be declining) for which that information is lacking. Since we lack baseline information about even common species and their distribution and status in this habitat type, we need to direct secondary efforts to conduct surveys to understand current status from which we can then measure future population changes over time.
  - Determine the breeding distribution and status of Cooper's and sharp-shinned hawks. Because of their secretive nature, traditional bird surveys do not adequately track these populations. Targeted tape "play-back" surveys will be needed.
  - Conduct nest-searching and spot-mapping bird surveys to determine limiting factors in productivity.
  - Determine the distribution and population status of mole salamander, four-toed salamander, northern two-lined salamander.

- Determine the status and distribution of timber rattlesnake.
- Determine the status and distribution of spotted and box turtles, particularly in more urbanized and rapidly urbanizing counties.
- Determine the status and distribution of small mammals and bats in Piedmont mesic forest.

- **Monitoring** – Protocols and procedures developed from baseline surveys should then provide a means to convert from a baseline survey mode to a long-term population monitoring mode. Current monitoring systems and protocols (e.g., MAPS and BBS) may need to be enhanced to better cover species not well covered by current monitoring efforts.
  - Establish MAPS and migration banding stations.
  - Conduct herpetofauna monitoring to track population trends for species of concern. Particular attention should be paid to mole salamanders and four-toed salamanders.
  - Establish monitoring systems and protocols for small mammals, bats and reptiles and amphibians to follow population trends

- **Research**

  Population demographics
  - Conduct life history studies on priority bat species, as well as investigations into specific habitat needs, particularly for silver-haired bats.
  - Conduct research on the effects of the loss of old-growth characteristics on herpetofauna populations.

  Predator effects
  - Examine impacts of cowbird parasitism and predation on neotropical migrant nesting productivity (e.g., hooded warbler, Kentucky warbler, eastern wood-pewee and worm-eating warbler).

  Habitat use
  - Study the impacts of habitat fragmentation and roads on reptile and amphibian survival and productivity.

  Other
  - Conduct economic and human dimensions research to determine how to encourage commercial forestry practices that promote multi-age stands with structural diversity.

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Within Piedmont mesic forest there are three major conservation needs. The highest priority is land use planning to minimize development within large, unfragmented tracts of mesic forest. This would be most appropriate and effective in the regions that are, as yet, not heavily developed, including Anson, Montgomery, Stanly, Randolph and Richmond counties in the southern Piedmont, and the northern tier counties of Surry, Stokes, Rockingham, Caswell, Person, and Granville. Planning for future infrastructure (roads, water lines, etc.) should be concentrated closer to existing development and should avoid dissecting larger tracks of unfragmented forest.

The next highest priority for this habitat is direct land protection through easements and land acquisition. Attempts should be made to connect mesic stands to adjacent patches of upland hardwoods or floodplain forests to establish larger core areas for wildlife. State and county parks departments, the Commission, the Ecosystem Enhancement Program, The Nature Conservancy, the Piedmont Land Conservancy, the Land Trust for Central North Carolina, and other regional land trusts are all important players in land protection. The Nature Conservancy's Piedmont Ecoregional Plan (when completed) and the One NC *Naturally* Initiative will help to prioritize

land protection efforts in the Piedmont.

The third major conservation need is habitat management and forestry practices that will encourage structural and species diversity. Possibly the greatest habitat management need is an increased focus on allowing longer forestry rotations and the development of older-growth forest characteristics. After timber harvest, landowners could consider establishing multi-tree species or multi-age stands. Also, allowing or encouraging periodic habitat disturbance will help to create tree-fall gaps and snags that will promote understory development and increase vegetative and structural diversity. The Forest Landbird Legacy Program can help provide technical guidance and cost share for management practices that promote late succession forest bird habitat.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

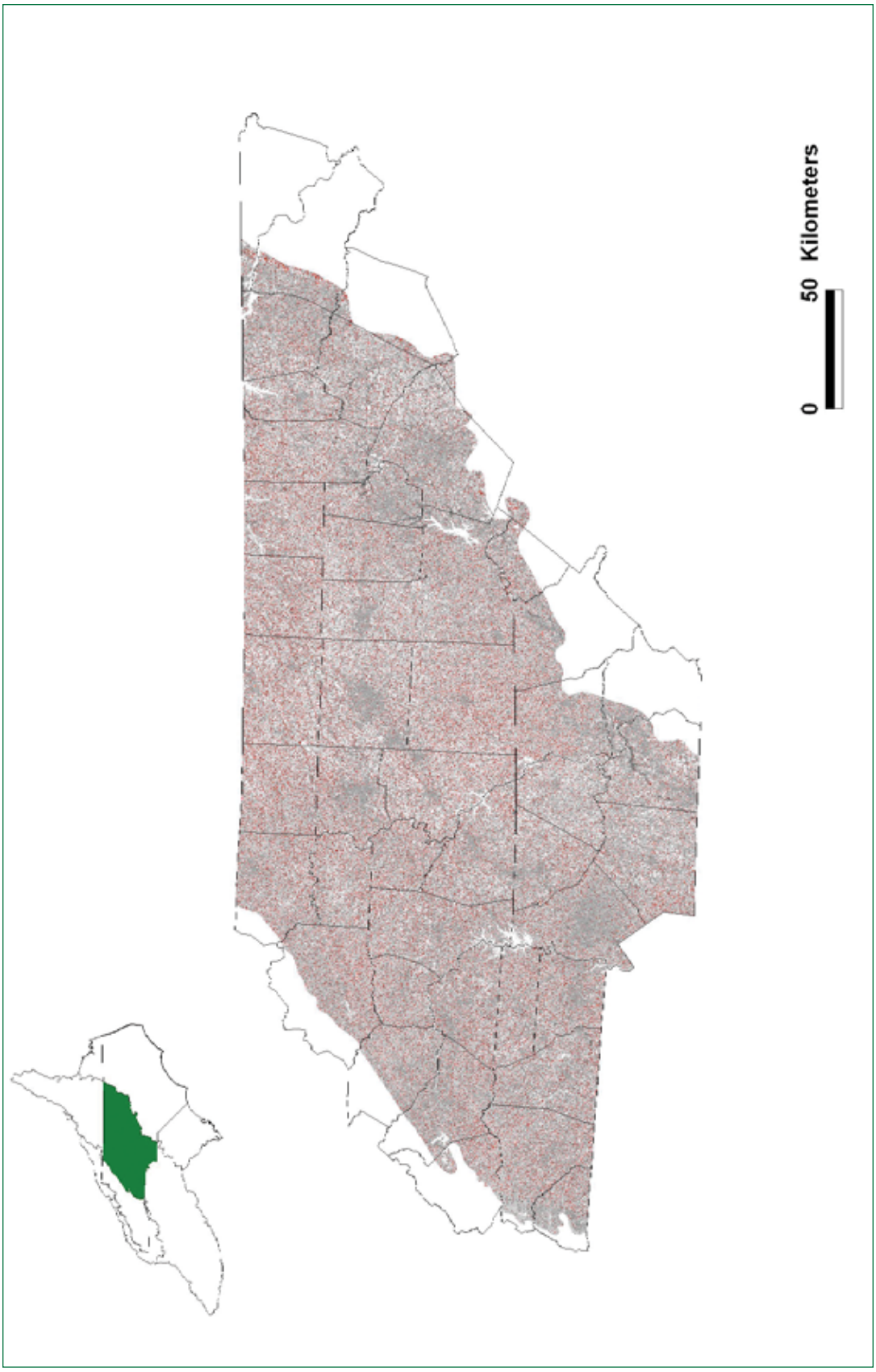


Figure 5A.15. Mesic forest habitat in the Piedmont ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

16. **Early successional habitats** – Piedmont early succession and scrub-shrub habitats, characterized by low woody vegetation and herbaceous plants, are often found associated with agricultural or forestry activities. This habitat includes grasslands, shrublands, clearcuts and regenerating forests, large canopy gaps, hayfields, pasture, row crops and field borders. For the purposes of this Plan, this habitat category will also include open savannas, or any habitat where dense understory vegetation is maintained through periodic disturbance. These habitats are created and maintained by disturbances like discing, clearcutting or burning.
To a lesser extent, extreme weather events or tree pests (insects and diseases) can also create early succession habitats. Historically, large herbivores and Native American land uses likely contributed to the creation and maintenance of these habitats.

    By their nature, early succession habitats are ephemeral and will have a limited longevity without repeated disturbance. The habitat structure changes as succession progresses, and many wildlife and plant species are adapted to different stages within the early succession continuum, from bare earth through pole-stage woodland. Managing for species dependent upon early succession habitats presents several management challenges, including the need to identify which successional stage is most appropriate for the species or assemblage of interest and the need for repeated management actions to maintain suitable habitat.

    Early succession habitats can contain a diverse assemblage of plants, with Piedmont prairies being a notable example of this (Davis et al. 2002). However, intensively managed habitats such as large lawns, golf courses, high production agricultural fields, monoculture hayfields, and intensively managed commercial timber stands often have low species and structural diversity, and thus have limited habitat value for wildlife. They may, however, play a role in the overall landscape scale habitat selection process of certain early successional species, provide transitional habitats, or provide habitat for a limited number of other species. Therefore, in a general sense or at a large scale, they can be included as part of the overall early successional habitat matrix, though most of the priority early successional species require a more diverse plant community than is often provided at these kinds of sites.

    The landscape context can be critical for success of maintaining populations of early succession species, as many of these species depend on the ability to rapidly colonize new areas as succession renders other areas unsuitable, and many of the species in this group are "area sensitive," requiring a minimum contiguous habitat patch size before they will colonize an area or successfully reproduce. Many early succession habitats with otherwise suitable habitat structure may have limited wildlife value if the habitat patch is too small or isolated from other similar habitats.

    Historically, the Piedmont contained some prairie-type habitats (Barden 1997) with high plant and, presumably, insect diversity. Around the time of colonization, these Piedmont prairies were maintained through fire and herbivore grazing. Today, remnant tracts of prairie are found primarily along powerline rights-of-way and sites managed specifically for prairie restoration and maintenance.

A. Location and condition of habitat (see Map 5A.16):

Ephemeral by definition, the distribution and location of early succession habitats across the Piedmont can change dramatically within a decade. Currently, most early succession habitats are found on private lands in farmland, recently harvested timberland, powerline rights-of-way, roadsides, and managed Piedmont prairies. The extent and quality of early succession habitats has been greatly dependent upon human land use patterns. While there is some uncertainty of the extent of early succession habitats prior to European settlement, it is likely that many early succession species' populations peaked in the early 1900s with extensive clearing of forests and low-intensity agricultural operations. In the second half of the 20th century, the quantity and quality of early succession habitats have diminished due to reduction of the use of fire, increasing development, encroachment of exotic vegetation, changing agricultural and forestry practices, and fragmentation of habitat patches into small isolated units (Cobb et al. 2002, Johnson and Igl 2001, Thompson and DeGraaf 2001, Warner 1994). Populations of many species that depend on these habitats have also declined during this time period (e.g., Hunter et al. 2001, Litvaitis 2001).

Priority species associated with piedmont early successional habitats:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Aimophila aestivalis*	Bachman's Sparrow	SC
	Ammodramus henslowii	Henslow's Sparrow	SR
	Ammodramus savannarum	Grasshopper Sparrow	
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Chordeiles minor	Common Nighthawk	
	Colinus virginianus	Northern Bobwhite	
	Dendroica discolor	Prairie Warbler	
	Dolichonyx oryzivorus	Bobolink	
	Empidonax traillii	Willow Flycatcher	
	Falco sparverius	American Kestrel	
	Icterus spurius	Orchard Oriole	
	Lanius ludovicianus	Loggerhead Shrike	SC
	Scolopax minor	American Woodcock	
	Spiza americana	Dickcissel	
	Spizella pusilla	Field Sparrow	
	Sturnella magna	Eastern Meadowlark	
	Tyrannus tyrannus	Eastern Kingbird	
	Tyto alba	Barn Owl	
Mammals	*Cryptotis parva*	Least Shrew	
	Microtus pennsylvanicus	Meadow Vole	
	Mustela frenata	Long-tailed Weasel	
	Peromyscus polionotus	Old-field Mouse	SR
	Scalopus aquaticus	Eastern Mole	
	Zapus hudsonius	Meadow Jumping Mouse	
Reptiles	*Lampropeltis calligaster rhombomaculata*	Mole Kingsnake	
	Lampropeltis getula getula	Eastern Kingsnake	
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Terrapene carolina	Eastern Box Turtle	

B. *Problems affecting species and habitats:*

– *Agricultural practices* – The routine land disturbance by agricultural operations provides the best opportunities for early succession habitat creation and maintenance in North Carolina. However, the value of modern farmland for early succession wildlife has been reduced as economic pressures, improvements in equipment and herbicides, and social factors have all led to larger, more uniformly shaped rowcrop fields, as well as "cleaner" fields with fewer weeds in the fields and less weedy edge. Few rowcrop fields are managed to include a fallow rotation. Some beneficial practices, such as no-till planting, have had mixed success in being adopted. In pastureland, the extensive use of exotic cool-season grasses has reduced habitat quality for wildlife. Cutting hay in mid-summer and overgrazing can adversely affect nesting grassland birds.

– *Forestry practices* – Commercial forestry operations create much of the early succession habitat available in the Piedmont. In 2002, about 1.1 million acres (10% of the total land area in the Piedmont) were classified as timber stands <10 years old (Brown and Sheffield 2003). Clear-cutting timber typically results in the creation of early succession habitat for a short period of time. Most of the understory grass, forb, and shrub layers are typically reduced or lost once a newly planted commercial timber stand "canopies out", which occurs typically

7–15 years after timber clearing and planting. Heavily stocked, even-aged pine monocultures typically retain very little understory structure after canopy closure. Economic pressures, improvements in equipment and herbicides, and fast-growing genetic strains of trees have all reduced the amount of time to canopy closure, contributing to loss of early succession habitat. In addition, intensive site-prep techniques can reduce the quality and quantity of herbaceous cover during the early phases of stand establishment. Conversion of longleaf to loblolly pine hampers the ability of foresters to conduct controlled burns during the early years of tree growth. Thinning of mature trees creates another opportunity for understory habitat development, but most commercial operations leave too high a basal area after thinning for much benefit to be realized. "High grading" of mature timber stands, instead of clear-cutting, reduces the potential for early succession habitat creation.

- *Fire suppression* – Suppression of wildfires and lack of controlled burning eliminates an important source of early succession habitat creation and maintenance within many forested habitats. Concerns about uncontrolled fire, liability, air quality, social acceptance, and smoke management, and lack of landowners with the experience and equipment to conduct controlled burns have limited the use of fire on private lands.
- *Habitat loss and fragmentation* – Grass/shrub habitat is lost through the natural process of succession and also through conversion to other land uses. Human development in rural areas of the Piedmont is causing loss and fragmentation of agriculture and forest lands (U.S. Department of Commerce 1992), and hinders the use of prescribed fire. While some early succession species, such as northern mockingbird, song sparrow and black rat snake, have adapted well to human development, most of the priority species for this habitat are harmed by the encroachment of development. While most birds can rapidly find and colonize early succession habitat patches, some bird species (and grassland birds in particular) are area sensitive and will not use small patches of habitat surrounded by forest or developed areas. Bobwhite quail may require large (>5,000 acres) areas of contiguous habitat for long-term population viability (based on Guthery et al. 2000). The isolation of suitable early succession habitats may be most problematic for mammals and herptiles which have limited dispersal ability and may suffer high mortality when traveling through unsuitable habitats. Forest managers can increase connectivity of early succession habitats by planning forestry operations in adjacent stands or creating corridors between timber harvests.
- *Excessive mowing* – Early succession cover in powerline rights-of-way and roadsides is often adversely affected by too frequent or poorly timed mowing. In addition, many areas of fallow ground near houses or businesses are frequently mowed to maintain a neat appearance, while opportunities exist to convert some of these areas to suitable wildlife cover.
- *Public perception* –- Fallow or un-mowed areas are seen by many as "messy" and "weedy," and an indicator of a lack of caring or effort by a landowner. This widespread public perception is partially responsible for fallow habitats being reduced in habitat quality or eliminated.
- *Loss of historical Piedmont prairie* – Piedmont prairies contain highly diverse and specialized plant and insect communities. Currently, only small remnant tracts remain. Fire and/or low intensity agricultural operations are necessary to maintain prairie communities. Current restoration efforts are focused on plant conservation and have been implemented on small acreages that have limited value for area-sensitive grassland species such as grasshopper sparrow and eastern meadowlark. Grasslands of >20 acres should be pursued to benefit these species.
- *Exotic species* – The effects of exotic plants, insects, and animals on early succession habitat and native wildlife populations are poorly understood. Impacts are likely to vary widely depending on the species involved, environmental conditions, and management activities. Fire ants are a species of particular concern, especially regarding their potential impact on herpetofauna, small mammals, and ground nesting birds.
- *Collecting for the pet trade* – The impacts of commercial collecting of box turtles on local populations are unknown.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with early successional habitats. This need is particularly acute for mammals and reptiles.
  - Survey small mammals to determine the composition of the early succession mammal community in the Piedmont.
  - Determine the distribution of the least shrew, meadow jumping mouse and old-field mouse surveys (especially in Rutherford Co.).
  - Document the status and distribution of mole kingsnake, eastern kingsnake and eastern slender glass lizard and survey for more common amphibians and reptiles using early succesional habitats.
  - Determine the importance of early succession habitats for foraging bats.
  - Implement winter surveys for birds (and other taxa) to measure populations at the time of the year when early succession habitat may be most limiting.
  - Survey for grassland birds that are considered to be steeply declining, are not tracked well by typical survey methods, or have poorly understood distribution and status in the region (e.g., barn owl, grasshopper sparrow, Bachman's sparrow, eastern meadowlark and eastern kingbird).
  - Conduct nocturnal surveys for Chuck-will's-widow and whip-poor-wills, concentrating on foraging areas.
  - Determine vesper sparrow breeding status and loggerhead shrike status and distribution.
  - Conduct migration surveys to determine the extent of use of early succession habitats by post-breeding and migratory birds.
- **Monitoring** – We are aware of few long-term monitoring programs in the Piedmont that are focused on early succession habitats. The best information currently exists for birds (primarily through the Breeding Bird Survey and Christmas Bird Count, though also through Commission and Mecklenburg County Department of Parks and Recreation monitoring programs), while very little population status and trend information is available for mammals and herptiles. High priority should be given to developing monitoring systems for these taxa. The identification of "surrogate species" (those species who may be representative of the habitat needs of a particular guild of species and are widespread enough to allow population monitoring) will facilitate monitoring efforts. For birds we suggest the following surrogate species—Grasslands: eastern meadowlark, northern bobwhite and grasshopper sparrow; Shrublands: field sparrow, indigo bunting, blue grosbeak, prairie warbler, and yellow-breasted chat; Open Woodlands: red-headed woodpecker and brown-headed nuthatch. Surrogate species should be identified for mammal, amphibian, and reptile communities.
  - Develop monitoring systems to determine population trend information for grassland-dependent small mammals.
  - Establish MAPS, winter, and migration bird banding stations—especially in grasslands and hay fields.
  - Continue and expand long-term monitoring of grassland and scrub-shrub birds on Piedmont Game Lands and other public lands.
- **Research** – Research priorities should include understanding the factors that limit populations of at-risk species, and the development and refinement of habitat and population management strategies. Particular effort should be made to find habitat management strategies that are easy and cost-effective to implement on "working" lands. NC State University and other research colleges and universities in the state will be important partners in accomplishing some of these research goals.

Habitat use

- Examine the habitat requirements of habitat specialists and ways to integrate management for these species into commercial agriculture and forestry operations.
- Examine the minimum habitat patch and habitat complex size required to sustain populations of shrub-scrub and grassland birds and mammals. Some studies suggest that patch size may be an important factor affecting both birds (Lanham and Guynn 1998) and mammals (Yates et al. 1997).
- Evaluate the landscape context (amount of suitable habitat in surrounding landscape) for sites where rare species are found.
- Study the responses of bird communities to early successional habitat in managed landscapes and unmanaged landscapes.
- Evaluate the habitat requirements and management needs of grassland-dependent herpetofauna.
- Identify factors limiting populations of loggerhead shrike.

Populations and communities

- Examine impacts of cowbird parasitism and predation on neotropical migrant nesting productivity (e.g., hooded warbler, Kentucky warbler, eastern wood-pewee and worm-eating warbler).

Predator effects

- Identify predators of field sparrow nests, and other species with high nest depredation rates.
- Determine if cowbirds are negatively impacting bird productivity in portions of the western Piedmont with higher densities of livestock and cowbirds.
- Examine the impacts of fire ants on herpetofauna, small mammals, and ground nesting birds, in addition to large scale management actions that could be used to control fire ants.

Other

- Conduct economics and human dimensions research to determine how to make early succession habitat creation and maintenance more financially and socially acceptable for private landowners.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

With a convergence of interest in the conservation of early succession habitats by both game and non-game communities, there is a great opportunity to bring a lot of resources to bear on problems facing this habitat. Both the Northern Bobwhite Conservation Initiative (Dimmick et al. 2002) and the Partners in Flight Southern Piedmont Bird Conservation Plan (Cooper and Demarest 1999) call for similar actions to promote early succession habitat, and both game and non-game objectives have been incorporated into the Commission's early succession habitat initiative, the Cooperative Upland habitat Restoration and Enhancement (CURE) program.

Since the greatest opportunities for creating and maintaining early succession habitat in the Piedmont exists on private "working" lands, the highest priority for conservation actions should be to forge and expand partnerships and programs to promote early succession habitat management on agriculture and forestry lands. Many financial incentive programs are currently in place to facilitate management of private lands (particularly through the Farm Bill), including the Wildlife Habitat Incentives Program, the "bobwhite buffers" (CP-33) program, and CURE, which are designed explicitly to enhance early succession wildlife populations. The most limiting factor for implementation of these programs seems to be technical guidance manpower to solicit and work with private landowners. Potential partners for implementing conservation practices on private lands include but are not limited to the Natural Resources Conservation Service, Farm Services Agency, Soil and Water Conservation districts, Cooperative Extension, consulting foresters, land trusts, sportsman groups (like Quail Unlimited), US Fish & Wildlife Service Partners program, and the Commission.

The Commission has identified "focal areas" for early succession habitat work within the Piedmont and upper coastal plain for the CURE program (see Howell et al. 2002). These focal areas contain landscapes that are considered to provide the greatest potential for early succession habitat management on private lands. These focal areas should be used to prioritize and focus other early succession habitat initiatives. Furthermore, conservation efforts should be geographically clustered, to the extent possible, to create larger areas of contiguous early succession habitat.

Habitat management and restoration actions

- The greatest need and opportunity within private agricultural lands in the Piedmont is to increase the habitat value of pasture and hayfields. Conservation programs should promote the integration of native warm season grasses into livestock operations, and discourage haying or overgrazing during the nesting season.
- On row crop farms conservation actions should focus on using technical guidance and outreach to help promote establishment of field borders, no-till agriculture, fallow rotations, hedgerows, and native herbaceous and shrub plantings. We should proactively encourage the establishment of large blocks of habitat and increasing the connectivity of existing habitats by encourage neighboring landowners to work together to create larger-scale habitat areas. The Commission's CURE program provides one example of how such an effort could be implemented.
- Cooperative agreements and incentive programs should be forged with industrial timber companies to promote best management practices to enhance early succession habitat structure, maintenance and connectivity. An example of such an agreement is the Upper Tar River Memorandum of Understanding signed between International Paper and several North Carolina conservation organizations in 2004. While this agreement focused primarily on riparian habitats, it provides a framework and precedent for the type of voluntary conservation agreement that can be reached with timber companies. Successful promotion of early succession habitat enhancement on industrial timberlands will require an understanding of the financial costs of implementing those practices. The Wildlife and Industry Together (WAIT) program may help with this endeavor. Timber companies, Partners in Flight, Partners in Amphibian and Reptile Conservation, the NC Forest Service, and the Commission will all be important players.
- An effort should be made to encourage the use of controlled burning, including promoting the training of certified burners and addressing liability concerns and air quality concerns. A critical partner in this endeavor will be the NC Forest Service.
- An effort should be made to promote best management practices among non-industrial private timber managers. Practices that should be promoted include pre-commercial thinning, thinning to lower basal areas, controlled burning, minimizing the linear edge of harvest units, and planting longleaf pine where appropriate. Practices that should be discouraged include "high-grade" timber thinnings. Critical partners in this effort include private consulting foresters and the NC Forest Service.
- Sites with potential for restoration of Piedmont prairies should be identified and beneficial management should be proactively promoted. Sources of local-ecotype native seed should be developed for use in restoration projects. The Piedmont Prairie Partnership is providing a framework for those interested in prairie restoration.

Policy-based actions

- The current NC Use Value Assessment Program for assigning land taxes charges higher land taxes for land managed exclusively for wildlife than for land in agricultural or forestry production. This creates a financial disincentive for landowners to convert working lands into permanent wildlife cover. This tax code [including N.C.G.S. 105-160A-49(fl), 105-277.2 through 105-277.7, 105-289(a)(5) and (6), 105-296(j), and 106A-37(fl)] should be amended to include managed wildlife habitat in the same land valuation category as agriculture and forestry (Cobb et al. 2002).

– Land use planning should be promoted to minimize development within large, unfragmented tracts of farm and forestland, particularly within the CURE focal areas and in regions that are not yet experiencing heavy development pressure. Critical partners in this endeavor include county commissions and zoning boards, developers, the NC Department of Transportation, land trusts, and the American Farmland Trust.

Protection actions

– Conservation organizations should consider acquisition of upland agricultural habitats, which could be subsequently leased to tenant farmers with stipulations for favorable early succession habitat management practices. A high priority should be placed on acquiring sites with potential for restoration of Piedmont prairies.
– Easement programs that protect farm and forestland from development should be promoted, particularly within the CURE focal areas. Land trusts and the Natural Resources Conservation Service will be important partners.
– Educate the public on the value of early succession habitats and on the beneficial role of controlled burning. Teachers, nature centers, Cooperative Extension agents, foresters, and the Commission's Division of Conservation Education are among the educators who can help in this endeavor.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Barden, L.S. 1997. Historic prairies in the Piedmont of North and South Carolina, USA. Natural Areas Journal 17:149–152.

Brown, M. J., and R. M. Sheffield. 2003. Forest statistics for the Piedmont of North Carolina, 2002. Southern Research Station. U.S. Department of Agriculture, Forest Service, Asheville, NC.

Cobb, D.T., T.L. Sharpe, D. Sawyer, and D.O. Baumbarger. 2002. Integrating early-successional wildlife and habitats into North Carolina's 21st century landscape. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 56:124–135.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Davis, J.E. Jr., C. McRae, B.L. Estep, L.S. Barden, and J.F. Matthews. 2002. Vascular flora of Piedmont Prairies: Evidence from several prairie remnants. Castanea 67:1–12.

Dimmick, R.W., M.J. Gudlin, and D.F. McKenzie. 2002. The northern bobwhite conservation initiative. Miscellaneous publication of the Southeastern Association of Fish and Wildlife Agencies, South Carolina.

Guthery, F.S., M.J. Peterson, and R.R. George. 2000. Viability of northern bobwhite populations. Journal of Wildlife Management 64(3):646–662.

Howell, D. L., D. T. Cobb, and T. L. Sharpe. 2002. Selection of focal areas for northern bobwhite habitat enhancement on private lands in North Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:159–170.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29(2): 440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Johnson, D.H., and L.D. Igl. 2001. Area requirements of grassland birds: a regional perspective. The Auk 118 (1): 24–34.

Lanham, J.D., and D.C. Guynn. 1998. Habitat-area relationships of shrub-scrub birds in South Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 52:222–231.

Litvaitis, J.A. 2001. Importance of early successional habitats to mammals in eastern forests. Wildlife Society Bulletin 29:466–473.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

Thompson III, F.R., and R.M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29(2):483–494.

U.S. Department of Commerce. 1992. Census of agriculture, North Carolina state and county data. Econ. And Stat. Admin. Bur. Census. U.S. Government Printing Office, Washington, DC.

Warner, R.E. 1994. Agricultural land use and grassland habitat in Illinois: future shock for midwestern birds? Conservation Biology 8:147–156.

Yates, M.D., S.C. Loeb and D.C. Guynn. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:501–510.

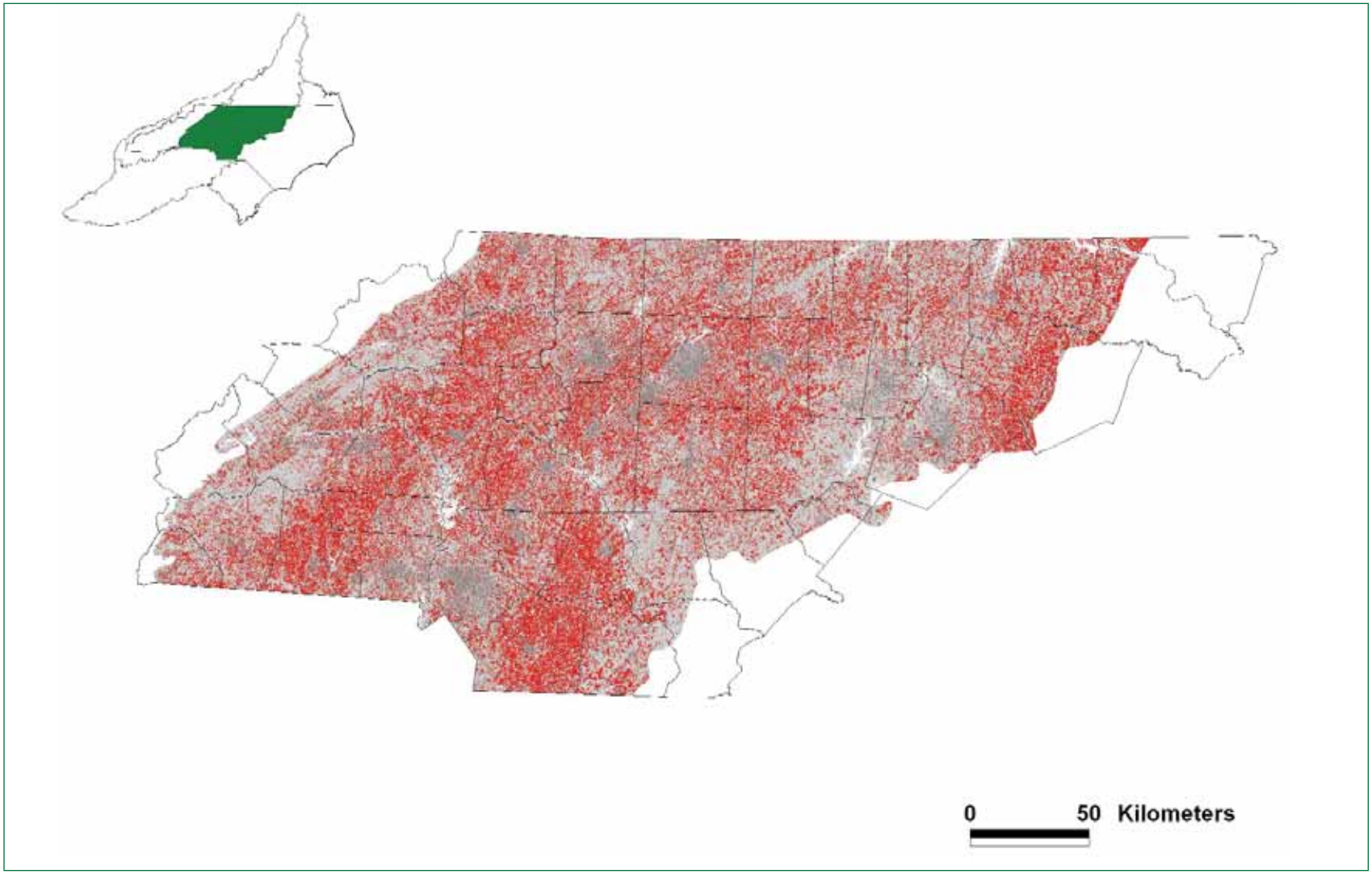


Figure 5A.16. Early successional habitats (including agricultural areas) in the Piedmont ecoregion of North Carolina (in red) (data source: NC GAP, 1992). *Note: Due to the ephemeral nature of these habitats, this coverage may not be entirely accurate as of 2005. However, it should still give readers an indication of the extent of these habitats across the region.*

17. **Floodplain forest** – Piedmont floodplain forests generally do not contain significant recognizable elevation differences easily seen in the larger coastal floodplain systems. In these smaller floodplains, the relief and size of the fluvial landforms (levees, sloughs and ridges), which differentiate the communities in large floodplains, become smaller and harder to find (Schafale and Weakley 1990). In larger and more expansive examples of these floodplains, the forest canopy contains a good mixture of bottomland and mesophytic (moderately moisture tolerant) plant species, such as green ash, red maple, swamp chestnut oak, willow oak, and American elm. In areas where floodplain landforms are apparent, levees may contain sycamore, river birch and box elder. Floodplain areas that have been farmed or clearcut recently are usually dominated by tulip poplar or sweetgum.

    Piedmont floodplain communities include Piedmont Levee Forest, Piedmont Swamp Forest, Piedmont Bottomland Forest, Floodplain Pool, Piedmont Semipermanent Impoundment and Piedmont Alluvial Forest (Schafale and Weakley 1990). Piedmont Alluvial Forest is quite common as a habitat type although the vegetative buffers surrounding them can be quite small or fragmented. Some of the best remaing examples of Piedmont Bottomland Forest and associated large floodplain communities are at New Hope Creek Bottomland in Durham County, Pee Dee National Wildlife Refuge in Anson and Richmond Counties, and along the Dan River. The widest floodplains are located within Triassic Basins, which contain more easily erodable sedimentary rock than are found elsewhere (metamorphic rock).

    Piedmont Alluvial Forests are distinguished from larger floodplain communities by the absence or poor development of the depositional fluvial landforms, which determine vegetation (Schafale and Weakley 1990). Levees, sloughs and ridges may be visible in alluvial forest communities but are usually small. Variation in these sites is likely related to frequency and recentness of large-scale flood events.

    Historically, many floodplains were maintained in switch cane (*Arundinaria gigantea*) and herbaceous plants through fire and other periodic disturbance. Small remnants of "canebrake" communities still exist throughout the Piedmont, but management strategies to maintain this feature are almost non-existent. Migratory landbirds that use switch cane areas for breeding include hooded warbler, Kentucky warbler and Swainson's warbler.

    Floodplain pools that occur in small depressions and are flooded for a portion of the year generally have few or no trees and are especially important sites for breeding amphibians such as spotted salamander, marbled salamander, four-toed salamander and many frogs. Piedmont floodplains are also important as movement corridors for mammals, reptiles, and amphibians. Birds use riparian corridors at all times of the year and these areas are especially important to neotropical migrants during the migration periods. Indeed, floodplain forests generally have the highest nesting bird concentrations in the state and they are arguably the most important habitats for birds. In general, our knowledge about how wildlife use altered or fragmented habitat is lacking especially for animals other than birds or bats (Ellis et al. 2002) and we need to develop more accurate and usable protocols for sampling many species using floodplains such as amphibians to better understand status, distribution and life histories (Taylor and Jones 2002).

A. Location and condition of habitat (see Map 5A.17):

Floodplain forests of some type are found beside most rivers and streams in the Piedmont. They are of varying widths, depending upon the topography of land adjacent to the river, and the transition between floodplain and upland forest is often gradual. In 2002, 150,900 acres in the Piedmont were classified as oak-gum-cypress and 97,000 acres as elm-ash-cottonwood for a total of 247,900 acres of bottomland-related trees, or a little over 2% of the land area in the Piedmont (Brown and Sheffield 2003).

Human-influenced alterations have affected much of the Piedmont's riverine and floodplain habitats. Logging, clearing land for agriculture, development, recreational use, and reservoir construction all cause direct loss and alteration of floodplain forests. In the past half century, an estimated 52% of bottomland forests in the south have been cleared for agriculture or development (Smith et al. 2001). Land clearing activities conducted adjacent to, and up and

Priority species associated with piedmont floodplain forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Caprimulgus vociferus*	Whip-poor-will	
	Coccyzus americanus	Yellow-billed Cuckoo	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Haliaeetus leucocephalus	Bald Eagle	T (T)
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Limnothlypis swainsonii	Swainson's Warbler	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Nyctanassa violacea	Yellow-crowned Night-heron	
	Oporornis formosus	Kentucky Warbler	
	Picoides villosus	Hairy Woodpecker	
	Scolopax minor	American Woodcock	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	T
	Lasiurus seminolus	Seminole Bat	
	Myotis austroriparius	Southeastern Bat	SC
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma talpoideum	Mole Salamander	SC
	Eurycea guttolineata	Three-lined Salamander	
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla versicolor	Northern Gray Treefrog	SR
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
Reptiles	*Clemmys guttata*	Spotted Turtle	
	Clemmys muhlenbergii	Bog Turtle	T (T)
	Crotalus horridus	Timber Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Lampropeltis getula getula	Eastern Kingsnake	
	Terrapene carolina	Eastern Box Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

down-stream of floodplain forests can cause indirect impacts to the floodplains, particularly related to hydrology. Areas adjacent to floodplains are often prime targets for general development and subdivisions, and buffer size is often inadequate to provide any protection from a variety of anthropomorphic disturbances over time. For instance, flooding events may occur with greater frequency in some areas due to increased upstream impervious surfaces and clearing of vegetation near buffers.

Managed river flows from dams have altered the natural flow regime, and in particular have impacted the timing and intensity of overbank flow into the floodplain, altering both water and sediment deposition. The input of nutrients from flood events makes levee sites along streams and rivers very fertile, and overbank flows help to recharge vernal pools in the wetland. Changes in flow regimes may eventually lead to changes in the floodplain plant and animal communities (Schafale and Weakley 1990).

Sediment pollution is a major concern in most stream and river systems in the Piedmont. The condition of some Piedmont floodplain forests is greatly degraded by these impacts. The Pee Dee and Dan River basins contain some of the larger tracts of intact floodplain forest left in the Piedmont and offer some of the best opportunities for large-scale habitat conservation. Beaver activity and the creation of beaver ponds in floodplain forest can have substantial impacts on trapping sediment and associated pollutants.

Exotic plant species such as Japanese honeysuckle, Japanese grass and Chinese privet are frequent invaders in small floodplain systems, especially if these areas have been logged in the past. The reduction in overall plant diversity is often extensive due to these invasive non-native plants and may cause problems for native fauna, though the extent of wildlife impacts is largely unknown.

Floodplain sites are often prime candidates for farmlands, and few bottomlands of any large size remain. Intact Bottomland Forests, especially without exotic species invasion, are among the rarest of natural communities in North Carolina (Schafale and Weakley 1990). Floodplain Pools are widespread in the Piedmont but are generally small in size. Pools that dry out less frequently (or seldom dry out) can develop permanent aquatic communities (with fish) that are often unsuitable for breeding amphibians. Sediment pollution is now a major problem for many floodplain pools in the Piedmont.

B. *Problems affecting species and habitats:*

- *Direct habitat loss* – Riparian forests have become scarce in the Piedmont because many of these areas are now used for food and fiber production. Additionally, many riparian areas were lost to create reservoirs, and some have been cleared for development. Many are damaged by construction of sewerlines, which are built almost exclusively in floodplains.
- *Altered hydrology* – The most significant source of habitat alteration is altered hydrology. Altered hydrology changes plant communities and also affects the availability of ephemeral wetlands for breeding amphibians. Building ditches and canals in floodplains dramatically alters hydrology and is often done to prepare a floodplain for agriculture, forestry, or development. Even in abandoned sites, ditches will continue to alter the hydrology for many decades. Bank stabilization efforts can alter riverine dynamics that create oxbow lakes and some ephemeral wetland habitats important to amphibians. Controlled flows downstream of dams and the construction of levees can reduce overbank flood events which are important for recharging ephemeral wetlands and spreading nutrients in the floodplain. However, excessive flooding can also be problematic. Increased severe flooding can be caused by reduction of vegetated floodplains and increases in impervious surfaces in the uplands. Dams can alter the timing and duration of flood events. Flooding for long periods of time during the breeding season can harm plant and animal reproduction and severe floods also threaten human safety and property.
- *Habitat fragmentation* – As floodplain forests are lost or altered, the remaining tracts of forest become smaller and more isolated. New highways and other corridors are often constructed across floodplains, fragmenting the floodplain forest. Floodplains are used as travel corridors by many species and fragmentation may alter dispersal and migration patterns. Reptiles and amphibians may be particularly vulnerable to reduced movement when the matrix surrounding the forest becomes unsuitable. The reduced size of remaining forest patches may impact area sensitive birds (Kilgo et al. 1998) and small mammals (Yates et al. 1997). Clearing of adjacent uplands can increase edge effects and limit the effective size of floodplain forest habitat.
- *Lack of old growth dynamic* – Old growth floodplain forests contain large diameter trees, snags, dead wood, and canopy gaps that support dense undergrowth. Some younger riparian forests and those that lack periodic habitat disturbance can have a reduced number of snags. Snags play a very important role in providing nesting, foraging, and roosting areas for many cavity nesting birds, bats, arboreal mammals, reptiles and amphibians. Lack of snags and den trees is often a limiting factor for several species of wildlife, especially secondary cavity users (McComb et al. 1986). Younger riparian forests can also lack dead wood on the ground,

which is important for some songbirds (e.g., Kentucky warbler), many reptiles, amphibians, and some small mammals. Habitat disturbance can be important for creating canopy gaps which create small pockets of dense, low growth (valuable for nesting for Swainson's warbler, hooded warbler, Kentucky warbler and wood thrush), provide cover for American woodcock, and are valuable foraging areas for many juvenile birds. Stream snagging (clearing woody debris within stream channels) after storms can reduce habitat structure, particularly for reptiles and amphibians among terrestrial creatures (*aquatic organisms are covered under the river basin sections in this Plan*). Snagging can also alter river hydrology and morphology. "High grade" logging operations removes the larger trees that provide important habitat structure for wildlife, while the low-quality trees that are left can often hamper the regeneration of more wildlife-favorable trees.

- *Water quality* – Poor water quality due to nutrient inputs, reduced dissolved oxygen levels, sedimentation, and chemical contamination (among others) can have a strong impact on amphibians, turtles, and other animals associated with floodplain forests that forage or breed in aquatic areas, in addition to the direct impacts on fully aquatic species. Sediment pollution is a major problem in the Piedmont of North Carolina. (*See river basin sections for further discussion of water quality issues within specific basins*).
- *Exotic plants* – Japanese grass (*Microstegium vimineum*) can suppress the growth of other plants, alter habitat structure, and has little wildlife value. Other common invasive plants that impact floodplain community structure include Chinese Privet and Japanese honeysuckle, though these plants have some limited wildlife value. In general, the density of exotic, invasive plants in small to medium sized floodplain forests in the Piedmont is significant though the resulting impact on wildlife populations is largely unknown.
- *Loss of canebrake communities* – Historical data indicate that extensive stands of switch cane (*Arundinaria gigantea*) have been drastically reduced throughout the Piedmont. Cane communities are maintained through fire or other periodic disturbance. While fires would likely not burn very hot or well through many floodplains due to the moist soils, floodplains with extensive canebrakes historically burned periodically, which helped to maintain and expand these canebrakes. Canebrakes benefit Swainson's warbler, Kentucky warbler, hooded warbler, wood thrush, American woodcock, and timber rattlesnake, among others. Fire suppression and development adjacent to floodplains has contributed to a loss of large canebrakes, which have been replaced primarily by other woody vegetation.
- *Commercial collecting of turtles* – The extent of commercial collecting of bog turtle and spotted turtle for the pet trade, and its impact on local populations is unknown, but potentially a problem.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on floodplain communities. Bat surveys and amphibian surveys are considered high priorities for this habitat. Secondary priority for surveys should be for species for which current distribution information is already available, or for species that are generalists in terms of habitat usage.
  - Determine the breeding distribution and status of floodplain associated bird species (e.g., Swainson's warbler and Louisiana waterthrush).
  - Conduct nocturnal surveys to determine the population status and distribution of Chuck-wills-widow and Whip-poor-will.
  - Inventory heron and egret rookeries.
  - Determine the distribution and population status of bats in Piedmont floodplain forests. Few systemic surveys have been conducted throughout the Piedmont region; most of these surveys have been conducted or coordinated by the NC Museum of Natural Sciences. In addition to Rafinesque's big-eared bat, Seminole bat, and southeastern bat, it is possible that other priority bats may be found in the Piedmont. Northern yellow bats may occur in the eastern Piedmont, and northern long-eared bats may occur in the western Piedmont. Hoary bats have been detected in acoustical surveys along the Pee Dee river.

- Determine the distribution and population status of terrestrial small mammals, like golden mouse and shrews, in Piedmont floodplain forests.
- Determine the status and distribution of mole salamander, four-toed salamander, gray treefrog, and timber rattlesnake (and conduct surveys to determine the distribution and status of many common reptiles and amphibians).
- Identify both breeding sites and travel corridors for bog turtle in the northwestern Piedmont.

- **Monitoring** – Few of the existing monitoring efforts adequately cover floodplains (e.g., the Breeding Bird Survey does not adequately sample floodplains).
  - Establish selective monitoring systems for bird species that are difficult to detect by conventional survey protocols (e.g., Swainson's warbler, Kentucky warbler and other floodplain bird species). (A monitoring program for birds in floodplain forests on Caswell Game Land, Caswell County, was initiated by the Commission in 2004).
  - Establish more MAPS and migration-period bird banding stations.
  - Conduct long-term monitoring of heron and egret rookeries.
  - Continue monitoring of bald eagle nesting territories.
  - Initiate long-term bat population monitoring.
  - Initiate long-term reptile and amphibian monitoring in floodplain pools in particular.

- **Research**

  Predator effects
  - Conduct studies about nesting success, productivity and survival of floodplain birds in buffers of different widths; this could provide some insight into population declines and help to guide management recommendations for buffer width.

  Habitat use
  - Identify those reptile and amphibian species that are most vulnerable to direct mortality and isolation from roads. Strategies to mitigate the impacts of roads should be devised and tested.
  - Determine the extent of the use of floodplains as travel corridors for bog turtle in the western Piedmont; determine any management actions that are needed to facilitate use by bog turtles.
  - Determine the extent and timing of use of riparian corridors by birds during the migration period.

  Management practices
  - Evaluate the distribution, impacts on native wildlife, and feasibility of control of feral hogs, which are very common at inner coastal sites along major rivers adjacent to the Piedmont (e.g., Howell Woods in Johnston County), and are found sporadically throughout the Piedmont.
  - Examine ways to effectively restore canebrake communities, and determine the response of birds, mammals, amphibians and reptiles to the reestablishment of switch cane stands.
  - Study the effects of various river flow regimes on ephemeral pool habitat in floodplains, to help develop management recommendations for dam releases. This research will be particularly critical to help guide management recommendations in the Federal Energy Regulatory Commission relicensing process for dams along the Yadkin, Pee Dee, and Catawba rivers.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Conservation of floodplains is complicated by the fact that many conservation actions also require protection of associated uplands and upstream riparian systems. However, floodplains are the highest priority habitat for conservation in the Piedmont because of their importance to birds (Cooper and Demarest 1999), bats, and herpetofauna. Intact floodplains are equally important for protecting aquatics habitats.

Habitat management and restoration actions

- Restoration projects are needed to create oxbow lakes, shallow wetlands, snags, and canopy gaps in appropriate locations. Smith et al. (2001) indicate that small openings (<0.26ha) comprising <22% of the total area of old-growth bottomland forest may help enhance bird species diversity. Incentive programs for landowners (like the Forest Landbird Legacy Program) could encourage reforestation or structural improvement of floodplain forests.
- In managed rivers, restore stream flows that promote controlled overbank flows and hydrological connectivity between the river and the floodplain.
- Opportunities to restore cane break communities should be sought, through controlled burning or other management.
- Large trees should be maintained around reservoirs for potential eagle nests, and forest cover should be maintained in the tailrace below dams for eagle foraging.
- Population control of feral hogs may be necessary in some areas in the near future.
- Greenways maintained for public recreation should be created and managed to reduce the width of pedestrian paths so that the overhead tree canopy is not broken, and native plant communities are not degraded (Novotny 2003, Hull 2003).

Policy-based actions

- Land use planning and zoning laws are needed to limit development, land clearing, and hydrology alterations within floodplains (e.g., route highways and other corridors that cross floodplains as closely as possible to existing corridors to avoid fragmenting an extensive corridor of forest; try to avoid routing sewerlines through high quality floodplain).
- Promote stormwater management regulations and efforts to control point source pollution.

Protection actions

- Land acquisition and/or conservation easements are key to maintaining or restoring connectivity between forest stands. Land protection efforts should be targeted to enhance the size and connectivity of existing protected areas.
- Establishment and conservation of large riparian buffers and land in the adjacent uplands could benefit many neotropical migrants, as well as other taxa. Riparian buffers should be at least 100m wide to benefit breeding area-sensitive forest birds (Keller et al. 1993, Hodges and Krementz 1996). For private lands, Cooper and Demarest (1999) recommend buffers of 30m per side on order 1–2 streams, 100m per side on order >3 streams, and 500m per side on all rivers.
- Minimize land clearing and disturbance around eagle nests and heron rookeries.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Brown, M.J. and R.M. Sheffield. 2003. Forest statistics for the Piedmont of North Carolina, 2002. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. Resource Bulletin SRS-86.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:210–218.

Hodges, M.F. and D.G. Krementz. 1996. Neotropical migratory breeding bird communities in riparian forests of different widths along the Altamaha River, Georgia. Wilson Bulletin 108(3): 496–506.

Hull, Jamie R. 2003. Can urban greenways provide high quality avian habitat? Masters Thesis, N.C. State University, Raleigh, NC.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Keller, Cherry M. E., Chandler S. Robbins, and Jeff S. Hatfield. 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. Wetlands 13(2):137–144.

Kilgo,J.C., R.A. Sargent, B.R. Chapman, and K.V. Miller. 1998. Effect of stand width and adjacent habitat on breedig bird communities in bottomland hardwoods. Journal of Wildlife Management 62(1): 72–83.

McComb, W.C., S.A. Bonney, R.M. Sheffield and N.D. Cost. 1986. Den tree characteristics and abundance in Florida and South Carolina. Journal of Wildlife Management 50(4):584–591.

Novotny, Kristen E. 2003. Mammalian nest predator response to greenway width, habitat structure, and landscape context. Masters Thesis, N.C. State University, Raleigh, NC.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Smith, W.P., H.E. Hunt, and W.K. Townley. 2001. A comparison of breeding bird communities and habitat features between old-growth and second-growth bottomland hardwood forest. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. Gen. Tech. Rep. SRS 42.

Taylor, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

Yates, M.D., S.C. Loeb and D.C. Guynn. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:501–510.

Piedmont Ecoregion

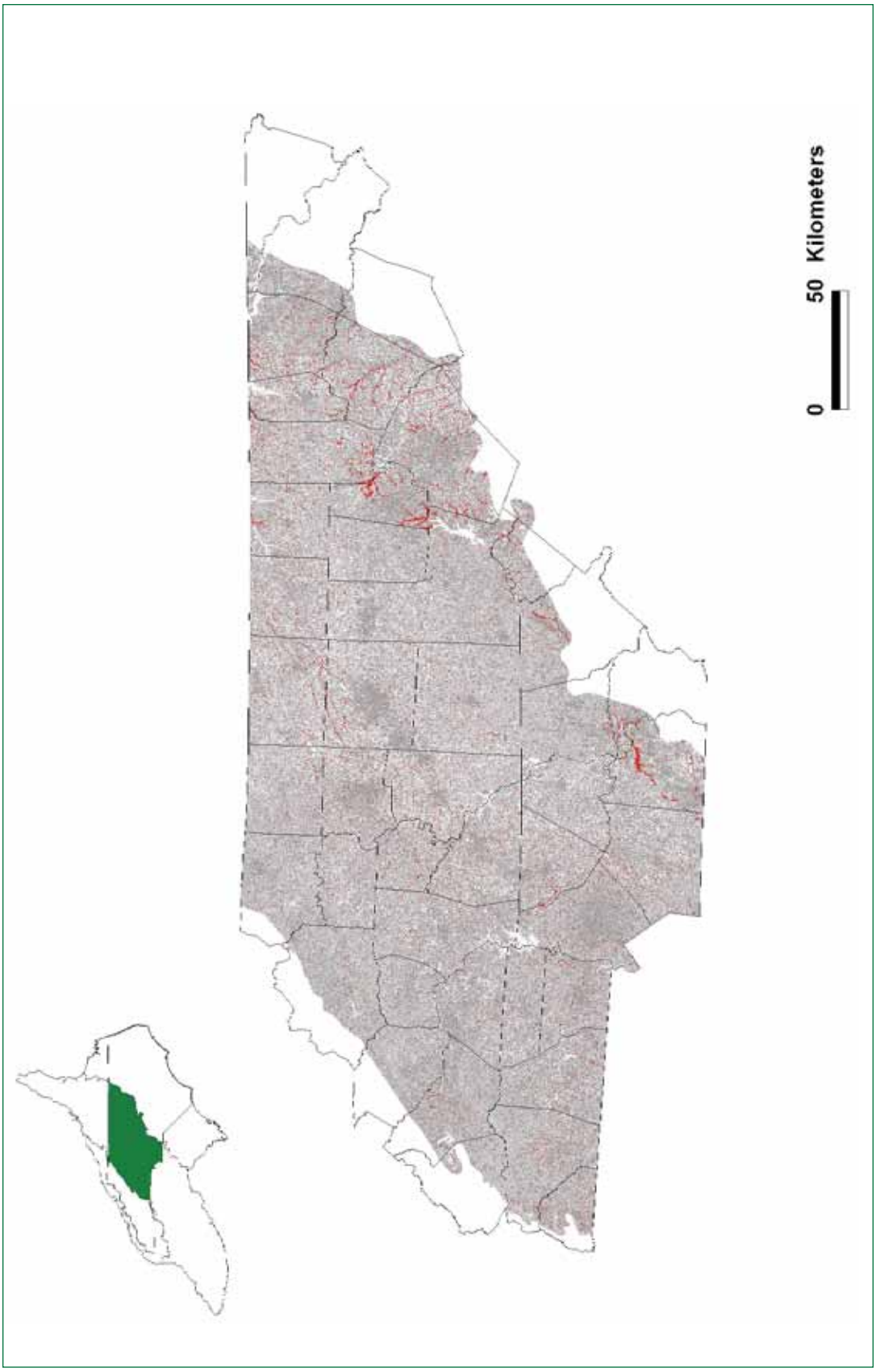


Figure 5A.17. Floodplain forest habitat in the Piedmont ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

18. **Small wetland communities** – This habitat type can include vernal pools, seeps, small depression ponds, ephemeral wetlands and beaver ponds. Some depressions may hold water for a significant portion of the year; others may be saturated for only a few months. All Piedmont wetland habitats are especially important as breeding sites for amphibian species. Small wetlands can also be important breeding habitat for crayfishes (*for more about crayfishes and other aquatic taxa, see the individual river basin sections*). Wading birds, waterfowl, and songbirds, too, may also use small wetland communities for nesting and feeding areas. (*Note: western Piedmont bog habitats are covered under the "Bogs and associated wetlands" section in the Southern Blue Ridge portion*).

    Piedmont communities in this category include Upland Pool, Upland Depression Swamp Forest, and Low Elevation Seep (Schafale and Weakley 1990). Upland Pools are a rare habitat type in the Piedmont, dominated by wetland shrubs and herbs and are small depressions where water is ponded by an impermeable substrate. Tree species along the edge of these habitats may include black gum, water oak, red maple, and sweet gum. Shrubs may include buttonbush, blueberries, and swamp doghobble. Royal ferns, sedges, sphagnum, and other mosses are found in the herb layer. Upland Depression Swamp Forest occurs on poorly drained upland flats or depressions scattered throughout the Piedmont. These communities often have several tree species present (e.g., willow oak, red maple, sweet gum) with a sparse shrub layer such as blueberry, black haw, or arrowwood (Schafale and Weakley 1990). Low Elevation Seeps are found at the edge of floodplains or the base of slopes and are generally covered in a variety of herbaceous species (though usually lacking in sphagnum moss).

Priority species associated with piedmont small wetland communities:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Melanerpes erythrocephalus*	Red-headed Woodpecker	
	Nyctanassa violacea	Yellow-crowned Night-heron	
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma talpoideum	Mole Salamander	SC
	Ambystoma tigrinum	Eastern Tiger Salamander	T
	Eurycea guttolineata	Three-lined Salamander	
	Eurycea quadridigitata	Dwarf Salamander	SC
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla gratiosa	Barking Treefrog	
	Hyla versicolor	Northern Gray Treefrog	SR
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Clemmys guttata*	Spotted Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat[1]*:*

Piedmont wetland habitats are heavily impacted, and have been greatly reduced, by development, roads and drainage throughout the region. While often small in size, cumulatively these habitats provide critical breeding habitat for many amphibian species. The loss of ephemeral wetland communities in the Piedmont has strong ramifications for future amphibian populations.

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

Beaver ponds are a natural community, but result from modification of other community types. Beavers were extirpated in North Carolina by the late 1800s, due to the high demand for beaver pelts, but were reintroduced in 1939. Since that time, beaver recovery has been wildly successful, resulting in an increase in wetland habitat, but also an increase in complaints about beaver-caused damage to private property (e.g., flooding in agricultural areas). With stable beaver populations, beaver ponds can be maintained for decades. However, beaver-caused damage to trees and property has resulted in the destruction of many beaver dams. A reduction of beaver ponds will place more importance on man-made ponds as the primary habitat for many lentic aquatic species. Dead trees in beaver ponds are important foraging and nesting habitat for woodpeckers, such as the red-headed woodpecker, and for wood duck nesting.

B. *Problems affecting species and habitats:*

- *Roads* – Increased road densities are correlated with declines in amphibian diversity and abundance (Vos and Chardon 1998, Findlay et al. 2001, Fahrig et al. 1995). Roads can cause heavy mortality for reptiles and amphibians and can effectively isolate breeding populations, or separate wetland habitats from upland habitats that are used during non-breeding portions of amphibian and reptile life cycles.
- *Water quality* – Increases in impervious surfaces causes excess stormwater runoff and pollution from point and non-point sources, which degrades water quality. Most amphibians are highly sensitive to changes in water quality.
- *Drainage* – Some wetland communities are drained for agriculture or development, causing direct habitat loss. Loss of ephemeral wetland habitats severely impacts amphibians (Bailey et al. 2004).
- *Alteration of hydrology* – Cutting ditches through wetlands can alter their hydrology and habitat quality. Excess stormwater runoff can also change wetland hydrology.
- *Introduction of fish, bullfrogs, and other predatory species* – Ephemeral and isolated wetlands are very valuable to amphibians because they typically do not support fish and other predators of amphibian eggs. The introduction of fish, bullfrogs, and other predatory species can devastate the breeding effort of amphibians in small wetlands.
- *Timber harvest* – Clearcutting near ephemeral wetlands causes higher solar radiation and an increase in probability of wetlands drying out; also, timber harvest may introduce weedy plant invasions of wetlands.
- *All Terrain Vehicles* – The excessive use of all terrain vehicles (ATVs) and other recreational vehicles can cause significant damage around wetland communities. ATVs can cause soil disturbance, increase erosion and sedimentation, elevate vehicle related mortality rates, and cause noise-related disruptions of faunal activities (Bailey et al. 2004).

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Identify the location of key small wetland communities in the Piedmont.
  - Initiate distribution surveys for all amphibian species associated with small wetland communities, but especially the mole salamander, eastern tiger salamander, dwarf salamander, and four-toed salamander.
  - Gather better information about the status and distribution of more common species associated with Piedmont wetland habitats (e.g., three-lined salamander, common ribbonsnake).
  - Determine woodpecker use of dead trees in beaver ponds.
- **Monitoring**
  - Determine population trends and persistence of small wetland breeding amphibian populations, particularly mole salamander, eastern tiger salamander, dwarf salamander, and four-toed salamander.

- **Research**
  - Focus habitat use studies on bats and small mammals to clarify how small mammals and bats use these wetlands; little is known about the value of small wetland communities in the Piedmont for those groups.
  - Study the efficacy and practicality of "toad tunnels" and other wildlife crossings that allow passage under roadways and help maintain connectivity between wetland metapopulations.
  - Determine minimum upland buffers required to sustain at-risk amphibian populations.
  - Explore management strategies to eradicate undesirable species, such as bullfrogs, from wetlands..

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

A high priority should be placed on protecting wetlands and adjacent uplands through acquisition or easement. Seasonal wetlands must have sufficient surrounding habitat in order to support the life history requirements of amphibian and reptile populations. Every effort should made to maintain continuous gradients between wetland and upland sites; roads, agriculture, or forestry operations between complimentary sites may render them ineffective at supporting amphibian and reptile populations (Bailey et al. 2004). Land trusts can be a valuable partner in this effort.

Wetland restoration efforts should focus on restoring the natural hydrology, water quality, and plant communities of degraded wetlands, and on creating new ephemeral wetlands in suitable locations. The Natural Resources Conservation Service's Wetlands Reserve Program provides a good tool for promoting wetland conservation on private lands. Several sources of information are available (Biebighauser 2002, Thompson and Luthin 2004, EPA 1993) to assist in constructing and restoring wetlands. The Ecosystem Enhancement Program will likely play a key role in wetland protection and restoration in North Carolina.

There is great need to promote the adoption of agricultural and forestry best management practices that reduce run-off, erosion, and pollution. The federal Farm Bill and other cost share programs provide incentives for land stewards to adopt these practices. Technical guidance manpower is needed to proactively promote and facilitate participation in these programs.

Beaver ponds can be a nuisance to landowners when they flood farm fields or commercial timber. Several techniques have been developed to minimize beaver damage while maintaining some benefit from impounded waters. The Beaver Management Assistance Program administered by US Department of Agriculture Wildlife Services offers assistance with lethal and non-lethal beaver management. Perhaps an even more effective way to mitigate beaver damage suffered by landowners is through property tax incentives. Strategies to promote techniques for managing beaver damage that minimize the loss of quantity and quality of beaver ponds should be explored.

Strategies for the effective removal of introduced aquatic predators must also be developed, and a mechanism for identifying and prioritizing sites for removals worked out.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Biebighauser, T.R. 2002. A guide to creating vernal ponds. U.S. Department of Agriculture, Forest Service, Morehead, KY.

Environmental Protection Agency (EPA). 1993. Constructed wetlands for wastewater treatment and wildlife habitat. Publication EPA832-R-93-005.

Fahrig, L., J. H. Pedlar, S. E. Pope, P. D. Taylor, and J. F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177–182.

Findlay, C. S., J. Lenton, and L. G. Zheng. 2001. Land-use correlates of anuran community richness and composition in southeastern Ontario wetlands. Ecoscience 8:336–343.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Somers, A. B., K. A. Bridle, D. W. Herman, and A. B. Nelson. 2000. The restoration and management of small wetlands of the mountains and piedmont in the Southeast: a manual emphasizing endangered and threatened species habitat with focus on bog turtles. The Watershed Science and Wetland Science Institutes of the Natural Resources Conservation Service, the University of North Carolina at Greensboro, and Pilot View Resource Conservation and Development, Inc.

Thompson, A.L. and C.S. Luthin. 2004. Wetland restoration handbook for Wisconsin landowners. 2nd edition. Wisconsin Department of Natural Resources, Madison, WI.

Vos, C. C., and J. P. Chardon. 1998. Effects of habitat fragmentation and road densities on the distribution pattern of the moor frog (*Rana arvalis*). Journal of Applied Ecology 35:44–56.

19. **Riverine aquatic communities** – Piedmont riverine habitats are important for a number of wildlife species that utilize aquatic habitats during part or all of their life cycle. Terrestrial species that are dependent upon riverine aquatic communities are often also intimately tied to floodplain forest habitats. Many of the issues from the floodplain forest section will also have relevance for these taxa. Examples for birds that utilize river and streams include the Louisiana waterthrush, some waterfowl, wading birds and some shorebirds. Piedmont riverine habitats are important for a number of reptiles and amphibians including certain turtles, frogs, and salamanders that utilize aquatic habitats during part or all of their life cycle. These habitats are also important for a variety of mammals that are semi-aquatic and/or that have an aquatic food base (e.g., muskrats, beavers, river otters, and certain bats).

    Piedmont rivers and streams provide a number of important habitat, life cycle, or prey components to a vast assemblage of terrestrial, semi-aquatic, and aquatic wildlife. In addition, the importance of maintaining water quality of riverine habitats cannot be overstated, both in terms of the species that rely upon rivers and streams for habitat, as well as those species which rely indirectly upon the habitat by virtue of provision of habitat for their prey.

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basin portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

Priority species associated with piedmont riverine aquatic habitat:

Group	Scientific Name	Common Name	State Status (Federal Status)
Amphibians	*Eurycea guttolineata*	Three-lined Salamander	
Reptiles	*Apalone spinifera aspera*	Gulf Coast Spiny Softshell	
	Farancia abacura abacura	Eastern Mudsnake	
	Kinosternon baurii	Striped Mud Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat[1]:

Riverine aquatic communities are found alongside and within all Piedmont rivers. Human-influenced alterations have affected much of the Piedmont's riverine and floodplain habitats. Water quality and quantity have been impacted by run-off from municipalities, some poorly managed agricultural operations and especially sediment pollution from construction and road building. Dam construction has altered flows and river hydrology and morphology. Removing woody debris from streams after storm events has influenced in-stream habitat structure. The ecological condition of some Piedmont rivers is greatly reduced due to these impacts. However, some sections of Piedmont rivers are designated High Quality Water and Outstanding Resource Water Management Zones and provide excellent opportunities for maintaining relatively pristine waterways (*see Broad, Catawba, Yadkin-PeeDee, Roanoke, Cape Fear, Neuse, and Tar-Pamlico River Basin sections*).

B. Problems affecting species and habitats:

Water quality deterioration, and changes in river morphology and hydrology are the most serious problems affecting wildlife that utilize riverine habitat. Water pollution, originating from both point and non-point sources, continues to pose a threat directly to species that occur in riverine habitat, and also impacts these species indirectly through alteration of the food base or habitat.

[1]See the basin maps associated with the Broad, Catawba, Yadkin-PeeDee, Roanoke, Cape Fear, Neuse, and Tar-Pamlico River basins.

– *Urban runoff* – A high priority concern is runoff from impervious surfaces. As more of a watershed is paved, flooding after storm events can become more severe, causing scouring and sedimentation in rivers. Scouring flows can strip salamander eggs from river banks and vegetation, reducing reproductive success. Lawn pesticides, road oil, and other pollutants are also carried into waterways. Direct and indirect impacts of decreased water quality upon wildlife associated with riverine habitat are difficult to quantify, and have not been as fully explored as have impacts upon fully aquatic species. However, there is little doubt that clean water is critical to a host of species that live in rivers and streams for a portion of their lives, and that sedimentation, channel scour, and other alterations of the physical habitat can lead to both deterioration of the habitat quality and negative impacts upon aquatic flora and fauna, which form the base of the food web for numerous wildlife species.

– *Agricultural runoff* – Another potential source of pollution is runoff of pesticides, fertilizers, and sediment from agricultural row crop fields. These problems are most severe where there are not sufficient vegetated buffers between agricultural fields and waterways. The presence of drainage tiles can circumvent the benefit of vegetated borders by carrying runoff directly to waterways.

– *Livestock operations* – Cattle that water in rivers and streams can cause bank erosion and increase sedimentation downstream. To alleviate this problem, cattle should be fenced out of natural waterways and provided with alternative water access.

– *Impoundments* – River and stream impoundments exist along most major (and many minor) waterways in the Piedmont. These impoundments serve a variety of purposes including hydroelectric power generation, flood control, water supply, and recreation/aesthetics. Impoundments convert lotic habitat to lentic, causing a shift in the food base and both direct and indirect effects on wildlife communities. We do not know the overall impact upon the presence of wildlife species from the indirect effects of river or stream impoundment. Alteration of hydrology, geomorphology, and connectivity (both within river systems and between river and floodplain) through artificial levees, rip rap, or dams can also impact in-stream habitat structure.

– *Development* – Human development in floodplains or riparian areas can degrade riverine habitat. River or stream-front development without sufficient buffers may impact water or habitat quality in the stream or river. The impacts of development includes potential problems associated with direct input of contaminants and sediment, alteration of hydrologic patterns and processes, temperature regimes, and loss of critical habitat adjacent to aquatic habitat that may be of equal importance to species that only spend a portion of their lives in the water, like some amphibians. Development can also lead to disturbance for birds nesting or foraging along rivers, such as bald eagle.

– *Habitat fragmentation* – Some priority species associated with riverine habitats may be dramatically affected by isolation or fragmentation of particular habitat stretches, due to limited distributions, unknown distributions or widely dispersed but small populations.

– *Exotic species* – The introduction of exotic plant and animal species (e.g., *Corbicula*) can have negative impacts on aquatic communities that provide the prey base for the terrestrial animals in this group. Some introduced exotics, like flathead catfish, may directly prey upon native species. The individual and collective impacts of exotic species on high-priority native fauna are not well known.

– *Stream snagging* – Clearing woody debris within stream channels after storms can reduce habitat structure, particularly for reptiles and amphibians, though the impact of this practice on wildlife populations is unknown.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

In order to begin to plan conservation strategies for these species, we must have a better understanding of their current distribution and status. Some of the priority species associated with riverine habitat in the Piedmont of North Carolina are known from few Piedmont localities, and are considered uncommon or rare. Priority needs to be placed on conducting baseline surveys to determine the current range and status of those species (e.g., gulf coast spiny

softshell, striped mud turtle, eastern mudsnake). Secondary priority should be directed towards gathering better information about the status and distribution of more common species associated with riverine habitats (e.g., three-lined salamander, common ribbonsnake). Collaboration between aquatic and terrestrial biologists will be beneficial for recording ancillary data on riverine species.

- **Monitoring** – When we have a better understanding of the current distribution of these species, survey efforts should be re-directed into development of long-term monitoring strategies to document population trends, from which conservation strategies can be specifically designed to target those species.
- **Research**
  - Gain information regarding the specific microhabitat needs of priority species to develop long term conservation strategies.
  - Study the extent and impact of exotic species introductions, as well as effective control measures for the most problematic exotics.
  - Determine the impacts of "snagging" (removing woody debris after storms) on wildlife populations.
  - Determine the effect beaver ponds have on downstream movement of pollutants (toxins and sediments).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

In general the most critical conservation actions necessary to sustain populations of riverine habitat species involve protection of water quality and aquatic habitats. Immediate and continuing efforts need to be undertaken to limit water quality deterioration from point sources of pollution as well as non-point sources though enacting new laws, better enforcement of existing laws, or through the development of voluntary incentive programs to reduce water pollution. The NC Citizens for Clean Water is one private organization that is working toward these goals. Regulatory agencies should be encouraged to protect wide buffers for riparian areas and adopt strict rules for stormwater and wastewater management. Cooperation from agencies and organizations at local, state and federal levels, in addition to public support and pressure on elected officials will be critical for improving water quality.

Land-use planning at the watershed scale will help to mitigate the cumulative and secondary impacts of impervious surfaces. Counties should be encouraged to adopt growth management plans that steer development away from riparian areas and other important habitats. This effort will require the coordination and collaboration of many stakeholder, including local, county, and state planning boards and natural resources agencies, and it will require the support of landowners and the general public.

Many farm bill programs, and the Environmental Quality Incentives Program (EQIP) in particular, provide an excellent opportunity to reduce sediment, fertilizer and pesticide runoff by subsidizing vegetated filter strips, reduced tillage farming, fencing to keep livestock out of streams, and other conservation practices. EQIP and other programs can also provide assistance for improving animal waste management. Closing abandoned and sub-standard waste lagoons should be one of the top priorities for protecting riparian ecosystems, particularly for eastern North Carolina. The conservation community should support the research and implementation of new generation animal waste management systems that reduce the risk of animal waste pollution entering the waterways.

River and stream ecosystem enhancement and restoration efforts and programs need to be enhanced and supported as well. And finally, within the frameworks afforded by state, local, federal, and private initiatives, riverine habitats need to be permanently protected from the negative impacts of development through conservation ownership (fee title or easement) of as much habitat as possible.

Protection actions

– Protect habitat along riverine systems through acquisition and easements. Eno River State Park could be used as a model for protecting a length of river. The state wide Greenways initiative provides an opportunity to protect riparian corridors.

Habitat management and restoration actions

– Promote the adoption of agricultural and forestry best management practices that reduce run-off and erosion, including fencing livestock out of streams and leaving wide buffers between development, agriculture, and some forestry practices (e.g., clearcutting) and riparian areas. The federal Farm Bill and other cost share programs provide incentives for land stewards to adopt these practices. Technical guidance manpower is needed to proactively promote and facilitate participation in these programs.

– Work with power companies to restore or simulate natural river ecological functions. The Federal Energy Regulatory Commission relicensing process offers and excellent opportunity to work towards this goal on the Yadkin, Pee Dee, and Catawba rivers.

– Manage riverine habitats to allow natural movement of woody and rocky structures; work to restore processes like bank dynamics, channel meanders, and flood regimes.

Policy-based actions

– Land use planning and zoning laws needed to limit development, land clearing, and hydrology alterations within floodplains.

– Work with municipalities to reduce stormwater runoff and wastewater discharges.

– Work to identify and promote the designation of Outstanding Resource Waters.

Also see the appropriate river basin sections for more detailed conservation recommendations regarding fully aquatic species.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

N.C. Natural Heritage Program. 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Wilson, L.A. 1995. Land manager's guide to the amphibians and reptiles of the south. The Nature Conservancy, Chapel Hill, NC.

20. **Lakes and reservoirs** – There are no natural lakes in the Piedmont. However, reservoirs, mill ponds, farm ponds and other water bodies provide habitat for a variety of fully- and semi-aquatic species. These areas are also important areas for many bird species (nesting, roosting, and feeding sites) and provide habitat for fish, reptiles, amphibians, and aquatic mammals. In addition, these water bodies are popular destinations for human recreation. *Beaver ponds are discussed in the 'Small wetland communities' section.*

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basin portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

Priority species associated with piedmont lakes and reservoirs:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Haliaeetus leucocephalus*	Bald Eagle	T (T)
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Nyctanassa violacea	Yellow-crowned Night-heron	
Reptiles	*Apalone spinifera aspera*	Gulf Coast Spiny Softshell	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat (see Map 5A.20):

The major impoundments in the Piedmont include W. Kerr Scott Reservoir, High Rock Lake, Tuckertown Reservoir, Badin Lake, Lake Tillery, and Blewett Falls Lake along the Yadkin/Pee Dee rivers; Lake James, Lake Rhodhiss, Lake Hickory, Lookout Shoals Lake, Lake Norman, Mountain Island Lake, and Lake Wylie along the Catawba River; Belews Lake, Townsend Lake, Farmer Lake, Hyco Lake, and Mayo Reservoir along the Dan River drainage; John H. Kerr Reservoir and Lake Gaston on the Roanoke River; B. Everett Jordan Lake and Harris Reservoir along the Haw/Cape Fear rivers; Falls Lake along the Neuse River; as well as Oak Hollow Lake, Kings Mountain Reservoir, and Coddle Creek Reservoir.

In addition, many smaller reservoirs and farm ponds are scattered throughout the Piedmont. All of these sites provide key habitat for many species of waterfowl, wading birds and other waterbirds throughout the year. Impoundments vary with age, water depth and disturbance history; the isolation of these ponds may be an important factors in the flora and fauna present (Schafale and Weakley 1990).

B. Problems affecting species and habitats:

– *Human development and use* – Development of lake shores causes loss and fragmentation of riparian habitat. Excessive human use of lake shores can cause disturbance for nesting bald eagles, and in some areas may cause vegetation trampling and erosion problems.

– *Water quality* – Pollution can cause problems for many aquatic organisms and their predators. Heavy metals can be a particular concern because of their ability to bioaccumulate. Smaller water bodies near agricultural or residential areas can suffer from excess nutrient run-off, leading to algal blooms and low dissolved oxygen levels.

– *Sedimentation* – Sediments build up behind an impoundment and over time can cause a degradation of underwater habitat quality above the dam. Plant diversity suffers due to sediment pollution.

– *Exotic species – Hydrilla sp., Corbicula malinensis, Ludwigia uruguayensis* and carp are among the exotics that can cause problems in water bodies.

– *Mowing of shoreline vegetation* – Reduction in submergent, emergent, and shoreline vegetation can lead to increased trampling and erosion. Many species associated with lakes and aquatic habitats rely on shoreline vegetation for shelter, foraging, breeding, and nesting.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys**
  - Determine the status and distribution of reservoir-associated birds (e.g., osprey, herons, swallows, possibly rails) and help identify threats to populations.
  - Survey for shorebird migration activity on large reservoirs (e.g., Falls Lake, Kerr Lake) in spring, summer and fall.
  - Initiate volunteer frog call surveys (a frog call CD is currently being developed by the Commission and NC Partners in Amphibian and Reptile Conservation, 2005).
- **Monitoring**
  - Continue bald eagle breeding activity monitoring.
  - Establish long-term surveys for waterbirds and rails to help determine population trends.
  - Monitor pond turtles and common ribbonsnake to track population trends.
- **Research**
  - Track and identify problems associated with avian vacuolar myelinopathy that cause mortality in American coots, other waterfowl and bald eagles (following up on recent research; Augspurger et al. 2003).
  - Assess the impacts of Federal Energy Regulatory Commission-mandated changes in water releases at hydro electric dams on high priority species.
  - Study the impacts of commercial collecting of turtles on population dynamics, and the impact that the 2004 turtle law may have on the trade.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

When considering conservation actions for large reservoirs, the conservation needs of flowing river habitat and floodplain forest habitat should generally trump the needs of reservoir habitat.

Needed conservation actions for lakes, reservoirs, and other impoundments include:

- Maintain natural shoreline vegetation and structure of adjacent terrestrial habitats if possible (many wetland-related amphibian and reptile species rely on both aquatic and drier upland sites for their life history and seasonal migrations).
- Retain or create snags, logs, rocks and other structures used by basking reptiles.
- Reduce disturbance and development along raceways and near bald eagle nest trees.
- Identify invasive and exotic species, their impacts on native wildlife, and practical methods for removal or control.
- Limit lakeshore development at sites where there is not protected buffer land.
- Acquire lakeshore buffer lands (e.g., as was done at Jordan and Falls reservoirs so as to exclude development).

Supporting References

Augspurger T., J.R. Fischer, N.J. Thomas, L. Sileo, R.E. Brannian, K.J.G. Miller, and T.E. Rocke. 2003. Vacuolar myelinopathy in waterfowl from a North Carolina impoundment. Journal of Wildlife Diseases 39: 412–417.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

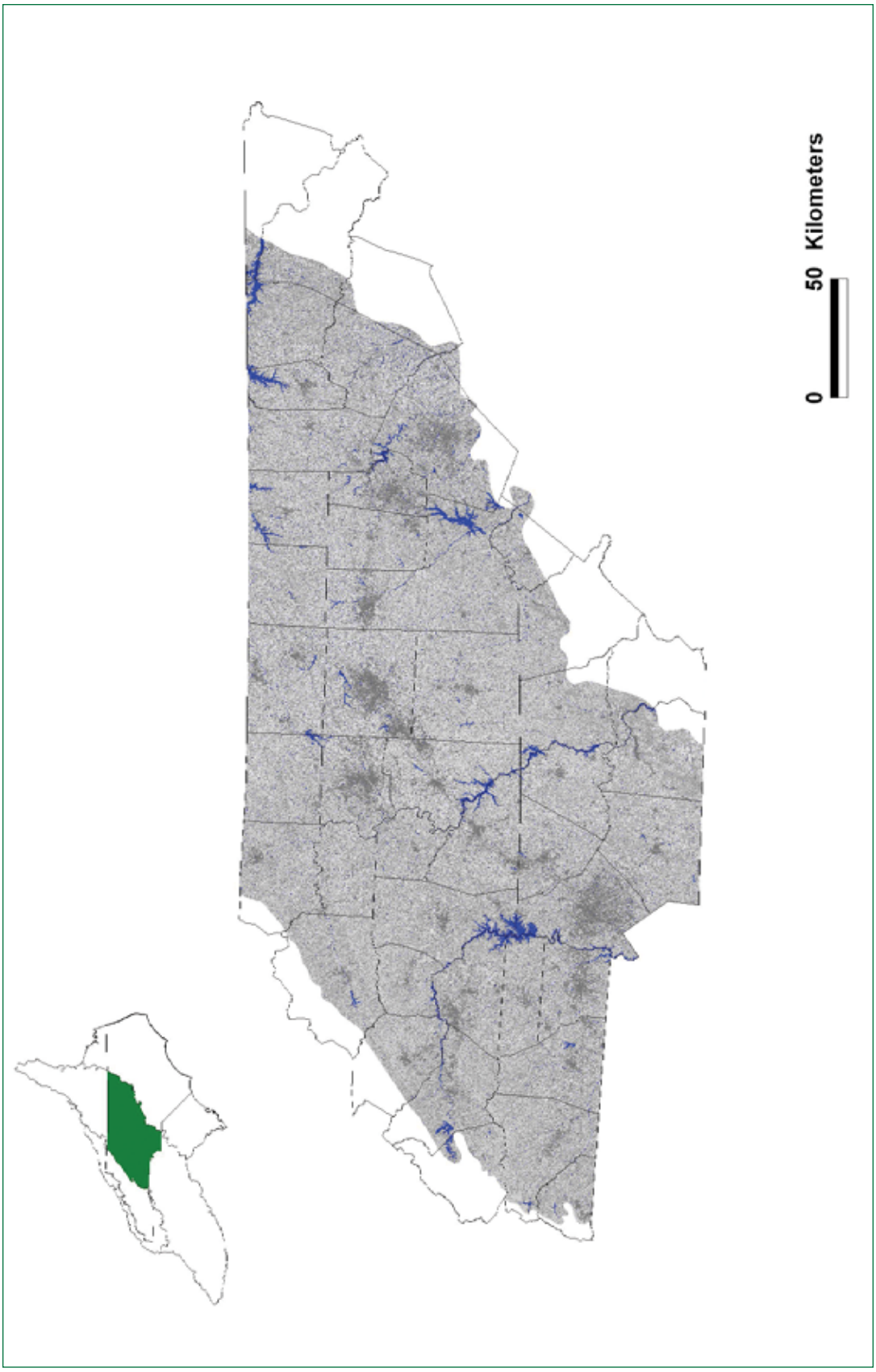


Figure 5A.20. Lakes and reservoirs in the Piedmont ecoregion of North Carolina (in blue) (data source: NC GAP, 1992).

Mid-Atlantic Coastal Plain Ecoregion

21. **Oak forest (including mixed hardwoods and pine)** – This habitat includes the traditional "oak-hickory" forest type, but may also contain large concentrations of tulip poplar, red maple, sweet gum and/or pine species in disturbed sites. In very dry settings, post oak and blackjack oak may dominate. This habitat category also includes sites that may have been longleaf pine stands at one time, but without fire have regenerated into closed canopy mixed hardwood/pine stands with crowded midstory development and low understory species diversity.

    In the Coastal Plain, two examples of oak dominated natural communities include Dry Oak-Hickory Forest and Dry-Mesic Oak-Hickory Forest (Schafale and Weakley 1990). Dry Oak-Hickory Forest is typically a more upland community and was once one of the predominant community types in the Piedmont, and although not as common in the Coastal Plain it was clearly widespread before European settlement and land clearing (Schafale and Weakley 1990). Dry-Mesic Oak-Hickory Forest was historically found throughout the Piedmont and Coastal Plain but much of this area in the Coastal Plain is now in agriculture or pine plantations (Schafale and Weakley 1990).

Priority species associated with coastal plain oak forest (& mixed hardwoods/pine):

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Coccyzus americanus	Yellow-billed Cuckoo	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Hylocichla mustelina	Wood Thrush	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides villosus	Hairy Woodpecker	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Mustela frenata*	Long-tailed Weasel	
	Scalopus aquaticus	Eastern Mole	
	Sciurus niger	Eastern Fox Squirrel	SR
Amphibians	*Ambystoma maculatum*	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Hemidactylium scutatum	Four-toed Salamander	SC
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Cemophora coccinea copei*	Northern Scarletsnake	
	Crotalus horridus	Timber (Canebrake) Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Terrapene carolina	Eastern Box Turtle	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

A. Location and condition of habitat (see Map 5A.21):

Oak dominated forest communities are located throughout the Coastal Plain but are no longer common except in small patches. Most of these forests have been logged or cleared at least once within the past 300 years, and many have been cleared multiple times. The quality of remaining tracts ranges widely across the Coastal Plain and depends primarily upon the age of the canopy trees, management history, and degree of fragmentation of the tract. The condition of many oak forests and mixed hardwood/pine stands in the Coastal Plain has degraded over the last century due to development, habitat fragmentation, fire suppression, high-grading of stands, and the resultant lack of understory and crowded midstory development, although the quality of some stands has improved with age.

Disturbed areas in Dry Oak-Hickory and Dry Mesic Oak-Hickory Forests have varying amounts of pines, red maple, tulip poplar and sweetgum depending on the degree of canopy opening and disturbance history. Heavily logged areas or high-graded sites have a mixture of pines and hardwoods. Usually these forests are uneven-aged with old trees occasionally present. Disturbance of many types, exotic plants and fire suppression has undoubtedly changed the species composition and structure of the Coastal Plain natural oak dominated forests. In turn, due to less frequent fires many areas once dominated by longleaf pine have been invaded oaks, hickories and other hardwoods. However, many of these areas have a high percentage of the total habitat patches dominated by weedy hardwood species such as sweetgum, tulip poplar and red maple if the areas are disturbed frequently.

B. Problems affecting species and habitats:

Microhabitat loss, lack of woody debris, and roads have impacted amphibians, reptiles and small mammals in oak/mixed hardwood stands in the Coastal Plain. Acquisition can be problematic in upland habitats since fewer options are available for grants. Conversion to single-aged loblolly pine stands is a threat; stands have also been high-graded, leaving the trees' form and functions altered. A lack of canopy gaps, affecting bird species that rely on those gaps for foraging areas (e.g., nightjars, eastern wood-pewee, northern flicker, red-headed woodpecker) is also a problem. Development and roads have caused habitat fragmentation, and amphibian species have been impacted by a loss of ephemeral habitats found within the matrix habitat of oak/mixed hardwoods. Lastly, the potential and realized impacts by gypsy moths and other non-native plants and animals are becoming a growing concern throughout hardwood dominated communities. Examples of large size and good quality oak dominated communities are now lacking in the Coastal Plain and habitat fragmentation presents a major problem for many wildlife species.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine the current baseline distribution and status of species mainly associated with oak and mixed hardwood/pine forests (especially those that are state-listed or believed to be declining) for which that information is lacking. Since we lack baseline information about even common species and their distribution and status in this habitat type, we need to direct secondary efforts to conduct surveys to understand current status from which we can then measure future population changes over time.
  - Document the status and distribution of neotropical migrant birds not adequately sampled by BBS (e.g., hooded warbler, Kentucky warbler, yellow-billed cuckoo, red-headed woodpecker, northern flicker, hairy woodpecker).
  - Conduct nocturnal surveys for chuck-will's-widow and whip-poor-will to determine status and distribution, especially in areas with open patches of habitat mixed with mature trees.
  - Determine the status and distribution of all bats using hardwood and hardwood/pine forests.
  - Determine the status and distribution of long-tailed weasel and other small mammals using the habitat.

  - Determine the status and distribution of eastern spadefoot and four-toed salamander.
  - Determine the status of amphibians (mainly salamanders such as marbled, spotted, redback and slimy salamander) that key on woody debris for part or all of their life cycle.
  - Determine the status and distribution of secretive, hard to survey reptiles (e.g., canebrake rattlesnake, mole kingsnake, northern scarletsnake and eastern smooth earthsnake) (in conjunction with surveys for more common reptiles).

- **Monitoring** – Protocols and procedures developed from baseline surveys should then provide a means to convert from a baseline survey mode to a long-term population monitoring mode. Current monitoring systems and protocols (e.g., MAPS and BBS) may need to be enhanced to better cover certain species not well covered by current monitoring efforts.
  - Establish MAPS and migration banding stations and migration monitoring surveys.
  - Initiate long-term monitoring for breeding neotropical migrants (especially ground-nesters and cavity nesters).
  - Initiate long-term monitoring for bats and small mammals (e.g., moles, shrews, rodents) following initial survey efforts.
  - Initiate long-term monitoring for amphibians that use woody debris as a microhabitat following initial survey efforts.
  - Initiate long-term monitoring needed for canebrake rattlesnakes and other secretive reptiles following initial survey efforts.

- **Research** – Research studies targeting birds need to be long-term and large-scale, replicated studies that have controlled experimental approaches and focus on population demographics and the response of species to habitat manipulations where appropriate as outlined by the National Partners in Flight Research working group (Donovan et al. 2002). Similar research priorities are needed for other oak/mixed hardwoods forest taxa including bats, small mammals, amphibians and reptiles.

  Population demographics
  - Conduct long-term life history studies for many birds, bats, small mammals, amphibians and reptiles, starting with those of highest conservation priority (Yates et al. 1997, Holmes and Sherry 2001, Ellis et al. 2002, Osbourne and Anderson 2002, Taylor and Jones 2002).

  Predator effects
  - Study predator effects on nest productivity (especially for shrub and ground nesters) via nest search and spot mapping studies.
  - Examine productivity of canopy and cavity nesting birds.

  Habitat use
  - Examine habitat use patterns on raptors and nightjars using telemetry (Mills 1986 and Lake et al. 2002).
  - Determine how large scale floods affect reptile and amphibian populations.

  Management practices
  - Determine the effects of management to improve vegetative structure (canopy gaps, prescribed fire, etc.) on habitat use patterns of birds, small mammals, bats, amphibians and reptiles (Blake and Hoppes 1986, Lanham and Guynn 1998, Osbourne and Anderson 2002).

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Acquisition whenever possible and proper management of these areas is key. Conservation of existing oak forest patches is imperative. As oak forests typically occur in small stands, it may be difficult to specifically target these stands for acquisition. However, acquisitions of large tracts (>500 acres) is recommended where some stands of oak forest are present.

Use of infrequent prescribed fire and canopy gap management may be needed to improve forest structural heterogeneity (frequent fire will limit shrub and understory development necessary to breeding bird species). Management and protection of mixed hardwoods/pine to promote future large, unfragmented tracts is especially important for amphibians, reptiles, small mammals and bats. Landowner incentives to promote extending rotation lengths may be another management option.

A portion of these lands should be dedicated to old growth habitat. Within the oak-mixed hardwoods/pine habitat, we must attempt to retain as many of the embedded habitats (e.g., seasonal wetlands) as possible. Some mixed hardwood stands should be considered for conversion back to longleaf pine habitat where appropriate. Long-term studies focusing on the habitat-use needs of many species in oak and hardwood/pine forests, as well as the response of wildlife species to habitat fragmentation, patch size and habitat management are needed.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Blake, J.G. and W.G. Hoppes. 1986. Influence of resource abundance on use of tree-fall gaps by birds in an isolated woodlot. The Auk 103: 328–340.

Donovan, T.M., C.J. Beardmore, D.N. Bonter, J.D. Brawn, R.J. Cooper, J.A. Fitzgerald, R. Ford, S.A. Gauthreaux, T. L. George, W.C. Hunter, T.E. Martin, J. Price, K.V. Rosenberg, P.D. Vickery and T.B. Wigley. 2002. Priority research needs for the conservation of neotropical migrant landbirds. Journal of Field Ornithology 73(4): 329–339.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 210–218.

Holmes, R.T. and T.W. Sherry. 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: Importance of habitat change. The Auk 118(3): 589–609.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Lake, L.A., D.A. Buehler and A.E. Houston. 2002. Cooper's hawk non-breeding habitat use and home range in southwestern Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies: 56: 229–238.

Lanham, J.D. and Guynn, Jr. D.C. 1998. Habitat-use relationships of shrub-scrub birds in South Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 52:222–231.

Mills, A.M. 1986. The influence of moonlight on the behavior of goatsuckers (Caprimulgidae). The Auk 103: 370–378.

Osbourne, J.D. and J.T. Anderson. 2002. Small mammal response to course woody debris in the central Appalachians. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 198–209.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Taylor, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

Yates, M.D., S.C. Loeb and D.C. Guynn, Jr. 1997. The effect of habitat patch size on small mammal populations. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 51:501–510.

Mid-Atlantic Coastal Plain Ecoregion

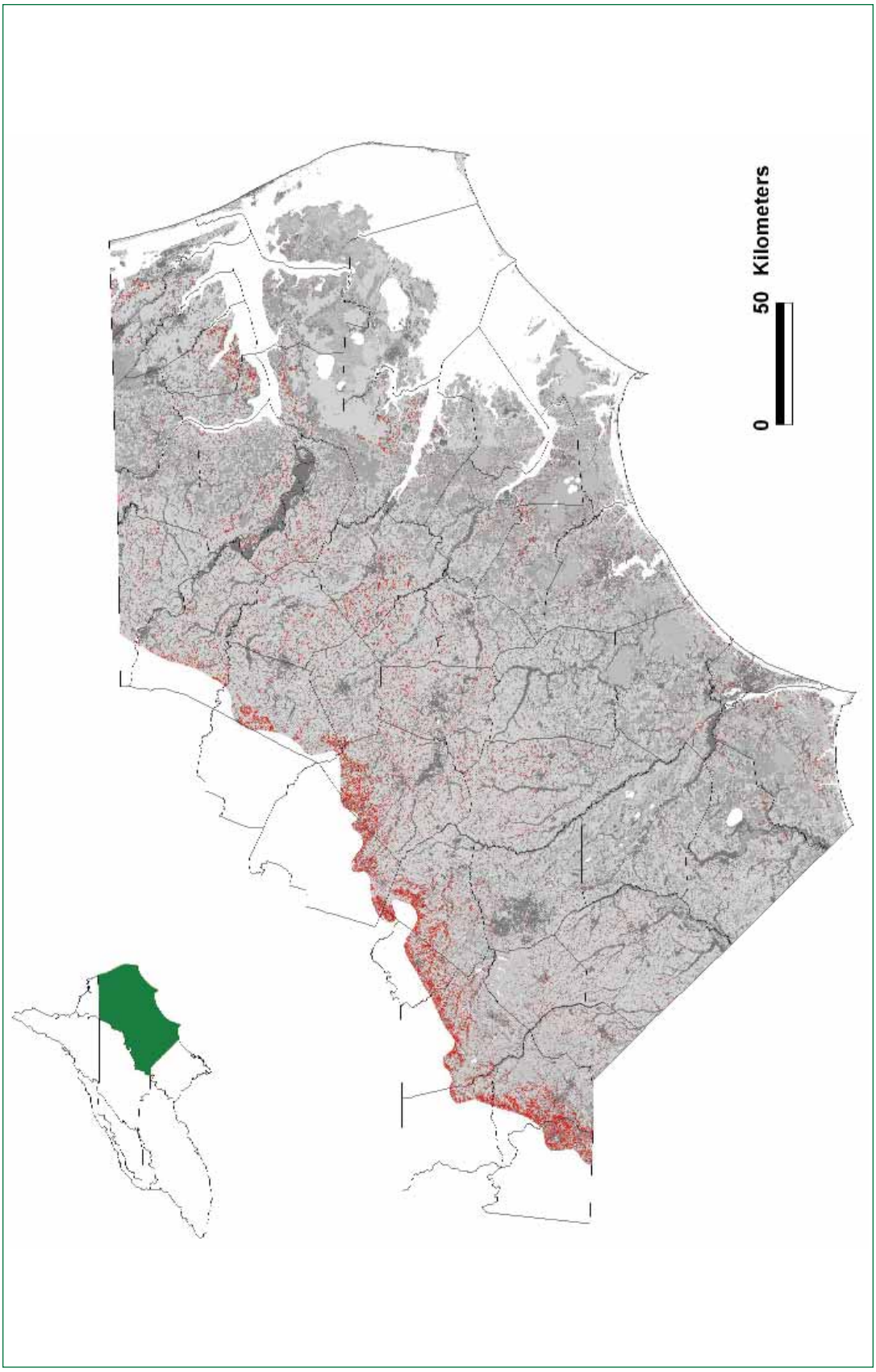


Figure 5A.21. Oak forest and mixed hardwoods habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

22. **Mesic forest** – Coastal Plain mesic forest occurs on moist portions of upland habitat protected from fire, north-facing slopes, high sections of outer floodplains and less commonly on upland flats surrounded by peatland. They may also be found on island ridges surrounded by swamps. These habitats can have well-developed understory and shrub layers, and are characterized by mesophytic canopy species such as American beech, tulip poplar, sweetgum, bitternut hickory, shagbark hickory, American elm, black walnut, white oak, swamp chestnut oak and red oak.

    Coastal Plain subtypes include Mesic Mixed Hardwood Forest (found throughout the Coastal Plain) and Basic Mesic Forest, scattered and found primarily in the area of marl outcrop in the eastern Coastal Plain south of the Neuse River but also on basic alluvial traces along the Roanoke River (Schafale and Weakley 1990). Mixed Mesic Hardwood Forests are distinguished from Basic Mesic Forests by having acidic rather than circumneutral to basic soils, a less well developed herb layer, lower floristic diversity and no or few basic indicator species (Schafale and Weakley 1990).

    Mesic forests usually occur on sites that are sheltered from fire by topography and moisture. Fires in these systems were likely much less frequent and intense than in uplands. Under natural conditions, mesic forests are uneven-aged, with some old trees present. Reproduction occurs primarily in canopy gaps, and disturbed areas have increased amounts of pines and weedy hardwoods such as tulip poplar and sweetgum, as well as exotics such as Japanese honeysuckle (Schafale and Weakley 1990).

A. Location and condition of habitat (see Map 5A.22):

Examples of the Mesic Mixed Hardwood Forest bluff/slope variant are found in Croatan National Forest, Merchant's Millpond State Park and Cliffs of the Neuse State Park. Examples of the swamp island variant are found in the Dismal Swamp National Wildlife Refuge and along the Waccamaw River in Columbus County and examples of the upland flat variant are found in Perquimans and Bertie County. Both variants of Basic Mesic Forest (marl outcrop and terrace slope) are rare because of the rarity of basic substrates on the Coastal Plain (Schafale and Weakley 1990).

The condition of coastal plain mesic forest is relatively poor due to almost complete fire suppression (infrequent fires helped control the extent of mesic vegetation), high-grading of stands, exotic species, and habitat fragmentation.

B. Problems affecting species and habitats:

Due to the relatively flat topography, coastal plain mesic forests are scarce compared to the Piedmont. Most sites are quite narrow bands on the landscape. In many cases, the flat land above these slopes has been converted to agriculture or loblolly pine plantations, compromising the quality of the mesic forest habitat. Development has fragmented the habitat and high-grading has changed the forest condition and composition. Although fires would have naturally swept through these sites relatively infrequently, even these infrequent fires have been suppressed, which affects community composition related to mesic plant species and likely exotics. Logging has depleted the amount of dead and downed material as well as other old growth characteristics such as tree cavities, hollow trees, vine tangles, etc. Exotic plants such as autumn olive, Japanese grass, Japanese honeysuckle, and privet have taken resources from native vegetation. A lack of canopy gaps in this habitat type has probably lead to a reduced number of some avifauna such as the eastern wood-pewee, red-headed woodpecker, northern flicker, hooded warbler, worm-eating warbler and Kentucky warbler. This reduction in canopy gaps has also caused a decline in midstory and understory vegetation which has impacted species such as the Swainson's warbler, Kentucky warbler, hooded warbler and wood thrush, as well as many small mammals and reptiles.

Priority species associated with coastal plain mesic forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Coccyzus americanus*	Yellow-billed Cuckoo	
	Colaptes auratus	Northern Flicker	
	Contopus virens	Eastern Wood-pewee	
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Limnothlypis swainsonii	Swainson's Warbler	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Oporornis formosus	Kentucky Warbler	
	Picoides villosus	Hairy Woodpecker	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Lasionycteris noctivagans*	Silver-haired Bat	SR
	Lasiurus intermedius	Northern Yellow Bat	SR
	Mustela frenata	Long-tailed Weasel	
	Peromyscus gossypinus	Cotton Mouse	
	Scalopus aquaticus	Eastern Mole	
Amphibians	*Ambystoma mabeei*	Mabee's Salamander	SR
	Ambystoma maculatum	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla gratiosa	Barking Treefrog	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Pseudacris brimleyi	Brimley's Chorus Frog	
	Pseudacris nigrita nigrita	Striped Southern Chorus Frog	
	Pseudacris ornate	Ornate Chorus Frog	SR
	Rana capito	Carolina Gopher Frog	T
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Clemmys guttata*	SpottedTurtle	
	Crotalus horridus	Canebrake Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Rhadinaea flavilata	Pine Woods Littersnake	
	Terrapene carolina	Eastern Box Turtle	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine the current baseline distribution and status of species mainly associated with mesic forests (especially those that are state-listed or believed to be declining) for which that information is lacking. Since we lack baseline information about even common species and their distribution and status in this habitat type, we need to direct secondary efforts to conduct surveys to understand current status from which we can then measure future population changes over time.
  - Conduct selective surveys to determine the status and distribution of birds hard to track by BBS (e.g., Swainson's warbler, worm-eating warbler, Kentucky warbler, hooded warbler, yellow-billed cuckoo) as well as more common breeding birds.
  - Determine distribution and status information for all bat species and many other mammals, especially for long-tailed weasel and cotton mouse.

  - Survey amphibians for which we have little information on status and distribution (e.g., Mabee's salamander, four-toed salamander, Brimley's chorus frog, ornate chorus frog) as well as other more common amphibians.
  - Determine the status and distribution of canebrake rattlesnake.
  - Determine the status and distribution of hard to track snakes such as mole kingsnake, pine woods littersnake and eastern smooth earthsnake.

- **Monitoring** – Protocols and procedures developed from baseline surveys should then provide a means to convert from a baseline survey mode to a long-term population monitoring mode. Current monitoring systems and protocols (e.g., MAPS and BBS) may need to be enhanced to better cover certain species not well covered by current monitoring efforts.
  - Expand MAPS and migration banding stations to better identify breeding bird and migratory bird productivity and other demographic information.
  - Establish long-term monitoring for small mammals and bats following initial surveys.
  - Conduct general long-term herpetofauna monitoring to track the effects of the loss of old growth characteristics in this habitat type.

- **Research**

  Productivity
  - Conduct bird nest productivity studies, including nest-searching and spot mapping, and studies of predator effects on bird nest productivity.

  Genetics
  - Examine the possibility of a sub-species for the coastal worm-eating warbler.

  Population demographics
  - Collect demographic information on all bat species; investigate specific habitat needs and conduct life history studies.

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Conservation actions will need to include land acquisition, easements and protection to promote remaining large, unfragmented tracts as well as management to maintain and re-establish mesic forest.

Land acquisition and easements should be the top priority for conservation actions; Land Trusts will serve as a major partner in these efforts. This is a relatively rare forest type and great effort should be made to protect mesic forest and their species assemblages.

We must continue to work with non-industrial foresters to promote and increase silvicultural practices that benefit birds of conservation concern (e.g., promote canopy gap management, longer rotations, introduction of fire) as well as small mammals, bats and reptiles and amphibians.

Supporting References

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Mid-Atlantic Coastal Plain Ecoregion

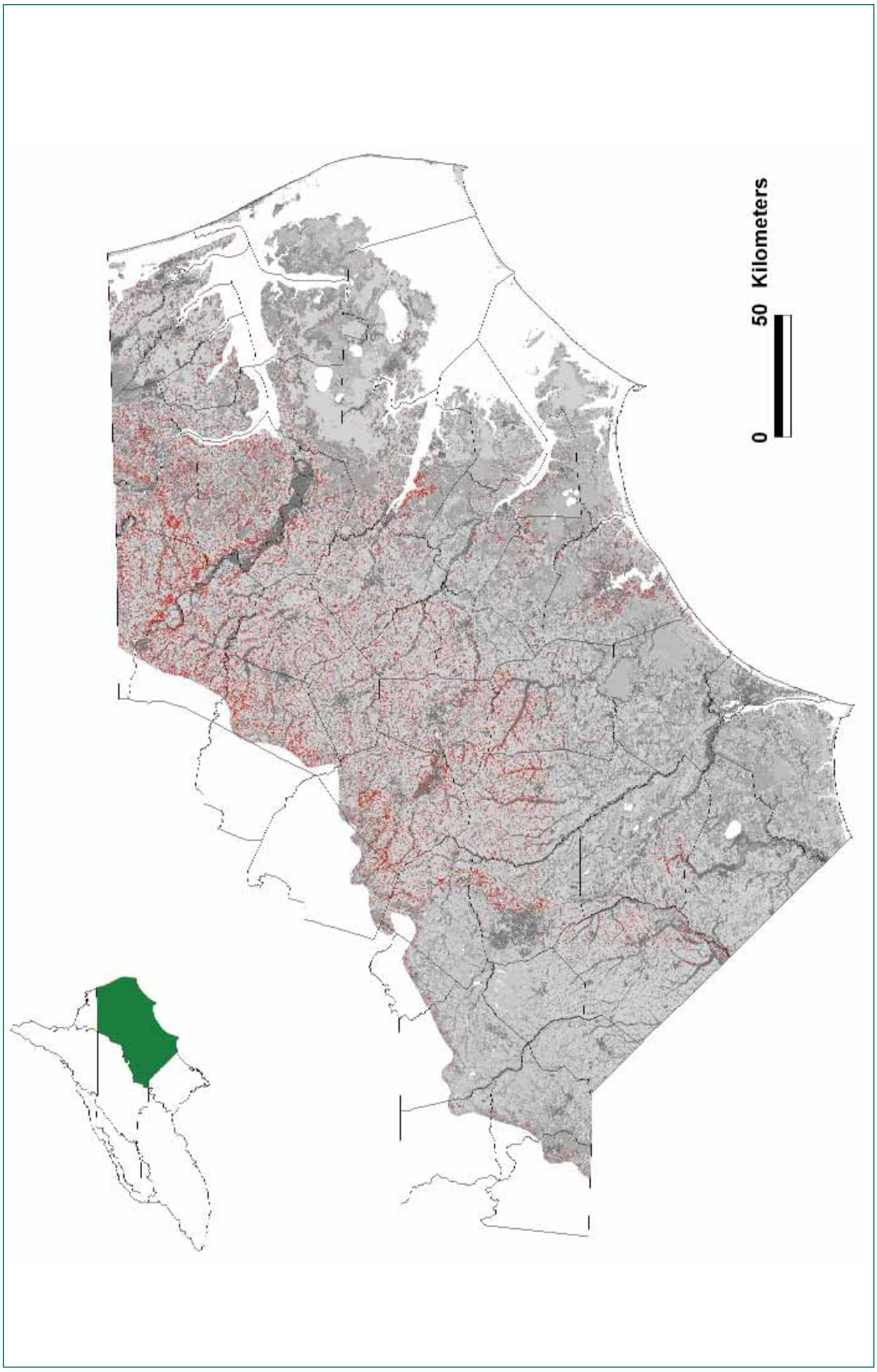


Figure 5A.22. Mesic forest habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

23. **Early successional habitats** – Coastal Plain early successional and scrub-shrub habitats, characterized by low woody vegetation and herbaceous plants, are often found at the transition between agricultural fields and nearby woodlands, created by disturbances like clearcutting, disking or burning. This habitat also includes agricultural hayfields, pastures, and field borders. Early successional habitats can also be mimicked in the understory of very open pine stands. Historically, these habitats were created by catastrophic natural fires, anthropogenic fires, large-scale wind events, insect pests, or pathogens such as fungal diseases. Early successional habitats are found throughout the region.

    This habitat category can contain a diverse assemblage of plants, and nearly always features some combination of human activity. That does not mean that environmental factors such as weather events, climate, and natural fires have not played a role in creation and maintenance of some areas. The theoretic role of beavers, historic herbivores, Native American uses and other factors point to additional mechanisms for creation and maintenance of at least some early succession habitats, at least historically; however, in the past century nearly all early successional habitats have been human-created. Natural succession will limit the longevity of many of these habitats, unless they are actively managed.

    There are numerous examples and types of communities that provide early successional habitat for an assortment of wildlife species. However, a number of them provide little benefit to a significant array of plant and animal species, especially those patches of small size, and thus could only be considered marginal wildlife habitat at best. These kinds of places generally reflect human use and activity as the primary goals of their management and include a number of places such as large lawns, monoculture hayfields, golf courses, airports, residential development and even urban and suburban development.

    High quality early successional wildlife habitats include a variety of pastures, croplands, recent clearcuts, and field borders. Pastures and other grasslands provide year-round habitat for several priority bird species. Croplands such as corn fields and soybean fields provide food (especially where the harvest was poor) for many game species, sparrows, and other wildlife in fall and winter.

    In the Coastal Plain, the quantity of early successional habitat is not lacking but the quality is often questionable for most species of wildlife. There are, however, excellent opportunities for quality early sucessional habitat of large patch sizes for wildlife on industrial forestland in the Coastal Plain. Partnerships with timber companies (and other large-scale landowners) featuring external cooperators that focus on creating management plans and strategies that benefit a diverse suite of wildlife species absolutely needs to continue, expand and be refined over time.

A. Location and condition of habitat (see Map 5A.23):

Quality early successional habitats have declined considerably over the past half-century, due to reduction of fire, increasing development, and changing agricultural practices. Management of these habitats, especially through fire, is essential for their continued existence and to benefit early successional wildlife. Ephemeral by definition, the distribution and location of early succession habitats across the Coastal Plain can change dramatically within a decade. Currently, most early successional habitats on private lands are located on farmland, recently harvested timberland, powerline right-of-ways and roadsides.

Regardless of how it is measured, high quality early successional wildlife habitat in the Coastal Plain of North Carolina is limited (other than industrial timberlands) and may be declining as a percentage of the landscape due to numerous factors.

The declines of grassland bird species, for example, is attributed to not only actual loss of habitat but also degradation of remaining tracts because of improper or inadequate management and encroachment of exotic vegetation, as well as fragmentation of habitat patches into small isolated units (Johnson and Igl 2001). We must determine if agricultural landscapes can indeed support healthy bird populations (Peterjohn 2003) and decide on the future direction of research related to grassland birds (Vickery and Herkert 2001). Many shrub-scrub birds are also declining according to the best information we have (Hunter et al. 2001), and further

Priority species associated with coastal plain early successional habitat:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Aimophila aestivalis*	Bachman's Sparrow	SC
	Ammodramus henslowii	Henslow's Sparrow	SR
	Ammodramus savannarum	Grasshopper Sparrow	
	Asio flammeus	Short-eared Owl	
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Chondestes grammacus	Lark Sparrow	SR
	Chordeiles minor	Common Nighthawk	
	Circus cyaneus	Northern Harrier	SR
	Cistothorus platensis	Sedge Wren	
	Colinus virginianus	Northern Bobwhite	
	Dendroica discolor	Prairie Warbler	
	Falco sparverius	American Kestrel	
	Icterus spurius	Orchard Oriole	
	Lanius ludovicianus	Loggerhead Shrike	SC
	Passerina ciris	Eastern Painted Bunting	
	Scolopax minor	American Woodcock	
	Spizella pusilla	Field Sparrow	
	Sturnella magna	Eastern Meadowlark	
	Tyrannus tyrannus	Eastern Kingbird	
	Tyto alba	Barn Owl	
Mammals	*Condylura cristata*	Star-nosed Mole	SC
	Cryptotis parva	Least Shrew	
	Microtus pennsylvanicus	Meadow Vole	
	Mustela frenata	Long-tailed Weasel	
	Scalopus aquaticus	Eastern Mole	
	Synaptomys cooperi helaletes	Southern Bog Lemming	
Reptiles	*Crotalus adamanteus*	Eastern Diamond-backed Rattlesnake	E
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Lampropeltis getula getula	Eastern Kingsnake	
	Masticophis flagellum	Eastern Coachwhip	SR
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Pituophis melanoleucus melanoleucus	Northern Pinesnake	SC
	Terrapene carolina	Eastern Box Turtle	

information is badly needed on how they relate to reduced patch size of early successional habitat (Lanham and Guynn, Jr. 1998).

B. *Problems affecting species and habitats:*

Development and large-scale mono-agricultural operations causing a shortage of quality habitat in large patches (except on industrial forestland) is a major concern, along with fire suppression. Modern agricultural practices (frequent mowing, lack of field borders, pesticide use, and non-native plants like kudzu and fescue) are also a problem for wildlife that use early successional habitat around farmland. Exotic species have caused particular problems in early successional habitats. Fire ants kill newly hatched ground nesting birds and reptiles as well as newly born mammals. Brown-headed cowbirds parasitize bird nests, and many exotic plant species take advantage of the light conditions in early successional habitats.

Human development is causing loss and fragmentation of early successional wildlife habitat, and hinders the use of prescribed fire. Suppression of wildfires and lack of controlled burning eliminates an important source of early succession habitat creation and maintenance. Understanding the way that people perceive, use and value early successional landscapes (human dimensions) needs more attention (Askins 2001 and Gobster 2001).

Some species, such as northern bobwhite, may require large areas of contiguous habitat for long-term population viability. Current restoration efforts often focus on small acreages that have limited value for area-sensitive grassland species such as grasshopper sparrow and eastern meadowlark. Grasslands of >50 acres should be pursued to benefit these species. Some research has suggested that grasslands of at least 500 acres or may be needed to support a diverse grassland bird fauna or rare species (Vickery et al. 1994 and Perkins et al. 2003). In addition roads have become a primary mortality factor for many birds, mammals and particularly reptiles and amphibians.

Early succession cover in powerline right-of-ways and roadsides can be adversely affected by too frequent or poorly timed mowing, as well as herbicide treatments (Bramble et al. 1992). In addition, many areas of fallow ground near houses or businesses are frequently mowed to maintain a neat appearance, while opportunities exist to convert these areas to suitable wildlife cover.

Most of the understory grass, forb, and shrub layers are lost once a newly planted timber stand "canopies out," which occurs typically 7-15 years after timber clearing and planting. Economic pressures, improvements in equipment and herbicides, and fast-growing genetic strains of trees have all reduced the amount of time to canopy closure, contributing to loss of early succession habitat. In addition, intensive site-prep techniques can reduce the quality and quantity of herbaceous cover during the early phases of timber planting (Morrison and Meslow 1984). "High grading" of mature timber stands, instead of clearcutting or thinning, also eliminates the potential for early succession habitat creation over the life of stands. Many researchers suggest that silviculture will play an important role in providing habitat for many early successional wildlife species (Askins 1998; Thompson and DeGraaf 2001) so wildlife biologists need to maintain open lines of communication with foresters, and especially with large industrial timber companies. Tremendous opportunities exist on industrial forestland in the Coastal Plain of North Carolina to meet the needs of shrub-scrub birds of high conservation concern.

Powerlines, fields and field borders are usually devoid of any dead and downed logs for herpetofauna. Even clearcuts that supply some dead and down material don't have near as much as what would have been available under natural conditions created by wildfires or hurricanes.

Economic pressures, improvements in equipment and herbicides, and social factors have all lead to larger, more uniformly shaped rowcrop fields, as well as "cleaner" fields with less weedy edge (Marcus et al. 2000). Few rowcrop fields are managed to include a fallow rotation. Some beneficial practices, such as no-till planting, have had mixed success in being adopted. In pastureland, the extensive use of exotic cool-season grasses have reduced habitat quality for wildlife. Cutting hay in mid-summer and overgrazing can adversely affect nesting grassland birds.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with early successional habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on early successional communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common.

  - Determine the status of high priority birds (e.g., Henslow's sparrow, eastern painted bunting, Bachman's sparrow, grasshopper sparow, loggerhead shrike, field sparrow, American woodcock, northern bobwhite, and barn owl) and secondarily for other more widely distributed early successional birds that seem to be declining, such as eastern meadowlark, orchard oriole, eastern kingbird.
  - Determine the status, distribution, and extent of breeding by short-eared owl, northern harrier, and American kestrel.
  - Conduct nocturnal surveys for chuck-will's-widow and whip-poor-will.
  - Determine the status and distribution of hard to detect species such as dickcissel, bobolink and lark sparrow.
  - Determine the status and distribution of small mammals that are rare or difficult to detect (e.g., star-nosed mole, shrews, long-tailed weasel, southern bog lemming) and secondarily for other small mammals using early successional habitats.
  - Survey for bats foraging in early successional habitats.
  - Survey for uncommon and/or hard to detect reptiles (e.g., eastern diamond-backed rattlesnake, mole kingsnake, eastern coachwhip, eastern slender glass lizard and northern pinesnake) in early successional habitats.

- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with early successional habitats. Many early successional bird species require monitoring attention, due to documented BBS declines, but BBS does not adequately sample irregularly distributed or clumped species. Declines for grassland species (grasshopper sparrow, Henslow's sparrow, eastern meadowlark) have been documented as being especially high, but birds that utilize shrub-scrub such as prairie warbler and common yellowthroat have also seen declines and are in need of additional long-term monitoring.
  - Establish MAPS and migration banding stations, especially in shrublands, grasslands, hay fields, and pastures.
  - Initiate long-term monitoring for Henslow's sparrow (and other grassland breeding and wintering birds) at the Voice of America (VOA) sites in Pitt and Beaufort Counties (Mangun and Kolb 2000).
  - Establish long-term monitoring for declining (according to our best information) early successional bird species in appropriate habitat at all seasons, like Bachman's sparrow (Stober and Krementz 2000).
  - Continue long-term monitoring of early successional birds needed on Game Lands, National and State Forests and National Wildlife Refuges.
  - Initiate long-term monitoring of mammal species of early successional habitats on habitat patches of varying sizes (Yates et al. 1997 and Litvaitis 2001).
  - Establish long-term monitoring of eastern diamond-backed rattlesnake and northern pinesnake (Woodward and Barthalmus 1996).

- **Research** – Research studies targeting birds need to be long-term and large-scale, replicated studies that have controlled experimental approaches and focus on population demographics and the response of species to habitat manipulations where appropriate as outlined by the National Partners in Flight Research working group (Donovan et al. 2002). Similar research priorities are needed for other early successional taxa including bats, small mammals, amphibians and reptiles.

  Genetics
  - Conduct genetics studies of the breeding sub-species of American kestrel in the lower Coastal Plain.
  - Conduct genetics studies on Henslow's sparrows at the VOA sites.
  - Conduct genetics studies on Coastal Plain shrew species.

Habitat use

– Examine Chuck-will's-widow and whip-poor-will foraging areas on industrial and non-industrial forestland.
– Study the effects of patch size and vegetative structure on nesting success of early successional birds (Burhans and Thompson 1999; Ricketts and Ritchison 2000).
– Study the effects of patch size on small mammal populations (Yates et al. 1997).
– Conduct movement studies on northern pinesnake and eastern diamond-backed rattlesnake (using telemetry).

Population demographics

– Conduct bird nest search and spot mapping studies on public land and on industrial forestland on various patch sizes.
– Examine loggerhead shrike productivity, especially near farms and Cooperative Upland habitat Restoration and Enhancement Program cooperatives.
– Examine nightjar productivity on industrial forestland compared to non-industrial forestland.
– Examine prairie warbler productivity on industrial forestland compared to non-industrial forestland.
– Expand bat research on industrial forestland (e.g., Weyerhaeuser and International Paper lands).

Predator effects

– Examine predators effects on nest productivity of ground- and shrub- nesting birds (Yahner and Wright 1985 and Davison and Bollinger 2000).
– Determine the effects of cowbirds on early successional bird productivity.
– Study the impacts of fire ants on bird nests, small mammals and reptiles in disturbed sites (Smith et al. 2004).

Management practices

– Determine the effects of clearcut stand size on shrubland birds (Krementz and Christie 2001).
– Examine the responses of bird communities to early successional habitat in a managed landscape (Wilson and Watts 2000, Yahner 2003).
– Determine the effects of silvicultural procedures on breeding, wintering and migrating birds on managed forests (Woodward et al. 2001, Easton and Martin 2002)
– Determine the effects of clearcut stand size on small mammals and reptiles (Yates et al. 1997).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

The use of native grasses, shrubs, and herbaceous plantings to support breeding birds, small mammals and herpetofauna should be encouraged. Prescribed burning should be conducted to restore and improve field borders, and the training of certified burners should become a priority. Liability and air quality concerns need to be addressed.

Management of large blocks (50 acres or greater) of shrub-scrub and grassland habitat is needed to restore ample suitable habitat and to serve as breeding sites for area-sensitive shrub-scrub and grassland species. Patches of early successional habitat should be connected whenever possible to form larger blocks by working with neighboring landowners to cooperate and create large-scale habitat areas. A better understanding of the predator community in early successional sites and their interactions with nesting birds and other wildlife at various habitat patch sizes are needed.

Establishment of field border systems may be an effective way to increase densities of some birds (especially wintering sparrows) on farms at certain times of the year (Marcus et al. 2000). Work needs to continue with private landowners to improve hayfield management (e.g., avoid cutting during prime bird nesting season: May – July). Biologists need to continue to work with private

landowners to establish no-till agriculture, fallow rotations and hedgerows on agricultural lands. Work is also needed to educate the public on the value of early successional habitats and the benefits of controlled burns (Gobster 2001).

Support is needed to help with implementation of federal Farm Bill programs, North Carolina's Cooperative Upland habitat Restoration and Enhancement program, and other programs that encourage the establishment and management of early succession habitats on private lands. We must also continue efforts to work in cooperation with species-specific initiatives such as the Eastern Painted Bunting Working Group and the Northern Bobwhite Conservation Initiative (Dimmick et al. 2002), and to follow prescriptions recommended by those groups. Biologists and researchers need to work with timber companies and private foresters to encourage best management practices that maintain early succession habitat for as long as possible in a timber rotation and reduce the amount of linear edge on some harvest units. Effort needs to be made to encourage early successional areas with dead and downed material present. Retention of snags within clearcuts will help with this effort. Finally, land use planning needs to be encouraged to minimize development within large, unfragmented tracts of farm and forestland that has habitat components that benefit early successional wildlife.

As nearly all early successional habitats are now created by humans, there is little need for outright acquisition of such habitats. For that matter, there may be increasing public pressure to minimize early successional acreage (e.g., return abandoned farmland to natural systems over time). Thus, it is important for biologists to creatively work to provide the best foraging, nesting, and roosting habitat for priority species in the remaining early successional habitats.

Supporting References

Askins, R.A. 1998. Restoring forest disturbances to sustain populations of shrubland birds. Restoration & Management Notes 16: 166–173.

Askins, R.A. 2001. Sustaining biological diversity in early successional communities: the challenge of managing unpopular habitats. Wildlife Society Bulletin 29(2): 407–412.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Bramble, W.C., R.H. Yahner and W.R. Byrnes. 1992. Breeding bird population changes following right-of-way maintenance treatments. Journal of Arboriculture 18 (1): 23–32.

Burhans, D.E. and F.R. Thompson III. 1999. Habitat patch size and nesting success of yellow-breasted chats. Wilson Bulletin 111(2): 210–215.

Davison, W.B. and E. Bollinger. 2000. Predation rates on real and artificial nests of grassland birds. The Auk 117(1): 147–153.

Dimmick, R. W., M. J. Gudlin, and D. F. McKenzie. 2002. The northern bobwhite conservation initiative. Miscellaneous publication of the Southeastern Association of Fish and Wildlife Agencies, South Carolina.

Donovan, T.M., C.J. Beardmore, D.N. Bonter, J.D. Brawn, R.J. Cooper, J.A. Fitzgerald, R. Ford, S.A. Gauthreaux, T. L. George, W.C. Hunter, T.E. Martin, J. Price, K.V. Rosenberg, P.D. Vickery and T.B. Wigley. 2002. Priority research needs for the conservation of neotropical migrant landbirds. Journal of Field Ornithology 73(4): 329–339.

Easton, W.E. and K. Martin. 2002. Effects of thinning and herbicide treatments on nest-site selection by songbirds in young managed forests. The Auk 119(3): 685–694.

Gobster, P.H. 2001. Human dimensions of early successional landscapes in the eastern United States. Wildlife Society Bulletin 29(2): 474–482.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2): 440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Johnson, D.H., and L.D. Igl. 2001. Area requirements of grassland birds: a regional perspective. The Auk 118 (1): 24–34.

Krementz, D.G. and J.S. Christie. 2000. Clearcut stand size and shrub-successional bird assemblages. The Auk 117(4): 913–924.

Lanham, J.D. and Guynn, Jr. D.C. 1998. Habitat-use relationships of shrub-scrub birds in South Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 52:222–231.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Litvaitis, J.A. 2001. Importance of early successional habitats to mammals in eastern forests. Wildlife Society Bulletin 29(2): 466–473.

Mangun, J.C. and R.L. Kolb. 2000. Effects of grassland management on Henslow's sparrow, Ammodramus henslowii, (Fringillidae), populations in eastern North Carolina. Journal of the Elisha Mitchell Society 116(1): 49–56.

Marcus, J.F., W.E. Palmer and P.T. Bromley. 2000. The effects of farm field borders on overwintering sparrow densities. Wilson Bulletin 112(4): 517–523.

Morrison, M.L. and E.C. Meslow. 1984. Response of avian communities to herbicide-induced vegetation changes. Journal of Wildlife Management 48(1): 14–21.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Perkins, D.W., P.D. Vickery and W.G. Shriver. 2003. Spatial dynamics of source-sink habitats: effects on rare grassland birds. Journal of Wildlife Management 67(3): 588–599.

Peterjohn, B.G. 2003. Agricultural landscapes: can they support healthy bird populations as well as farm products? The Auk 120(1): 14–19.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Ricketts, M.S. and G. Ritchison. 2000. Nesting success of yellow-breasted chats: effects of nest site and territory vegetation structure. Wilson Bulletin 112(4): 510–516.

Smith, J.E., S.J. Taylor, C.J. Whelen, M.L. Denight and M.M. Stake. 2004. Behavioral interactions between fire ants and vertebrate nest predators at two black-capped vireo nests. Wilson Bulletin 116(2): 163–166.

Stober, J.M. and D.G. Krementz. 2000. Survival and reproductive biology of the Bachman's sparrow. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 54: 383–390.

Thompson, F.R. and R.M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29(2): 483–494.

Vickery, P.D. M.L. Hunter and S.M. Melvin. 1994. Effects of habitat are on the distribution of grassland birds in Maine. Conservation Biology. Vol. 8 (4): 1087–1097.

Vickery, P.D. and J.R. Herkert. 2001. Recent advances in grassland bird research: where do we go from here? The Auk 118(1): 11–15.

Wilson, M.D. and B.D. Watts. 2000. Breeding bird communities in pine plantations on the coastal plain of North Carolina. The Chat 64(1): 1–14.

Woodward, D.K. and G. Barthalmus. 1996. Distribution and habitat indices of northern pinesnakes in North Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 50: 271–279.

Woodward, A.A., A.D. Fink and F.R. Thompson III. 2001. Edge effects and ecological traps: effects on shrubland birds in Missouri. Journal of Wildlife Management 65(4): 668–675.

Yahner, R.H. and A.L. Wright. 1985. Depredation on artificial ground nests: effects of edge and plot age. Journal of Wildlife Management 49(2): 508–513.

Yahner, R.H. 2003. Responses of bird communities to early successional habitat in a managed landscape. Wilson Bulletin 115(3): 292–298.

Yates, M.D., S.C. Loeb and D.C. Guynn, Jr. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:501–510.

Mid-Atlantic Coastal Plain Ecoregion

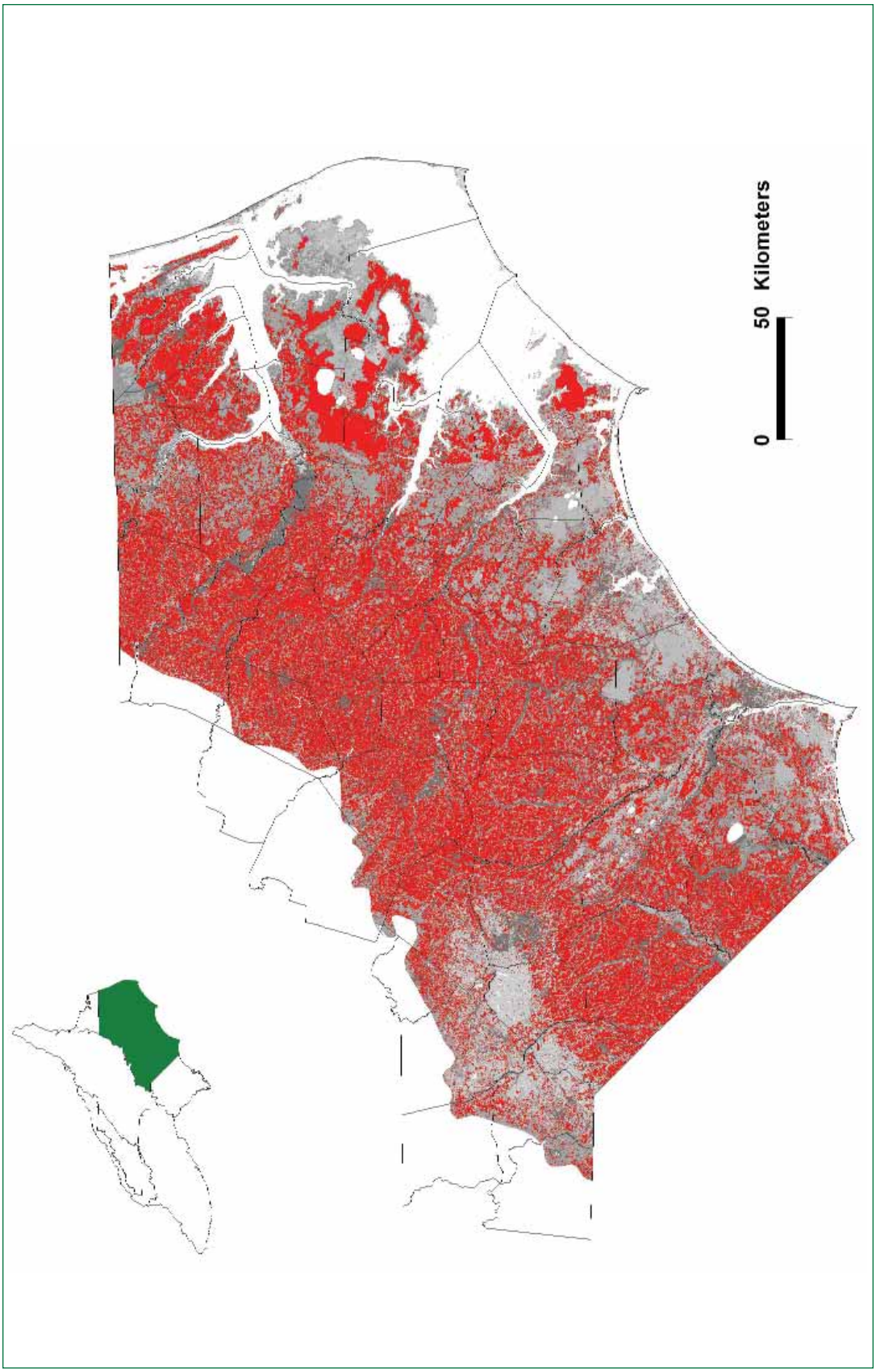


Figure 5A.23. Early successional habitats (including agricultural areas) in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992). *Note: Due to the ephemeral nature of these habitats, this coverage may not be entirely accurate as of 2005. However, it should still give readers an indication of the extent of these habitats across the region.*

24. **Dry coniferous woodlands (Loblolly/slash pine forest)** – Non-longleaf pine coniferous woodlands occur throughout the Coastal Plain in areas planted in upland loblolly pine or slash pine. This habitat might also include sites that, due to lack of fire, lost their original longleaf component and naturally regenerated in other pine species. The understory and midstory in these areas may be dominated by dense growing pocosin shrubs (e.g., wax myrtle), and hardwood tree species such as oaks, hickories, sweetgum or red maple. The exact midstory and understory species composition and structural diversity in plantations will be influenced by past management strategies and rotation schedules. This in turn determines the wildlife species present at various stages in the history of the stands.

Priority species associated with coastal plain loblolly/slash pine woodlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Accipiter cooperii*	Cooper's Hawk	SC
	Aimophila aestivalis	Bachman's Sparrow	SC
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Chordeiles minor	Common Nighthawk	
	Colaptes auratus	Northern Flicker	
	Colinus virginianus	Northern Bobwhite	
	Contopus virens	Eastern Wood-pewee	
	Falco sparverius	American Kestrel	
	Helmitheros vermivorous	Worm-eating Warbler	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides borealis	Red-cockaded Woodpecker	E (E)
	Sitta pusilla	Brown-headed Nuthatch	
Mammals	*Lasiurus seminolus*	Seminole Bat	
	Sciurus niger	Eastern Fox Squirrel	SR
Reptiles	*Crotalus horridus*	Timber (Canebrake) Rattlesnake	SC
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Tantilla coronata	Southeastern Crowned Snake	

A. Location and condition of habitat (see Map 5A.24):

There are over 1 million acres of pine plantations (mainly loblolly pine) in the Coastal Plain owned by industrial timber companies that provide a variety of age classes and conditions of stands. Most of this habitat is found in the upper coastal plain since drainage is better there, but it can be found throughout. Most stands are harvested between 18 and 33 years of age, but there are some exceptions. Generally the harvest strategies provide exceptional habitat on a landscape scale for a variety of early successional wildlife species, pine specialists and even forest species for some periods of time over the life of many stands and adjacent areas. (*Also see the coastal plain Early Successional Habitat section*). Silvicultural strategies (e.g., thinnings, herbicide treatments, fertilization, pruning of pines, and prescribed fire) used determine the species composition and structure of the midstory and understory. Areas that were most likely dominated by longleaf have evolved to a loblolly component due to lack of fire are scattered throughout the Coastal Plain and are generally in poor structural condition with dense a midstory and sparse to moderate understory.

B. Problems affecting species and habitats:

In former longleaf pine stands now dominated by loblolly pine, fire suppression is the single most important factor causing deterioration in these woodlands. It has greatly increased the hardwood component of these stands, changed the structure of the stands as well as the vegetative species in both the understory and overstory. Acquisition can be problematic in these upland habitats since fewer grant options are available. The Natural Heritage Trust Fund and Recovery Land Acquisition Grants are good possibilities.

Habitat fragmentation has also occurred in some areas, although many former hardwood stands and pond pine pocosins have been converted to loblolly or slash pine plantations for timber production. Site suitability for commercial and residential development is one factor contributing to the habitat fragmentation threat and complicating management of remaining stands. These plantations are well suited for some fauna (prairie warbler, worm-eating warbler) but are not suitable to others (eastern fox squirrel, red-cockaded woodpecker) due to the lack of an open canopy layer, high stocking rate, and short rotation age. These highly managed pine plantations also lack age diversity within stands and few old growth stands are available. High grading of stands, lack of gap management and overstocked stands are leading to a lack of structural diversity for many species. Roads cause particularly high mortality to reptiles and amphibians.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Initial efforts need to be directed towards surveys to determine the current baseline distribution and status of species associated with loblolly/slash pine stands (especially those that are state-listed or believed to be declining) for which that information is lacking. Since we lack baseline information about even common species and their distribution and status in this habitat type, we need to direct secondary efforts to conduct surveys to understand current status from which we can then measure future population changes over time.
  - Identify locations of red-cockaded woodpecker colonies around and between designated recovery populations.
  - Determine breeding status/distribution of Cooper's hawk.
  - Conduct status/distribution surveys for the brown-headed nuthatch, red-headed woodpecker, worm-eating warbler, American kestrel, chuck-will's-widow, whip-poor-will, and common nighthawk.
  - Conduct status/distribution surveys of neotropical migrant landbirds on industrial forestland.
  - Conduct species specific surveys for bird species not well tracked by BBS.
  - Determine the status of Bachman's sparrow in stands with the appropriate structure and basal area (e.g., some industrial forestland stands).
  - Conduct distribution and population surveys for eastern fox squirrel.
  - Determine the status and distribution of timber and pigmy rattlesnakes.
  - Determine the status and distribution of priority small mammals, bats, reptiles and amphibians on industrial forestland.
- **Monitoring** – Protocols and procedures developed from baseline surveys should then provide a means to convert from baseline surveys to long-term population monitoring. Current monitoring systems and protocols (e.g., MAPS and BBS) may need to be enhanced to better cover certain species not well covered by current monitoring efforts.
  - Expand MAPS and migration bird banding stations, especially on industrial forestland.
  - Conduct long-term monitoring of winter birds, small mammals, bats, reptiles and amphibians on industrial forestland (compare results in older pine forests to those of typical industrial forestland).

- **Research**

  Population demographics
  - Examine causes of declines among nightjars on industrial forestland (Weyerhaeuser has conducted some of this research already on pine plantations).
  - Conduct life history studies on priority bat species.
  - Conduct life history and activity patterns of eastern fox squirrel.

  Genetics
  - Explore possibility of a sub-species for the coastal worm-eating warbler.

  Predator effects
  - Study predator effects (and cowbird parasitism) on bird nest productivity.

  Genetics
  - Document timber (canebrake) rattlesnake activity patterns on industrial forestland (using telemetry).

  Management practices
  - Explore the impacts of various silvicultural practices on industrial forestland on neotropical migrants, cavity nesters and ground nesting birds.
  - Examine the effects of habitat enhancement in Cooperative Upland Habitat Restoration and Enhancement (CURE) project sites on bats and herpetofauna.

  Habitat use
  - Explore habitat-area relationships of shrub-scrub birds on industrial forestland (Lanham and Guynn 1998).
  - Examine the effects of large scale floods on herpetofauna.
  - Examine the response of small mammal and herpetofauna to pine management strategies (Hood et al. 2002 and Yates et al. 1997).
  - Explore bat habitat use of managed pine stands (Ellis et al. 2002).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Unlike nearly all other forest types mentioned in this Plan, the loblolly/slash pine forest is mostly non-natural (either through fire suppression of longleaf pine stands or conversion of other types to pine plantations). Thus, there is a need to decrease this habitat type and return acreage to natural types. Management and protection of non-longleaf pine woodlands to promote large, unfragmented tracts along with land and easement acquisition on non-industrial forestland should be considered. Fire should be re-introduced, and the fire frequency should be increased to at least once every three years on most tracts when possible. This will necessarily involve resolving smoke management issues, negative public sentiment and liability concerns associated with prescribed burning. Restoration of natural fire frequency, intensity, and seasonality is critical for pine-related reptiles, amphibians, and their prey (Bailey et al. 2004). Restoration of dry longleaf communities should be the primary goal. Additional older aged pine acreage is needed, or management to mimic the characteristics of older stands (e.g., provide canopy gaps, leave dead and downed material, leave cavity trees). Specific management will need to be implemented/continued to manage for red-cockaded woodpecker populations (banding efforts, population monitoring).

Cooperative efforts related to management activities need to continue and expand with large-scale industrial forest landowners to continue to try and improve habitat conditions at the landscape and stand level for a variety of wildlife species (Measells et al. 2002). In addition continued cooperative efforts with red-cockaded woodpecker working groups (for translocation, or to manage the Sandhills and coastal populations of red-cockaded woodpeckers) is needed.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 210–218.

Hood, S.A., D.A. Miller, B.D. Leopold and L.W. Burger. 2002. Small mammal and herpetile response to mid-rotational pine management in Mississippi. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 171–186.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Lanham, J.D. and D.C. Guynn, Jr. 1998. Habitat-area relationships of shrub-scrub birds in South Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 52:222–231.

Measells, M.K., S.C. Grado and L.M. Capella. 2002. Forestry and forest industry: a fish and wildlife agency's current perspective. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 148–158.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Weigl, P. D., M. A. Steele, L. J. Sherman, J. C. Ha, and T. L. Sharpe. 1989. The ecology of the fox squirrel (Sciurus niger) in North Carolina: implications for survival in the southeast. Tall Timbers Research Station, Tallahassee, FL.

Yates, M.D., S.C. Loeb and D.C. Guynn, Jr. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:501–510.

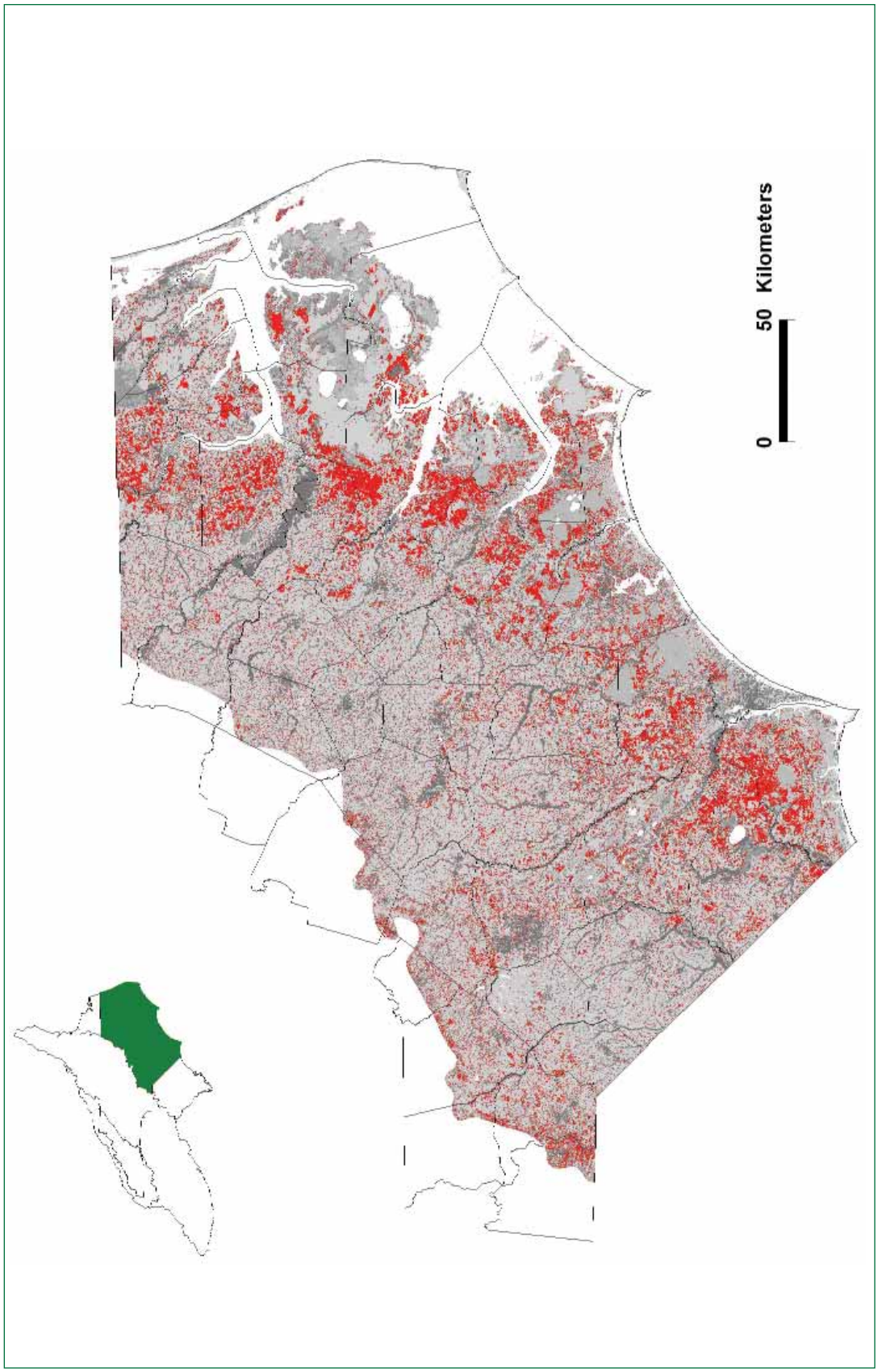


Figure 5A.24. Dry coniferous woodland habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

25. **Dry longleaf pine** – Longleaf pine habitats can range from moist to very well drained sites, including Mesic Pine Flatwoods, Pine/Scrub Oak Sandhill, Xeric Sandhill Scrub, and Coastal Fringe Sandhill. These types often grade into each other or occur as a mosaic on the landscape. Frequent fire maintains a canopy dominated by longleaf pine, an open midstory, and an understory dominated by wiregrass or other grass/herb ground cover. When fire is absent or infrequent, scrub oaks, other hardwoods, and shrubs become common in the midstory and shade out native grasses and forbs. The historical expanse of longleaf pine habitats likely supported stable populations of many early seral species without the understory of a mature or old growth pine forest. Longleaf pine is a very long lived species, so the old growth component of this habitat type was very significant. Prescribed growing season fire needs to increase dramatically in these systems and midstory reduction is essential.

    Coastal Fringe Sandhill communities typically occur within a few miles of the coast on the central and southern Coastal Plain. They have an open to sparse canopy of longleaf pine, scattered scrub oaks, abundant lichens and bare sand, and like sandhill communities naturally experienced frequent low intensity fire except in areas with to little herb cover to carry a fire (Schafale and Weakley 1990). Without fire, oaks and shrubs increase in dominance, leading to litter buildup and shading that reduces herb diversity. With long-term fire suppression the litter buildup and changes in the microenvironment can allow invasion by more mesic species (Schafale and Weakley 1990).

    Mesic Pine Flatwood sites occur on mesic (non-wetland) sites, range throughout the Coastal Plain and Sandhills and have a closed to open canopy of longleaf pine occasionally mixed with loblolly pine (Schafale and Weakley 1990). The low shrub layer can be dense and the herb layer is dominated by wiregrass in frequently burned areas. These communities naturally experience frequent low to moderate intensity surface fires that maintained a rather open canopy, open to sparse shrub layer and thick diverse herb layer (Schafale and Weakley 1990). Many of these sites were cleared for agriculture due to high fertility, whereas others are rapidly in transition to pine-hardwood forests or to loblolly pine forests with a well developed hardwood midstory due to lack of fire.

    Pine/Scrub Oak Sandhill communities are found on rolling to more steeply sloping sites with Coastal Plain sediments with a clay layer near the surface, or sandy to loamy well-drained soils primarily in the Sandhills region but also in the Coastal Plain in sandy areas (Schafale and Weakley 1990). Longleaf pine typically dominates the open canopy with open to dense understory dominated by scrub oaks like turkey oak, blackjack oak and bluejack oak. These communities naturally experienced frequent low intensity surface fires and in the absence of fire the scrub oaks become denser and larger, forming a closed or almost closed subcanopy (Schafale and Weakley 1990). This is the dominant upland community in the 'Sandhills' region of the state.

    Xeric Sandhill Scrub sites occur on deep sand ridges and swale systems. Relict aeolian sand deposits, Carolina bay rims and sandy uplands in mainly the Sandhills region and southern Coastal Plain (Schafale and Weakley 1990). Longleaf pine dominates the open canopy with open to dense understory of turkey oak. Although the least productive, most barren sites produce too little fuel to sustain frequent fires, most of these communities naturally experienced frequent low intensity surface fires with the peak fire season believed to be in early summer (Schafale and Weakley 1990). In absence of fire the scrub oaks become denser and larger and in turn reduce the herb layer and possibility of surface fires.

A. Location and condition of habitat (see Map 5A.25):

Longleaf pine communities, once the most abundant Coastal Plain habitat, now exist in just 3% of their previous range throughout the southeast (Frost 1995). Longleaf pine forest and savanna is one of the most endangered habitats in the country today (Noss and Peters 1995). Urban development and a lack of fire continue to threaten many of these forests. Frost (1993) states that "Of 352 longleaf pine remnants examined in North Carolina, only 91 stands (26%) were being maintained by fire, while the rest (74%) were fire-suppressed and in transition to other forests types." Longleaf pine forests presently occur in the following North Carolina counties, with number of acres in parentheses: Moore (30,200) Hoke (28,300), Richmond (25,800),

Priority species associated with coastal plain dry longleaf pine habitats:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Aimophila aestivalis*	Bachman's Sparrow	SC
	Ammodramus henslowii	Henslow's Sparrow	SR
	Caprimulgus carolinensis	Chuck-will's-widow	
	Caprimulgus vociferus	Whip-poor-will	
	Colaptes auratus	Northern Flicker	
	Colinus virginianus	Northern Bobwhite	
	Contopus virens	Eastern Wood-pewee	
	Dendroica discolor	Prairie Warbler	
	Falco sparverius	American Kestrel	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides borealis	Red-cockaded Woodpecker	E (E)
	Sitta pusilla	Brown-headed Nuthatch	
Mammals	*Lasiurus seminolus*	Seminole Bat	
	Sciurus niger	Eastern Fox Squirrel	SR
Amphibians	*Ambystoma tigrinum*	Eastern Tiger Salamander	T
	Bufo quercicus	Oak Toad	SR
	Hyla andersonii	Pine Barrens Treefrog	
	Hyla gratiosa	Barking Treefrog	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Pseudacris ornata	Ornate Chorus Frog	SR
	Rana capito	Carolina Gopher Frog	T
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Cemophora coccinea copei*	Northern Scarletsnake	
	Crotalus adamanteus	Eastern Diamondback Rattlesnake	E
	Crotalus horridus	Timber (Canebrake) Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Heterodon simus	Southern Hog-nosed Snake	SC
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	
	Masticophis flagellum	Eastern Coachwhip	SR
	Micrurus fulvius	Eastern Coral Snake	E
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Pituophis melanoleucus melanoleucus	Northern Pinesnake	SC
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Tantilla coronata	Southeastern Crowned Snake	

Bladen (25,400), Brunswick (25,200), Cumberland (22,600), Pender (18,600), Scotland (17,900), Onslow (17,800), Carteret (10,800), New Hanover (8,100), Sampson (5,800), Craven (5,200), Pitt (3,100), Columbus (2,800), Harnett (2,800), Robeson (2,500), Jones (2,200), and Lenoir (400).

The best remaining examples of the dry longleaf pine habitat in the Coastal Plain are on the military bases of Fort Bragg, Camp Lejeune, Sonny Point, and Cherry Point, the Croatan National Forest, Holly Shelter Game Land, and Sandhills Game Land. Most of the acreages on the above sites are in fair to good condition, due to regular prescribed burning. There are many other sites on both public and private lands where little to no burning has depleted the value of the habitat; these sites are considered to be in poor condition.

B. Problems affecting species and habitats:

The majority of the loss of this habitat type has been due to urbanization, agriculture, and regeneration of other timber types. Longleaf is considerably more difficult to get established than loblolly, and many foresters do not have the training in order to feel comfortable making recommendations to plant longleaf. Pine production on the Coastal Plain is typically high intensity with short rotations, resulting in densely stocked, closed canopy plantations of loblolly or slash pine with very little herbaceous understory.

Other threats to dry longleaf pine communities are lack of fire, urban development, and intensive pine straw raking. Fire suppression (or only cool season fires) has caused the deterioration of many additional sites, particularly on private lands and around urban areas where smoke management issues create problems for managers and landowners. In absence of fire, scrub oaks (or mesic trees) become larger and more dense and form closed canopies that reduce understory vigor. The loss of understory grass and the presence of oak leaf litter (less flammability) reduces the likelihood and effectiveness of future surface fires (Schafale and Weakley 1990). Designated Wilderness Areas are a good example of where longleaf is being lost to a lack of fire. Longleaf cannot regenerate itself without fire to control competing vegetation. Remaining stands are often fragmented.

Urban development continues to be a problem and can be excessive on these sites. Dry longleaf pine communities occur on sandy, loamy, or other fine textured soils that are moderately to excessively drained, making them ideas sites for residential and commercial development. In addition, the scenic quality of longleaf pines, coupled with the white sands, make longleaf sandhills ideal sites for golf courses and associated development; many thousands of acres have been developed, particularly around Southern Pines and Pinehurst, North Carolina, for these purposes.

Pine straw raking has tremendously impacted understory habitat by removing understory grasses and forbs, preventing their growth, and somtimes creating an almost bare sandy forest floor.

Old growth characteristics (canopy gaps, red-heart fungus, cavities, snags, hollow trees) are lacking throughout, except where red-cockaded woodpeckers are managed, impacting both primary (e.g., woodpeckers) and secondary (e.g., rodents, bats and other birds) cavity users. Habitat loss and lack of fire affects bird species that rely on a grass-dominant understory and open pine ecosystems (red-cockaded woodpecker, Bachman's sparrow, brown-headed nuthatch, Henslow's sparrow, and northern bobwhite). Microhabitat features such as large woody debris have been lost, impacting reptiles and small mammals (Loeb 1999). Fire ant impacts are also a growing threat.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with dry longleaf pine habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on dry longleaf pine communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common.
  - Focus avian status and distribution surveys on Bachman's sparrow, brown-headed nuthatch, red-headed woodpecker, American kestrel, Henslow's sparrow, nightjars and red-cockaded woodpeckers (on nonfederal lands) first and then continue for other birds using dry longleaf pine habitats; of particular importance is documentation of red-cockaded woodpecker clusters around designated recovery populations (see USFWS 2003).
  - Conduct winter surveys for Henslow's sparrow in appropriate grass dominated understory habitat (Carrie et al. 2002).
  - Document the status and distribution of small mammals, bats and eastern fox squirrel.
  - Conduct herpetofaunal surveys for eastern tiger salamander, oak toad, Carolina gopher frog, pine barrens treefrog, northern scarletsnake, southern hog-nosed snake, eastern coachwhip, northern pinesnake and pigmy rattlesnake, canebrake rattlesnake and eastern coral snake and expand eventually to include other reptiles and amphibians.

– Inventory reptile and amphibian species on key public lands where good examples of this habitat type still exist; then expand to areas not well managed or fragmented.
– Conduct extensive surveys to determine the status and distribution of the eastern diamondback rattlesnake in order to facilitate initial habitat protection measures.

- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with dry longleaf pine habitats. Many North Carolina dry longleaf pine bird species require specialized monitoring attention, since neither BBS (nor standard point counts) adequately sample for many species like Bachman's sparrow, nightjars, American kestrel, Henslow's sparrow and red-headed woodpecker. Long-term monitoring for amphibians and reptiles needs to be developed or enhanced (Taylor and Jones 2002) and there is a decided lack of long-term monitoring information on most small mammals and for bat species (Ellis et al. 2002).
  – Establish additional MAPS and migration bird banding stations.
  – Initiate long-term monitoring related to snag ecology and cavity nesting birds during different seasons (e.g., northern flicker, red-headed woodpecker and brown-headed nuthatch) (Wilson and Watts 1999; Kreisel and Stein 1999).
  – Initiate long-term monitoring during breeding, winter and migration periods for all priority landbirds (Wilson and Watts 2000; Brown et al. 2002).
  – Initiate long-term monitoring for priority reptiles and amphibian species associated with dry longleaf pine systems (Taylor and Jones 2002).

- **Research**

  Genetics
  – Determine if the southeastern sub-species of the American kestrel breeds and/or winters in these habitats in North Carolina.

  Habitat use
  – Study nightjar habitat-use and foraging patterns (using telemetry).
  – Conduct habitat-use studies on eastern diamondback rattlesnake (using telemetry).
  – Explore spatial and temporal distribution patterns of amphibians related to temporary and scattered water sources (similar to current work being done on International Paper lands in the southeastern Coastal Plain).

  Population demographics
  – Conduct productivity and nest success research on Bachman's sparrow and brown-headed nuthatch to determine limiting factors for population growth (Wilson and Watts 1999, Stober and Krementz 2000).
  – Conduct Seminole bat life history research, as well as demographic information on other bats (Ellis et al. 2002).

  Predator effects
  – Study predator and cowbird parasitism effects on bird productivity for canopy- and ground-nesting birds.
  – Study the effect of fire ants on ground nesting birds and herpetofauna.

  Management practices
  – Examine the effects of red-cockaded woodpecker management on other birds and reptiles, amphibians, and bats (Krementz and Christie 1999, Conner et al. 2002, Provencher et al. 2002).
  – Develop strategies for pine straw raking that minimizes impacts to understory habitat structure.
  – Examine the effects of intensive fire management on the habitat requirements of the eastern fox squirrel (Weigl et al. 1989).
  – Examine the effects of herbicides used to control hardwoods on non-target herbaceous plants; also, study techniques and preferred chemicals for hardwood control that have the least negative impacts on non-target herbaceous plants.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat restoration through native understory reestablishment, longleaf pine plantings and growing season prescribed burning is needed to maintain the understory and open pine ecosystem. Controlling midstory development and encouraging understory development through prescribed burning are major objectives in order to restore these communities to presettlement conditions (Lorimer 2001). Although a total eradication of oaks when trying to restore longleaf habitat reduces the food base for many mammals (e.g., eastern fox squirrel), restoration of natural fire frequency, intensity, and seasonality is critical for pine-related reptiles, amphibians, and their prey (Bailey et al. 2004). Acceptance of controlled burning can be enhanced through public education, programs to "fire-safe" properties, and cost-share programs to install fire lines and conduct controlled burns. Mechanical or chemical vegetation controls can supplement or replace burning where appropriate. Snag management should be practiced to increase populations of cavity nesting birds (e.g., red-cockaded woodpecker, USFWS 2003).

We must encourage thinning of pine forests and planting longleaf pine (restoration work) in clearcuts and abandoned fields. We must also work with the NC Forest Service to allow wildfires to burn where safety and property protection considerations allow. Opportunities exist to take advantage of existing initiatives and programs such as Partners for Fish and Wildlife, Safe Harbor, the Forest Landbird Legacy Program and Farm Bill programs to influence and improve habitat conditions for birds and other longleaf pine related wildlife. We must also continue coordination with red-cockaded woodpecker working groups, such as the translocation working group, as well as the Sandhills and Coastal group efforts to better manage for that species.

Management and protection of longleaf communities to promote large, unfragmented tracts is needed for reptiles and some bird species. In order to accomplish this goal, land acquisition and easements, especially for existing unfragmented longleaf pine forest, should be sought through cooperation with land trusts and The Nature Conservancy. This protection could potentially involve poor sites (e.g., recent clearcuts, loblolly pine plantations) whereby conversion to longleaf can be accomplished. Two high priority regions for accomplishing landscape-level connection, protection, and management of longleaf pine and associated communities are the Sandhills region and the Onslow Bight region. In the Sandhills, Fort Bragg, Sandhills Game Lands, and other key priorities need to be connected to facilitate dispersal among the high quality habitats of these managed and protected properties. The Onslow Bight region is located on the Coastal Plain from the Pamlico River to the Cape Fear River. Croatan National Forest, Camp Lejeune, and Holly Shelter Gamelands need to be connected to each other and to other key properties to facilitate dispersal and create a landscape-level mosaic of protected, managed, and high quality habitats. The Natural Heritage Trust Fund and the Recovery Land Acquisition Grants are the primary funding sources at this time for acquisition funds within this habitat.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Brown, D.R., C.M. Strong and P.C. Stouffer. 2002. Demographic effects of habitat selection by hermit thrushes wintering in a pine plantation landscape. Journal of Wildlife Management 66(2): 407–416.

Carrie, N.R., R.O. Wagner, K.R. Moore, J.C. Sparks, E.L. Keith and C.A. Melder. 2002. Winter abundance of and habitat use by Henslow's sparrows in Louisiana. Wilson Bulletin 114(2): 221–226.

Conner, R.N., C.E. Shackelford, R.R. Schaeffer, D. Saenz and D.C. Rudolph. 2002. Avian community response to southern pine ecosystem restoration for red-cockaded woodpeckers. Wilson Bulletin 114(3): 324–332.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 210–218.

Frost, C.C. 1993. Four Centuries of Changing Landscape Patterns in the Longleaf Pine Ecosystem. Pages 17–44 in: The Longleaf Pine Ecosystem: Ecology, Restoration, and Management. Proc. Tall Timbers Fire Ecology Conf., No. 18. S.M. Hermann, ed. Tall Timbers Research Station, Tallahassee, FL.

Frost, C. C. 1995. Presettlement fire regimes in southeastern marshes, peatlands, and swamps. 1995. Pages 39–60 in: Proceedings of the Tall Timbers fire ecology conference, No. 19. Cerulean S.I., Engstrom R.T., editors. Tall Timbers Research Station, Tallahassee, FL.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Kreisel, K.J. and S.J. Stein. 1999. Bird use of burned and unburned coniferous forests during winter. Wilson Bulletin 111(1): 243–250.

Krementz, D.G. and J.S. Christie. 1999. Scrub-successional bird community dynamics in young and mature longleaf pine-wiregrass savannahs. Journal of Wildlife Management 63(3): 803–814.

Loeb, S.C. 1999. Responses of small mammals to course woody debris in a southeastern pine forest. Journal of Mammalogy 80:460–471.

Lorimer, C.G. 2001. Historical and ecological roles of disturbance in eastern North American forests: 9,000 years of change. Wildlife Society Bulletin 29(2): 425–439.

Noss, R. F. and R. L. Peters. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Defenders of Wildlife.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Provencher, L., N.M. Gobris, L.A. Brennan, D.R. Gordan and J.L. Hardesty. 2002. Breeding bird response to midstory hardwood reduction in Florida Sandhill longleaf pine forests. Journal of Wildlife Management 66(3): 641–661.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Stober, J.M. and D.G. Krementz. 2000. Survival and reproductive biology of the Bachman's sparrow. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 54: 383–390.

Taylor, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in Southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 301–311.

US Fish & Wildlife Service. 2003. Recovery plan for the red-cockaded woodpecker (Picoides borealis): second revision. US Fish & Wildlife Service, Atlanta, GA.

Weigl, P. D., M. A. Steele, L. J. Sherman, J. C. Ha, and T. L. Sharpe. 1989. The ecology of the fox squirrel (Sciurus niger) in North Carolina: implications for survival in the southeast. Tall Timbers Research Station, Tallahassee, FL.

Wilson, M.D. and B.D. Watts. 1999. Response of brown-headed nuthatches to thinning of pine plantations. Wilson Bulletin 111(1):56–60.

Wilson, M.D. and B.D. Watts. 2000. Breeding bird communities in pine plantations on the coastal plain of North Carolina. The Chat 64(1):1–14.

Mid-Atlantic Coastal Plain Ecoregion

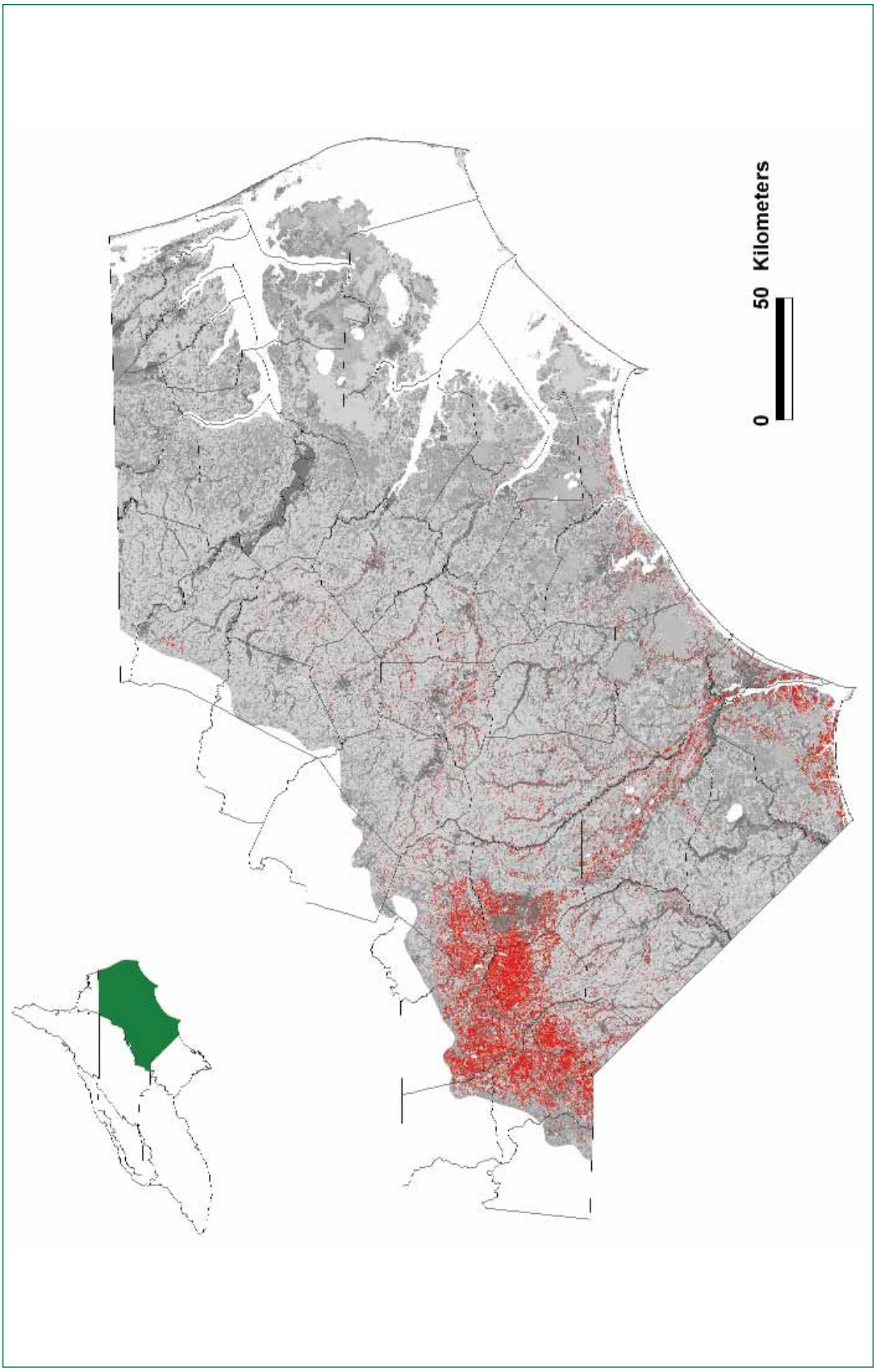


Figure 5A.25. Dry longleaf pine habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

26. **Pocosin** – Peatland communities of the Coastal Plain include low pocosin, high pocosin, pond pine woodlands, peatland Atlantic white cedar forest, bay forest, streamhead pocosin, and streamhead Atlantic white cedar forest. These communities occur on peatlands of poorly drained interstream flats, and peat-filled Carolina bay depressions and swales of the eastern coastal plain (Schafale and Weakley 1990). The streamhead communities occur primarily in the Sandhills along small headwater streams, either on flat bottoms or extending up adjacent seepage slopes.

    Extremely acidic in nature due to organic soils, in general these habitats are nutrient poor and usually continuously saturated with water. Fires were historically associated with droughts, and fire frequency and intensity strongly influence vegetative structure dominance, composition, stature and diversity. All but the streamhead communities occur along a gradient of moisture, nutrients, and peat depth and typically occupy different locations with the domed peatlands of interstream flats and Carolina Bays and swales. The wettest sites (or the center of bays) may contain only low shrubs and stunted pond pine, with beds of sphagnum, pitcher plants, and cranberry. Higher, drier sites are characterized by an extremely dense shrub layer.

    Both High and Low Pocosins are extremely nutrient poor, with little normal nutrient input other than rainfall. Under natural conditions, fire was an important component shaping the structural diversity of these communities. Low Pocosins are centrally located on peatlands on the deepest peat. They are the least productive and most stunted of all the pocosin habitats. True Low Pocosins are much rarer than High Pocosins or Pond Pine Woodlands and differ from the others by having a persistent low stature (<1.5m tall) of shrubby vegetation and sparse, stunted trees. High Pocosins are intermediate between Low Pocosins and Pond Pine Woodlands in terms of location, depth of peat, shrub height and density, and stature of trees. The shrub layer is typically 1.5-3 meters in height and trees still tend to be scattered and small in stature.

    Pond Pine Woodlands occur on parts of domed peatlands on poorly drained interstream flats, peat-filled Carolina bays, and shallow swales and are found throughout the Coastal Plain (Schafale and Weakley 1990). Some stands occupy many thousands of acres, such as in Croatan National Forest, Holly Shelter Game Land, and Green Swamp. These communities are wet and nutrient poor, though less so than Low and High Pocosins, and fire played a role in shaping them historically. In areas where frequent fires have occurred over long periods of time, the understory is dominated by switch cane (Arundinaria) and in general the less frequent the fire regime the greater the dominance by pond pine (Schafale and Weakley 1990). Red-cockaded woodpeckers exist in some of these pond pine-dominated sites.

    Another community that occurs within large peatland landscapes is the peatland Atlantic white cedar forest. Atlantic white cedar-dominated forests are found throughout the Coastal Plain but are most common in the outer Coastal Plain and usually exists as a mosaic with Pond Pine Woodlands, bay forests, nonriverine swamp forests and other communities (Schafale and Weakley 1990). Their occurrence is determined by fire history. They become established after a catastrophic fire removes all competing vegetation and, therefore, usually occur as even-aged stands. Atlantic white cedar dominates in some remaining pocosins where fire is infrequent, but its overall abundance and distribution has been greatly reduced by lack of fire, logging and drainage (Schafale and Weakley 1990).

    Bay forests occur throughout the outer and middle Coastal Plain and also typically exist as a mosaic with pond pine woodlands, Atlantic white cedar forests, and nonriverine swamp forests (Schafale and Weakley 1990). Bay forests occur on shallow organic soils and the canopy is dominated by loblolly bay, sweet bay, and red bay. Bay forests are believed to be a late-successional community that replaces pond pine woodlands and Atlantic white cedar after a long absence of fire. Bay forests may be solely a product of fire suppression, or there may be sites which naturally supported them (Schafale and Weakley 1990).

    Streamhead pocosin communities resemble peatland pocosins but they are found in very different physical settings: ravines in permanently saturated Sandhill seeps. These habitats are subject to influence from fire on adjacent uplands and are characterized by an open canopy of pond pine, with potential for red maple, sourwood, swamp black gum, and tulip poplar. A dense shrub layer is usually present and herbs are sparse. There is a higher shrub and tree diversity in

Priority species associated with coastal plain pocosin habitat:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Colaptes auratus*	Northern Flicker	
	Dendroica discolor	Prairie Warbler	
	Dendroica virens waynei	Wayne's Black-throated Green Warbler	
	Helmitheros vermivorous	Worm-eating Warbler	
	Limnothlypis swainsonii	Swainson's Warbler	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides borealis	Red-cockaded Woodpecker	E (E)
	Wilsonia citrina	Hooded Warbler	
Mammals	*Condylura cristata*	Star-nosed Mole	SC
	Mustela frenata	Long-tailed Weasel	
	Peromyscus gossypinus	Cotton Mouse	
	Sylvilagus palustris	Marsh Rabbit	
	Synaptomys cooperi helaletes	Southern Bog Lemming	SR
Amphibians	*Bufo quercicus*	Oak Toad	SR
	Desmognathus auriculatus	Southern Dusky Salamander	
	Hyla andersonii	Pine Barrens Treefrog	
	Stereochilus marginatus	Many-lined Salamander	

these communities due to nutrients released by burning in adjacent uplands and more frequent disturbance from fires that burn into the edges (Schafale and Weakley 1990).

Pocosins are particularly important for wintering birds because of the high amount of soft mast available. Greenbrier (*Smilax* spp.), red bay, sweet bay, and many ericaceous shrubs produce large quantities of berries that are persistent through much of the winter. Pocosin habitats are important for a variety of shrub-scrub birds though we are lacking status and distribution data, as well as detailed information, about the bird communities that utilize them (Karriker 1993). We also lack detailed information about populations of small mammals, bats, reptiles and amphibians in pocosin habitats, in part because of the very dense (often impenetrable) nature of most pocosin habitats (Mitchell 1994).

A. Location and condition of habitat (see Map 5A.26):

Pocosin habitats are found throughout the outer coastal plain; in the inner Coastal Plain they are found mainly in the Sandhills region or in Carolina bays. The condition of pocosin habitats in much of the Coastal Plain is poor due to fire suppression, changes in hydrology, intensive silviculture, and conversion of forest types. Extensive examples of low and especially high pocosins still exist in the Green Swamp, Croatan National Forest, Holly Shelter Game Land, Camp Lejeune, much of the Albermarle-Pamlico peninsula and many other places as well. The Croatan National Forest, Dare Bombing Range, Camp Lejeune, and Holly Shelter Game Land do conduct some pocosin burns, but all other fire introduced into pocosin habitats tends to be on small acreages (<100 acres).

Extensive examples of Pond Pine Woodlands exist in the Green Swamp, at Alligator River Natianal Wildlife Refuge, Pocosin Lakes National Wildlife Refuges and in Dare County at the Dare Bombing Range. Atlantic White cedar dominates in some remaining pocosins where fire is infrequent, but its overall abundance has been greatly reduced by lack of fire, logging, and drainage (Schafale and Weakley 1990). Atlantic white cedar-dominated communities still exist at Alligator River and Pocosin Lakes National Wildlife Refuges, and in the Great Dismal Swamp.

Public lands hold the highest concentrations of pocosin and peatland communities in the Coastal Plain. Pocosins on private land have largely been ditched and converted to loblolly pine plantations by the forest products industry. Pond pine is a very long-lived tree and is very tolerant to fire, so under natural conditions pond pine woodlands and high pocosin habitats would have a very old component. That is to say that many of the trees in these habitats would normally by over 100 years old. Although much of the pond pine dominated sites are still very old, fire suppression is causing a large build-up of fuel. Concerns are that once these stands burn under wildfire conditions, the fire will be so intense that the ground will burn, thus killing the entire stand.

B. Problems affecting species and habitats:

Fire suppression is an important factor threatening many remaining pocosin, peatland, and streamhead communities due to the strong influence fire has on their vegetative structure, composition, and diversity. Fire-suppressed stands may be invaded by species such as red maple; maples are reaching the canopies of some cedar stands in the long absence of fire. Many managers and landowners are wary of introducing fire to long fire-suppressed peatland communities due to the volatile nature of these communities and to smoke management concerns. When fire is introduced, firelines are often placed directly in the transition zone between uplands and pocosins destroying the species-rich ecotone and preventing fire from burning into pocosins.

Conversion of habitat also threatens pocosin habitats; ditching and draining of these sites leads to alteration of hydrology. When done in preparation for conversion to another land use, these activities ultimately lead to destruction of pocosin vegetation. Conversions for development, agricultural and forestry interests are the major contributors. However, conversion to industrial pine plantations has slowed in recent years. Sedimentation due to clearing of adjacent uplands is also a problem for some streamhead communities.

Habitat fragmentation (as a result of habitat conversion and urbanization) threatens the integrity of pocosin and peatland communities since these communities typically occur as mosaics on the landscape and fire plays an important role in determining the structure of that landscape. As the landscape becomes fragmented, prescribed fire becomes more difficult to use as a management tool because of smoke management concerns and safety issues around urban areas.

In general, little detailed information exists for many species of wildlife that use pocosin habitats because of the impenetrable nature of these habitats. Few surveys have been done on a long-term basis, which makes land management decisions difficult. Pocosin habitats are important for a variety of shrub-scrub birds yet we are lacking status and distribution data, as well as detailed information, about the bird communities that utilize them (Karriker 1993). We also lack detailed information about populations of small mammals, bats, reptiles and amphibians in pocosin habitats (Mitchell 1994)

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with pocosin habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on pocosin communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common. Many pocosin-associated bird species have experienced significant declines across North America over the past four decades according to BBS trend data.
  - Determine status and distribution for Wayne's black-throated green warbler, worm-eating warbler, Swainson's warbler, black-billed cuckoo (may warrant further documentation) and other neotropical migrants, including shrub-scrub specialists like prairie warbler, common yellowthroat and yellow-breasted chat.
  - Conduct helicopter surveys for red-cockaded woodpeckers.
  - Initiate surveys for priority small mammals and investigate bat use of pocosin habitats.

  - Initiate amphibian surveys, especially for the oak toad, southern dusky salamander, pine barrens treefrog, and many-lined salamander.
  - Initiate surveys for reptiles using pocosin habitats.
  - Establish frog call survey stations in pocosin habitats.

- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with pocosin habitats. Many North Carolina pocosin bird species require specialized monitoring attention, since BBS (nor standard point counts) does not adequately sample for species like Wayne's black-throated green warbler, worm-eating warbler, Swainson's warbler, black-billed cuckoo and red-headed woodpecker. Long-term monitoring for amphibians and reptiles needs to be developed or enhanced (Taylor II and Jones 2002) and there is a decided lack of long-term monitoring information on most small mammals, and for bat species foraging in pocosins (Ellis et al. 2002).
  - Establish MAPS and migration bird banding stations in pocosin habitats.
  - Initiate long-term monitoring of breeding and wintering birds in pocosin habitats on public lands and industrial forestland (Karriker 1993 and Watts 2002).
  - Initiate long-term monitoring for mammal populations (including bats) in pocosin habitats on public lands and industrial forestland (Mitchell 1994).
  - Initiate long-term monitoring of reptiles and amphibians in pocosin habitats on public lands and industrial forestland.

- **Research** .

  Genetics
  - Determine the genetic relationships of pocosin habitat small mammals (e.g., shrews and rodents).
  - Examine the possibility of a sub-species for the coastal worm-eating warbler.

  Habitat use
  - Examine the relationship between habitat patch size and nesting success of shrubland birds (Burhans and Thompson 1999) and habitat use by small mammals (Litvaitis 2001).
  - Measure soft mast (berry) production in pocosins and wintering bird use of these areas.
  - Determine breeding bird habitat use in Atlantic white cedar stands.

  Population demographics
  - Conduct studies to obtain basic demographics information on priority birds, small mammals, amphibians and reptiles.

  Predator effects
  - Study predator effects on bird nest success and productivity, as well as other productivity or behavioral studies such as nest-searching and spot-mapping, on public lands and industrial forestland (Mamo and Bolen 1999, Karriker 1993).

  Management practices
  - Determine the best ways to burn these sites, or alternative management that will mimic the effects of fire at sites where birds, mammals, reptiles and amphibians are being monitored.
  - Determine how the use of chipping (using a hydro-ax or other heavy chipping machinery) midstory and understory vegetation affects the plant and animal communities. This practice is becoming more common, particularly in areas where red-cockaded woodpeckers are present.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

The increased use of prescribed fire where possible is one conservation action that can be used to increase heterogeneity in some pocosin habitats related to vegetative dominance, stature and diversity. Fire will increase vegetation structural diversity and should help promote establishment of an herbaceous ground cover such as switchgrass in pond pine dominated woodlands

over time. Fire cycles may be important at certain stages in the life cycle of Atlantic white cedar stands; this needs to be explored.

Burning can often be accomplished on uplands without the use of fire-lines in transition zones between upland sites and pocosin habitats (especially in winter). This promotes a healthy transition zone between the two habitats that is critical for many plant species and allows for nutrient flow to some pocosin habitats

Though extensive amounts of pocosin lands are already protected, some specialized types require more protection, such as Carolina bays (Bladen Lakes area) and white cedar stands. Acquisition partnerships via land trusts and The Nature Conservancy will be important. Opportunities exist to take advantage of initiatives and programs that promote pocosin restoration (Forest Landbird Legacy Program, Partners for Wildlife, North American Wetland Conservation Act). Identified funding sources for acquisition include the Clean Water Management Trust Fund, Coastal Wetlands Grants, Natural Heritage Trust Fund, Forest Legacy, and Recovery Land Acquisition Grants.

Finally, land managers and planners need to address management issues related to pocosin habitats in conservation and land-use planning efforts and also work to understand what the public wants and is willing to accept regarding the management of pocosin habitats and the wildlife associated with these habitats (Thompson and DeGraaf 2001).

Supporting References

Burhans, D.E. and F.R. Thompson III. 1999. Habitat patch size and nesting success of yellow-breasted chats. Wilson Bulletin 111(2):210–215.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:210–218.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Karriker, K.S. Effects of intensive silviculture on breeding and wintering birds in North Carolina pocosins. Masters Thesis, N.C. State Univ., Raleigh, NC.

Litvaitis, J.A. 2001. Importance of early successional habitats to mammals in eastern forests. Wildlife Society Bulletin 29(2):466–473.

Mamo, L.B. and E.G. Bolen. 1999. Effects of area, isolation and landscape on the avifauna of Carolina bays. Journal of Field Ornitholology 70(3):310–320.

Mitchell, M.S. 1994. Effects of intensive forest management on the mammal communities of selected North Carolina pocosin habitats. NCASI Tech. Bull. No. 665.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Richardson, C. 1981. Pocosin wetlands: an integrated analysis of coastal plain freshwater bogs in North Carolina. Hutchinson Ross Publishing Company.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Taylor, J.D. II, and J.C. Jones. 2002. Quantifying amphibian richness in Southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

Thompson, F.R. and R.M. DeGraaf. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29(2):483–494.

Watts, B.D. 2002. Winter use of early successional habitats by birds within the Alligator River, NWR and Pocosin Lakes, NWR: Evaluating the benefit of management scenarios. Center for Conservation Biology Technical Report Series. CCBTR-02-07. College of William and Mary, Williamsburg, VA.

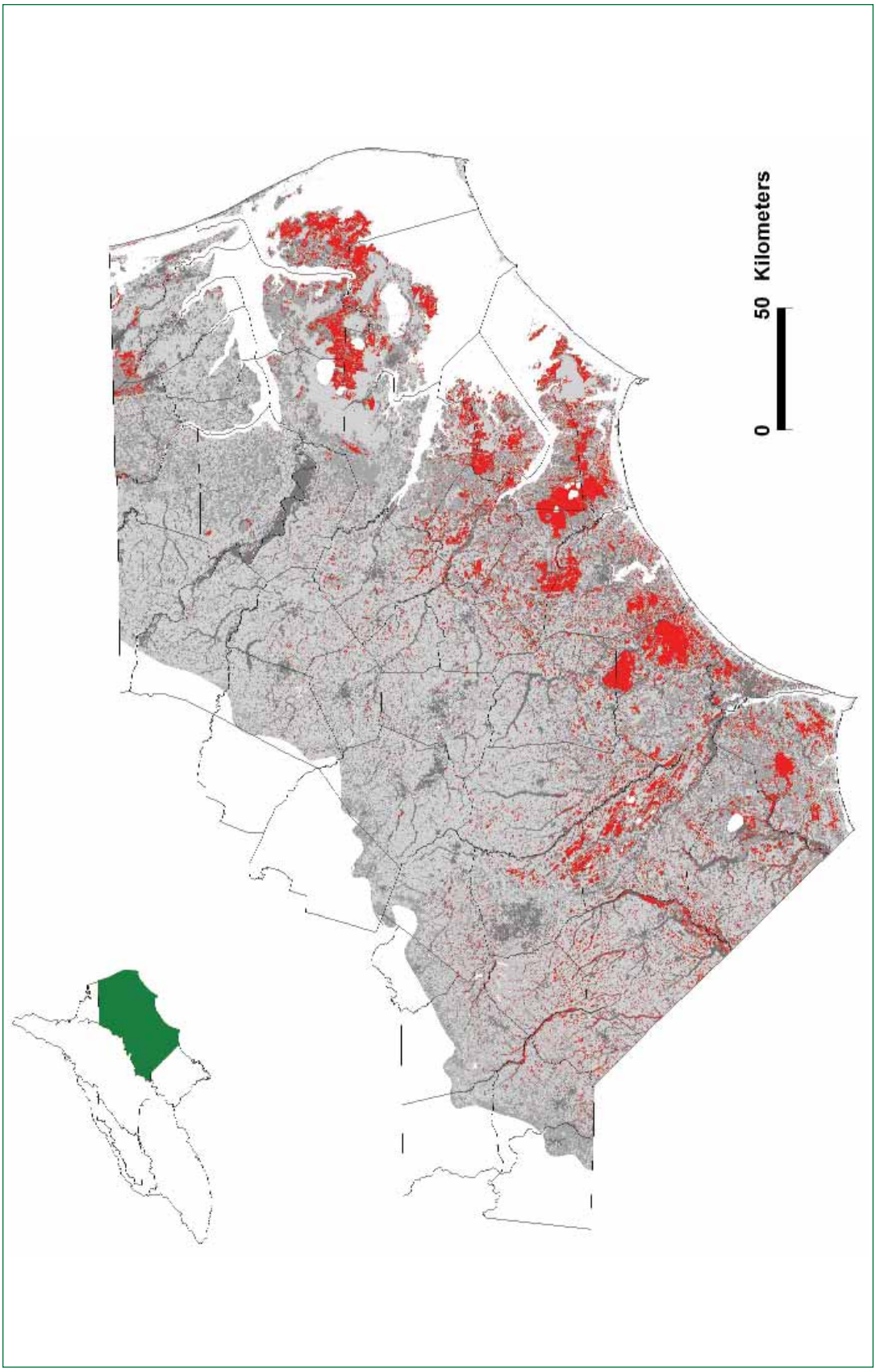


Figure 5A.26. Pocosin habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

27. **Wet pine savanna** – This habitat type includes Pine Savanna, Sandhill Seep, and Wet Pine Flatwoods communities, all of which are mineral wetlands that under natural conditions are subject to frequent burning. With fire, they are characterized by an open canopy dominated by longleaf pine or pond pine, an open midstory, and an understory comprised of some mixture of wiregrass, cane, herbs, and pocosin shrubs depending on soil moisture and fire frequency. Some of the herbaceous plant diversity in these systems, particularly in Pine Savannas, is the highest in temperate North America if burned on a consistent and frequent basis. When fire is suppressed, a dense shrub understory develops and herb diversity declines drastically. These pine communities are similar to dry longleaf pine communities in that they often grade into each other and can occur as a mosaic on the landscape. They may also grade into dry longleaf pine communities, pond pine woodlands, and pocosins.

    Wet Pine Flatwoods are found on seasonally wet to usually wet sites on flat or nearly flat Coastal Plain sediments, and are widespread in the outer and middle Coastal Plain and found occasionally in the Sandhills. These communities have a closed to open canopy of longleaf pine that is sometimes mixed with loblolly or pond pine, and have a low shrub and herb layer of varying density. These sites naturally experienced frequent, low to moderate intensity surface fires (Schafale and Weakley 1990).

    Pine Savannas are found in the lower Coastal Plain on wet, flat areas, and occasionally low "islands" in peatlands or swamps, and are saturated at least part of the year (Schafale and Weakley 1990). These communities naturally experienced frequent fairly low intensity surface fires and with such conditions have a dense herb layer, a very high herb species diversity and an open to sparse pine canopy. In the absence of fire the canopy becomes denser, shrubs invade and herb diversity drops (Schafale and Weakley 1990). There are many rare plants associated with this community type.

    Sandhill Seep communities are found on wet sands underlain by clays on slopes in sand ridges or sandhill areas, primarily in the Sandhills region, but are also present in scarps and sand ridges in the Coastal Plain (Schafale and Weakley 1990). Community structure is strongly controlled by fire regime, and with fire these areas are open and herb dominated and somewhat resemble Pine Savannas but can quickly shift to shrub-dominated understory in the absence of fire (Schafale and Weakley 1990). Like other small natural communities in sandhill areas, nutrients mobilized by fire may be available to Sandhill Seeps even if they do not themselves burn (Schafale and Weakley 1990). Many of these Sandhill Seep areas are becoming overgrown with shrubs due to declining fire frequency.

A. Location and condition of habitat (see Map 5A.27):

The condition of wet pine savanna communities in the Coastal Plain has been greatly reduced due to fire suppression. In the absence of fire, herb diversity and density greatly decline as shrubs present in the understory or surrounding habitat quickly invade and attain dominance. In many areas where fire has been used on adjacent stands, plow-lines at the edge of the wetland have caused a marked loss in transition habitat into these savannas where plant diversity would naturally be very high. Also, a lack of fire has allowed loblolly pines (which are less resistant to fire, especially when young) to invade some areas. This has resulted in a heavier canopy which reduces light to the forest floor, once again inhibiting plant diversity. The additional overstory also somewhat dries the site through transpiration. Ditching, draining and conversion to loblolly plantations has also reduced historic savanna habitat.

A few good examples of these community types still do exist on lands managed by The Nature Conservancy (Green Swamp), the Commission (Holly Shelter Game Lands, Sandhills Game Land), and the US Forest Service (Croatan National Forest). Originally probably the nicest example of wet pine savanna was a 1500 acre site called the Big Savanna in Pender County. Although this site was converted to farmland in the late 1950's, a small (117 acre) but significant extension to the site called Pelham Savanna has been purchased by the North Carolina Coastal Land Trust. The Coastal Land Trust is now in the process of restoring some of the remaining habitat on Pelham Savanna with fire and midstory chipping. Fortunately, experience has shown that even after decades of fire suppression, chipping or burning the midstory in these fire-suppressed stands produces diverse herbaceous understory vegetation.

Priority species associated with coastal plain wet pine savanna:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Aimophila aestivalis*	Bachman's Sparrow	SC
	Ammodramus henslowii	Henslow's Sparrow	SR
	Colaptes auratus	Northern Flicker	
	Colinus virginianus	Northern Bobwhite	
	Dendroica discolor	Prairie Warbler	
	Falco sparverius	American Kestrel	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Picoides borealis	Red-cockaded Woodpecker	E (E)
	Sitta pusilla	Brown-headed Nuthatch	
Mammals	*Mustela frenata*	Long-tailed Weasel	
Amphibians	*Ambystoma mabeei*	Mabee's Salamander	SR
	Ambystoma tigrinum	Eastern Tiger Salamander	T
	Bufo quercicus	Oak Toad	SR
	Eurycea quadridigitata	Dwarf Salamander	SC
	Hyla andersonii	Pine Barrens Treefrog	
	Hyla gratiosa	Barking Treefrog	
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Pseudacris brimleyi	Brimley's Chorus Frog	
	Pseudacris nigrita nigrita	Striped Southern Chorus Frog	
	Pseudacris ornata	Ornate Chorus Frog	SR
	Rana capito	Carolina Gopher Frog	T
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Elaphe guttata*	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	
	Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	
	Ophisaurus mimicus	Mimic Glass Lizard	SC
	Rhadinaea flavilata	Pine Woods Littersnake	
	Sistrurus miliarius	Pigmy Rattlesnake	SC

These habitats are particularly important for reptiles and amphibians where ponds are embedded in savannas or flatwoods; however, little is known about herpetofauna in these areas. Red-cockaded woodpeckers also use these habitats since they typically have a sparse overstory and open midstory that is preferred by the woodpeckers.

B. *Problems affecting species and habitats:*

Many of the problems affecting dry longleaf pine communities also affect wet pine savannas. Intensively managed pine plantations, urban development, a lack of fire, and subsequent habitat fragmentation continue to threaten these communities, and have caused a great deal of losses to wet pine savanna sites. Draining and clearing have altered hydrology and vegetative assemblages. Poor logging practices, especially on non-industrial forestlands, have severely rutted or high-graded many areas.

Fire suppression and a lack of growing-season prescribed burning has caused a thick shrubby understory to develop which shades out grasses and herbaceous ground vegetation and greatly reduces overall plant and animal diversity. The loss of a transition zone between uplands and savannas and between savannas and pocosins due to fireline construction is also a major

concern. Microhabitats and ecotones have been lost due to this practice, and a lack of woody debris particularly impacts reptiles, amphibians and small mammals. Many of the bird species of highest conservation concern inhabit these communities and depend on frequent fire to create suitable habitat conditions (e.g., red-cockaded woodpecker, Bachmans's sparrow, Henslow's sparrow, brown-headed nuthatch, American kestrel, prairie warbler) according to Partners in Flight (Hunter et al. 2001 and Johns 2004).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with these habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on these communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common. Many bird species associated with these community types have experienced significant declines across North America over the past four decades according to BBS trend data.
  - Conduct priority bird surveys for Bachman's sparrow, Henslow's sparrow, brown-headed nuthatch, American kestrel, nightjars, prairie warbler and red-cockaded woodpeckers (on nonfederal lands), then for other species.
  - Determine the status and distribution of the long-tailed weasel, as well as small mammals and bats.
  - Conduct amphibian surveys with focus on the Mabee's salamander, eastern tiger salamander, dwarf salamander, ornate chorus frog, Brimley's chorus frog, Carolina gopher frog and Pine Barrens treefrog (Taylor and Jones 2002).
  - Determining the status and distribution of hard to find reptile species or species for which we have little information (e.g., pigmy rattlesnake, scarlet kingsnake, pine woods littersnake and glass lizards) (Taylor and Jones 2002).
- **Monitoring** – Long term monitoring should be initiated once baseline surveys have been conducted. Focus should begin with herpetofauna and bird species in decline, or for which little is known about the population fluctuations and demographics.
  - Establish MAPS and bird migration banding stations.
  - Establish long-term monitoring for all birds of high conservation concern.
  - Establish long-term monitoring for all reptiles and amphibians in this habitat type (Taylor and Jones 2002).
- **Research**

  Genetics
  - Determine the sub-species status of the American kestrel.

  Habitat use
  - Initiate studies of cavity nesters' use of snags in these systems.
  - Conduct habitat use research on pigmy rattlesnakes.

  Predator effects
  - Study predator effects (including fire ants) on ground nesting bird nest productivity, and productivity as related to cowbird parasitism (Dawson and Bollinger 2000).
  - Study impacts of fire ants on herpetofaunal communities.

  Management practices
  - Document the response of birds, small mammals, amphibians and reptiles to burned vs. unburned wet savanna habitats.
  - Determine habitat response to different seasons/timing of burns (e.g., winter burns vs. spring burns).
  - Explore alternatives (herbicides or mechanical) to using fire for the initial restoration of severely fire-suppressed wet pine savannas.
  - Explore hydrologic restoration of extensively drained sites.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat restoration should primarily occur through growing season prescribed burning, to develop and maintain the herbaceous layer and open pine stands. Where growing season burns can not be administered, winter burns can be constructive. Burning should be accomplished without placing firelines in transition zones from uplands to wetlands and with the fire allowed to burn through transition zones.

Snags should be retained during logging operations to increase the numbers available for cavity-using wildlife species. Efforts need to be made to maintain sufficient levels of woody debris in stands for reptiles, amphibians and small mammals. In disturbed sites, consideration should be given to create barrow sites or ponds for breeding use by amphibians. Otherwise, amphibians are scarce in most flatwoods and savannas devoid of pools or open water.

Management, restoration, and protection of all wet pine savanna communities is needed to promote large, unfragmented tracts, which is especially important for reptiles and amphibians. We must begin to explore opportunities for hydrologic restoration of extensively drained sites. Education and financial or technical guidance incentives should be offered to persuade landowners not to log when soil moisture conditions are conducive to rutting.

Because of the great number of rare plants and animals in these habitats, protection of remaining sites is of utmost importance and urgency. Land acquisition and easements should be promoted through cooperation with land trusts and The Nature Conservancy. Opportunities exist to take advantage of existing initiatives and programs with the US Fish & Wildlife Service and the Natural Resources Conservation Service, such as the Forest Landbird Legacy Program, Partners for Fish and Wildlife, and Farm Bill programs, to improve forest habitat for birds and other wildlife on privately-owned lands. Regional landscape-level conservation initiatives such as those in the Sandhills and Onslow Bight regions for dry longleaf pine also apply to wet pine savanna communities. Identified funding sources for acquisition include the Clean Water Management Trust Fund, Coastal Wetlands Grants, Natural Heritage Trust Fund, Forest Legacy, and Recovery Land Acquisition Grants.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Dawson, W.B. and E. Bollinger. 2000. Predation rates on real and artificial nests of grassland birds. The Auk 117(1):147–158.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Hunter, W.C. and D.A. Buehler, R.A. Canterbury, J.L, Confer and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29(2):440–455.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O.

Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P. and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Taylor, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in Southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

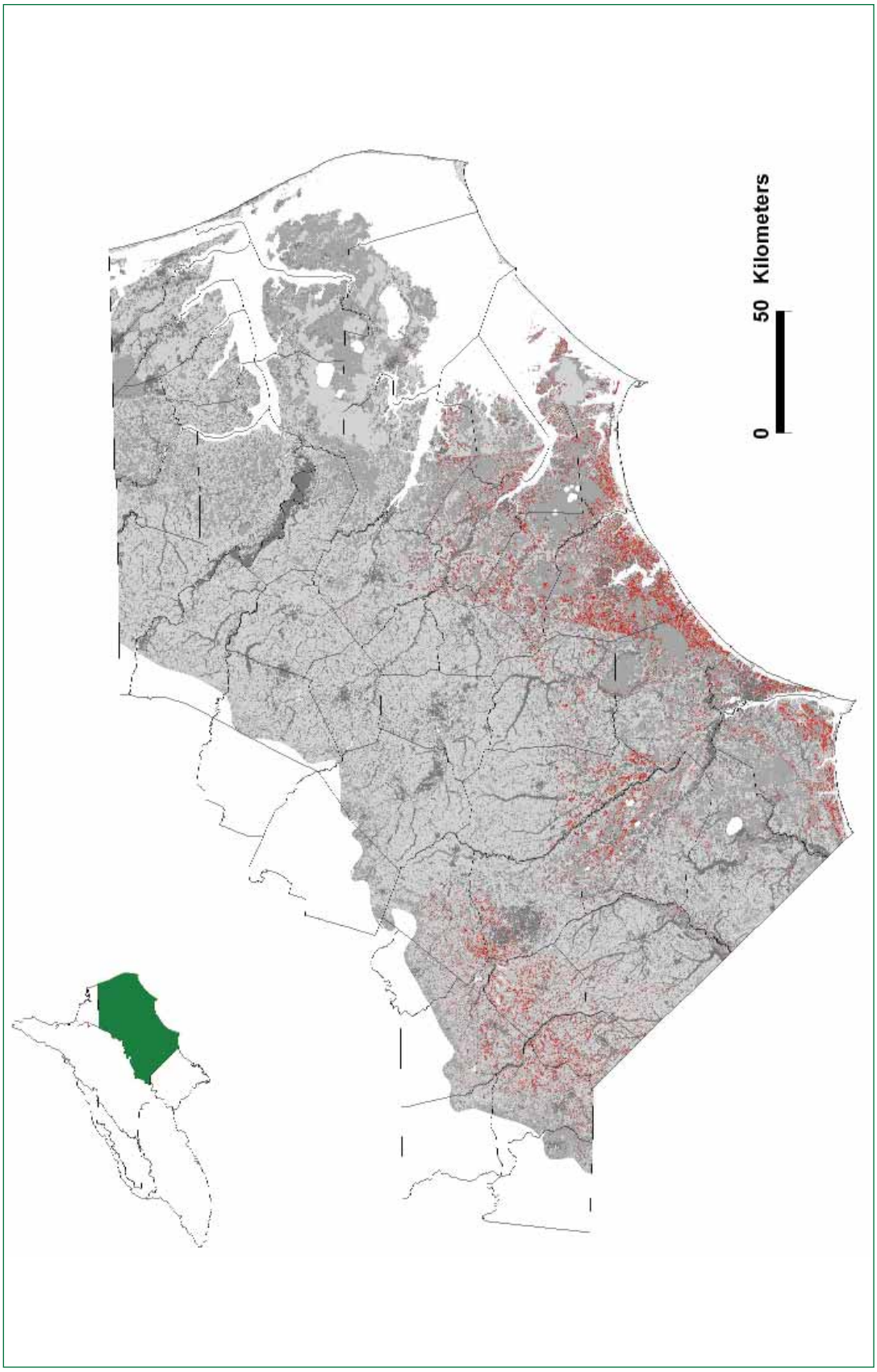


Figure 5A.27. Wet pine savanna habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

28. **Floodplain forest** – The Coastal Plain floodplain forest habitat includes levee forest, cypress-gum swamps, bottomland hardwoods, and alluvial floodplains with small poorly defined fluvial features (such as Small Stream Swamps), as well as semipermanent impoundments (beaver ponds and mill ponds), sand and mud bars, and oxbow lakes. Floodplain forest may be associated with blackwater rivers (originating in the Coastal Plain) or brownwater rivers (originating the Piedmont or Mountains but flowing into the Coastal Plain). The floodplain forest systems of the Coastal Plain in the southeast are now only small fragments and sections of the original millions of acres present before European settlement and have been lost or altered by development, drainage, agriculture and logging (Weller and Stegman 1977). Several of the species of wildlife that once called large floodplain systems home are gone or greatly reduced in numbers.

    Sand and Mud Bar communities are found throughout the Coastal Plain and are usually in and adjacent to streams and rivers and these areas are mostly too wet, young or severely flooded to support a forest canopy (Schafale and Weakley 1990). The dynamic nature of these sand and mud bars also prevents establishment of vegetation. These communities are small and vary widely within and among sites with the size and gradient of river, frequency of duration of flooding, degree of consolidation of substrate, amount of regular fluvial deposition and location within the Coastal Plain (Schafale and Weakley 1990). They are common sites for migrating shorebirds or wading birds to briefly stopover and rest or forage. Coastal Plain Semipermanent impoundments are distinguished from the surrounding floodplain communities by having permanent or semipermanent standing water (beaver ponds, and similar manmade impoundments) and are found throughout the Coastal Plain (Schafale and Weakley 1990). Oxbow Lakes are abandoned river channel meanders with permanent nonflowing water found throughout the Coastal Plain along major rivers (Schafale and Weakley 1990).

    Levee Forest communities in blackwater systems occur on natural levee deposits along channels of large rivers. Dominant trees include wetland hardwoods such as laurel oak, overcup oak, willow oak, river birch, sweetgum, red maple and American elm. Loblolly pine may be common, especially in disturbed sites. These areas are seasonally to intermittently flooded, and typical of blackwater river systems, there is a highly variable flow regime with floods of short duration and periods of very low flow (Schafale and Weakley 1990). The shrub layer ranges form sparse to dense and the herb layer is usually well developed. These areas are greatly affected by the forces of the river and are the rarest of the blackwater floodplain natural communities (Schafale and Weakley 1990).

    Bottomland Hardwoods in blackwater systems occur on high parts of the floodplain away from the channel and are dominated by laurel oak, water oak, willow oak, overcup oak, red maple, sweetgum, loblolly pine, and occasionally Atlantic white cedar (Schafale and Weakley 1990). Shrub layers can be very dense and switch cane can be common. Vines can be dense, but usually not as dense as on levees, and the herb layer is usually sparse. Flooding occurs in these sites occasionally but they are seldom disturbed by flowing water like levees. Blackwater rivers carry little inorganic sediment so flooding does not provide a substantial nutrient input as it does in brownwater systems (Schafale and Weakley 1990). These areas may carry fires (due to dense lower layers of vegetation) when dry and the occurrence of fire would affect the plant community composition and structure.

    Brownwater Levee Forests, in contrast to blackwater levee habitats, tend to have periods of sustained high flow and the water is high in pH, nutrients and mineral sediment (Schafale and Weakley 1990). Forests are dominated by bottomland hardwood species such as sycamore, sugarberry, green ash, river birch, boxelder, water hickory and sweetgum, with moderately dense shrub layers, abundant vines and a dense herb layer (Schafale and Weakley 1990).

    Bottomland hardwoods in brownwater systems are found throughout the Coastal Plain and typical trees include swamp chestnut oak, cherrybark oak, laurel oak, water oak, willow oak, Shumard's oak, sweetgum, green ash, shagbark hickory, bitternut hickory, water hickory and American elm (Schafale and Weakley 1990). These systems are seasonally to intermittently flooded and the water table may be high for long periods even when the site is not flooded (Schafale and Weakley 1990).

Priority species associated with coastal plain floodplain forest:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Anhinga anhinga*	Anhinga	SR
	Chaetura pelagica	Chimney Swift	
	Coccyzus americanus	Yellow-billed Cuckoo	
	Contopus virens	Eastern Wood-pewee	
	Dendroica cerulea	Cerulean Warbler	SR
	Dendroica virens waynei	Wayne's Black-throated Green Warbler	
	Elanoides forficatus	Swallow-tailed Kite	
	Haliaeetus leucocephalus	Bald Eagle	T (T)
	Helmitheros vermivorous	Worm-eating Warbler	
	Hylocichla mustelina	Wood Thrush	
	Ictinia mississippiensis	Mississippi Kite	SR
	Limnothlypis swainsonii	Swainson's Warbler	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Nyctanassa violacea	Yellow-crowned Night-heron	
	Oporornis formosus	Kentucky Warbler	
	Picoides villosus	Hairy Woodpecker	
	Scolopax minor	American Woodcock	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Condylura cristata*	Star-nosed Mole	SC
	Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	T
	Lasiurus intermedius	Northern Yellow Bat	SR
	Lasiurus seminolus	Seminole Bat	
	Myotis austroriparius	Southeastern Bat	SC
	Neotoma floridana	Eastern Woodrat	T
	Peromyscus gossypinus	Cotton Mouse	
	Sorex hoyi winnemana	Southern Pygmy Shrew	
	Sylvilagus palustris	Marsh Rabbit	
Amphibians	*Ambystoma mabeei*	Mabee's Salamander	SR
	Ambystoma maculatum	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Desmognathus auriculatus	Southern Dusky Salamander	
	Eurycea guttolineata	Three-lined Salamander	
	Eurycea quadridigitata	Dwarf Salamander	SC
	Eurycea sp 1	Sandhills Salamander	
	Hemidactylium scutatum	Four-toed Salamander	SC
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Clemmys guttata*	Spotted Turtle	
	Crotalus horridus	Timber (Canebrake) Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Lampropeltis getula getula	Eastern Kingsnake	
	Terrapene carolina	Eastern Box Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

Blackwater Cypress-Gum Swamps contain just a few tree species, tolerant of nearly permanent flooding: bald cypress, pond cypress, and swamp black gum. These communities get little input of nutrients due to the poor inorganic sediment load carried by blackwater rivers and the infertile acidic soils and wetness produce slow growth in the trees (Schafale and Weakley 1990). The difference between cypress and gum dominance is probably related to logging history, but environmental factors such as flooding frequency and depth, water chemistry, soil type and latitude also contribute (Schafale and Weakley 1990). Since cypress-gum swamps flood for long periods of time their vegetational diversity is usually low but they may serve as important habitat for some aquatic animals and plants. Hollow cypress and swamp black gum are particularly important for bats, chimney swifts and other cavity dwelling species. In addition, several colonial waterbird species rely on swamp forests for nesting habitat.

Pond cypress and swamp black gum are unusual in brownwater Cypress-Gum Swamp systems, replaced by a mix of water tupelo and bald cypress as dominant tree species. Carolina water ash and red maple are typical in the understory of blackwater Coastal Plain cypress-gum swamps with Carolina water ash the predominant understory species in brownwater subtypes (Schafale and Weakley 1990). Floodplain forests are usually a mix of trees of different types growing close together that may be associated with different microenvironments that are close enough to interact with trees in different microenvironments. If a floodplain contains levees and ridges large enough to support distinctive communities, larger than the zone of edge effect between them, then the low areas between them may be considered Cypress-Gum Swamps (Schafale and Weakley 1990).

A. Location and condition of habitat (see Map 5A.28):

Floodplain forest communities in various conditions and sizes can be found throughout the Coastal Plain region. The condition of coastal plain floodplain forests of all types have been greatly reduced in recent years throughout North Carolina and the entire southeast (Weller and Stegman 1977, Schafale and Weakley 1990) by a variety of anthropogenic factors.

Factors that impact these systems include flooding regime patterns that have been changed by dams and other development, habitat fragmentation, changes in water chemistry and organic matter loads, increased nitrogen from agricultural and development-related runoff, exotic species and high-grading of stands and logging that reduces wide buffers. All of these factors individually or interactively produce abrupt or gradual changes in floodplain plant and wildlife communities. In particular, the sediment load in many brownwater rivers is now a major problem in the Coastal Plain, and even many blackwater systems now have high sediment loads (Schafale and Weakley 1990).

Floodplain forest along the Roanoke River may be the finest example remaining in the state, yet even there flow regime has been greatly impacted by dams. Other large floodplain forests are associated with the Cape Fear River, Neuse River, Tar/Pamlico River, and Chowan River. Non-point source and point source pollution from a variety of human introduced activities has greatly increased in many drainages due to growing human population. Untreated stormwater runoff from large cities and towns is a major problem that impacts both aquatic life and terrestrial wildlife associated with floodplain forests.

B. Problems affecting species and habitats:

Alteration of hydrology due to dam creation and the draining of wetlands are one of the primary problems affecting this habitat type. Long-duration flooding has had impacts on all ground nesting bird species. Loss of old growth characteristics (canopy gaps, vine tangles, hollow trees, dead and downed woody material) and fragmentation of stands is a major concern. A lack of standing dead or older trees has impacted the availability of quality bat and chimney swift roosting and breeding sites and nesting productivity for species such as wood duck and hooded merganser. Lack of downed woody debris has impacted a variety of amphibians and reptiles.

Fragmentation of stands has contributed to the loss of intact large riparian corridors and the width of many riparian corridors has been greatly reduced. Breeding area-sensitive bottomland-hardwood birds have likely been impacted by the loss of intact woodland systems. Large patches of floodplain habitat are lacking in much of the Coastal Plain. Swallow-tailed kites are one such

species that is area sensitive and although are not presently known to breed within the state, do breed just across the South Carolina border. High-grading of stands has changed plant species diversity and stand vegetative structure. Forestry activities (e.g., logging) have reduced colonial waterbird and eagle nesting areas. Increases in amounts of non-native plants (e.g., Privet, Japanese grass, Japanese honeysuckle) and the overall loss of large canebreaks are partly due to the lack of infrequent fire and also certain logging practices. Understory vegetative diversity has declined in many areas due to modified flooding regimes and increases in invasive non-native plant species. Sewerlines have been constructed along many floodplain corridors, especially in the upper Coastal Plain.

Drainage of wetlands has exacerbated the problems in and adjacent to floodplain forest habitats. This habitat loss impacts all floodplain species, including furbearers, breeding amphibians, overwintering birds, and migrant species that use these areas as stopover sites. Water quality is also an issue in certain major river drainages that negatively affects many invertebrates, fish, amphibians and reptiles.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with floodplain forest habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on floodplain forest communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common.
  - Design specific surveys to determine status and distribution of birds not adequately picked up by the Breeding Bird Survey in floodplain forests (e.g., cerulean warbler, Swainson's warbler, Kentucky warbler, worm-eating warbler, hooded warbler, prothonotary warbler).
  - Determine the status and distribution of Wayne's black-throated green warbler.
  - Determine the status and distribution of swallow-tailed kite, Mississippi kite, yellow-crowned night-heron and anhinga (as well as other colonial nesting waterbirds).
  - Determine the breeding and roosting status and distribution of chimney swift in natural conditions along major floodplains with appropriate habitat conditions (e.g., older, hollow trees).
  - Determine the status and distribution of priority bat species (e.g., Rafinesque's big-eared bat, northern yellow bat, Seminole bat and southeastern bat).
  - Conduct small mammal surveys, especially for the eastern woodrat with a focus on circumneutral soils (other small mammal survey needs include the cotton mouse and southern pygmy shrew).
  - Determine the status and distribution of the numerous salamanders associated with floodplain forests (Taylor and Jones 2002).
  - Determine the status and distribution of canebrake rattlesnakes, as well as other snakes using floodplain forest habitats (Taylor and Jones 2002).
  - Document bald eagle nesting sites..
- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for all wildlife species associated with floodplain forest habitats. Many North Carolina floodplain forest bird species require specialized monitoring attention, since neither BBS (nor standard point counts) adequately sample irregularly distributed or clumped species like cerulean and Swainson's warbler. Long-term monitoring for amphibians and reptiles needs to be developed or enhanced (Taylor and Jones 2002) and there is a decided lack of long-term monitoring information on most bat species (Ellis et al. 2002).
  - Continue long-term monitoring of active bald eagle territories, successful breeding pairs, and fledged eagles.
  - Conduct long-term monitoring for floodplain forest birds (breeding, migration, and winter periods) in forest patches of varying size (Robbins et al. 1989 and Doherty, Jr. and Grubb, Jr. 2000).

- Establish MAPS and migration banding stations, as well as specialized long-term monitoring for hard to sample species such as cerulean and Swainson's warbler (Graves 2001).
- Establish long-term monitoring for all bat species.
- Establish long-term monitoring for herpetofauna using floodplain forest habitat (especially breeding salamanders and canebrake rattlesnakes).

• **Research** – Research studies targeting birds need to be long-term and large-scale, replicated studies that have controlled experimental approaches and focus on population demographics and the response of species to habitat manipulations where appropriate as outlined by the National Partners in Flight Research working group (Donovan et al. 2002). Similar research priorities are needed for other floodplain forest taxa including bats, small mammals, amphibians and reptiles.

Genetics

- Research the genetic makeup of the coastal population of the black-throated green warbler.
- Research the genetic relationships among floodplain salamanders.

Management practices

- Examine the response of bird, amphibian, small mammal and plant communities to canopy gap management (Kilgo et al. 1999, Grialou et al. 2000, Twedt et al. 2001 and Moorman et al. 2002).
- Examine the impacts of long-term flooding regimes on ground-nesting birds (e.g., Swainson's warbler) (Swift et al. 1984); similar studies are also needed for salamanders.
- Determine the conservation and restoration efforts needed for canebrakes in floodplain forests (Brantley and Platt 2001).

Predator effects

- Conduct bird productivity research (especially neotropical migrants) with a focus on nest searching studies to determine the predator community and bird nesting success in patches of different size and with various landscape context (Rodewald and Yahner 2001).

Population demographics

- Obtain information on the demographics and habitat-use of floodplain neotropical migrant landbirds during breeding and migration periods (Donovan et al. 2002).
- Examine demographics and habitat-use of bats in floodplain forests; there is also a need to identify, monitor, and maintain (or recruit) key bat habitats and microhabitats in floodplain forests (Ellis et al. 2002).
- Examine the demographics and habitat-use of small mammals in floodplain forests (Yates et al. 1997).

Habitat use

- Conduct studies (similar to the long-term studies ongoing in South Carolina) to document habitat-use and nesting success of Swainson's warbler in managed and unmanaged systems (Graves 2002 and Somershoe et al. 2003).
- Study the effects of riverine buffer width characteristics on bird species diversity, richness, survival, nest success and productivity (Perkins et al. 2003) (similar studies also needed for small mammals, bats, amphibians and reptiles to determine long-term productivity in buffers of various widths).
- Examine resource abundance (e.g., insects and fruits) in canopy gaps and use by breeding and migrant birds (Blake and Hoppes 1986).
- Study the territory and nest-site selection of cerulean warblers along the Roanoke River (Jones and Robertson 2001).
- Examine the demographics, habitat-use patterns, and impacts of feral hogs on ground nesting birds, salamanders and small mammals (Warren and Ford 1997).
- Examine the effects of habitat patch size on small mammal populations (Yates et al 1997).

- Determine the habitat-use patterns of salamanders and reptiles in floodplain forests.
- Document habitat-use patterns of canebrake rattlesnakes in floodplain forests (using telemetry).
- Study the impacts of beaver and beaver ponds on species composition (both flora and fauna) to determine negative or positive impacts of beaver or beaver control measures.
- Study nutria impacts on both floral and faunal communities and individual species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Land acquisition and easements should be pursued through cooperation with land trusts with an effort to increase the width of riparian buffers and create larger patches of connected habitat. Priority should be given to brownwater bottomlands, as these are the most species-rich and are more susceptible to clearcutting and other timber harvest than are cypress-gum swamps (i.e., wetter sites). Wherever possible, maintenance or restoration of floodplain forest connectivity should be pursued; floodplain forest are important distribution and dispersal corridors for many species (Bailey et al. 2004). The South Atlantic Coastal Plain Partners In Flight Bird Conservation Plan calls for eight patches of forested wetlands of at least 10,000 acres in size throughout the South Atlantic Coastal Plain (Hunter et al. 2000). Identified funding sources for fee simple or easement purchases are the Clean Water Management Trust Fund, the Natural Heritage Trust Fund, the Coastal Wetlands Grant program and the North American Wetland Conservation Act program. An attempt should be made to protect waterbird nesting colonies.

Efforts need to be made to retain old growth floodplain forest (e.g., for chimney swifts, bats, and herpetofauna). Partnerships to begin cane restoration projects and research should be initiated with the Natural Resources Conservation Service. Floodplain buffers of 300–600 feet should be realized in as many areas as possible. This would benefit floodplain forest species such as northern parula, yellow-throated warbler, prothonotary warbler, wood thrush, Swainson's warbler, worm-eating warbler, and acadian flycatcher, as well as amphibians, canebrake rattlesnakes and forest bats. The Forest Landbird Legacy Program (a cooperative effort between the Commission, the US Fish & Wildlife Service, and the Natural Resources Conservation Service) should be further expanded to influence habitat for birds and other wildlife in mature floodplain forest through canopy gap management and other options. The cooperative efforts with colonial waterbird (wading bird) working groups should continue and future management recommendations from the North American Waterbird Management Plan should be followed (Kushlan et al. 2002).

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Blake, J.G. and W.G. Hoppes. 1986. Influence of resource abundance on use of tree-fall gaps by birds in an isolated woodlot. The Auk 103:328–340.

Brantley, C.G. and S.G. Platt. 2001. Canebrake conservation in the southeastern United States. Wildlife Society Bulletin 29(4):1175–1181.

Doherty, Jr. P.F. and T.C. Grubb, Jr. 2000. Habitat and landscape correlates of presence, density and species richness of birds wintering in forest fragments in Ohio. Wilson Bulletin 112(3):388–394.

Donovan, T.M., C.J. Beardmore, D.N. Bonter, J.D. Brawn, R.J. Cooper, J.A. Fitzgerald, R. Ford, S.A. Gauthreaux, T. L. George, W.C. Hunter, T.E. Martin, J. Price, K.V. Rosenberg, P.D. Vickery and T.B. Wigley. 2002. Priority research needs for the conservation of neotropical migrant landbirds. J. Field Ornithol. 73(4):329–339.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:210–218.

Graves, G.R. 2001. Factors governing the distribution of Swainson's warblers along a hydrological gradient in Great Dismal Swamp. The Auk 118(3):650–664.

Graves, G.R. 2002. Habitat characteristics in the core breeding range of the Swainson's warbler. Wilson Bulletin 114(2):210–220.

Grialou, J.A., S.D. West and R.Neal Wilkins. 2000. The effects of forest clearcut harvesting and thinning on terrestrial salamanders. Journal of Wildlife Management 64(1):105–113.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Jones, J. and R.J. Robertson. 2001. Territory and nest-site selection of cerulean warblers in eastern Ontario. The Auk 118(3):727–735.

Kilgo, J.C., K.V. Miller and W.P. Smith. 1999. Effects of group-selection timber harvest in bottomland hardwoods on fall migrant birds. Journal of Field Ornithology 70(3):404–413.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Moorman, C.E., D.C. Guynn, Jr. and J.C. Kilgo. 2002. Hooded warbler nesting success adjacent to group-selection and clearcut edges in a southeastern bottomland forest. The Condor 104:366–377.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the Land Birds of the United States. American Bird Conservancy, The Plains, VA.

Perkins, M.W., R.J. Johnson and E.E. Blankenship. 2003. Response of riparian avifauna to percentage and pattern of woody cover in an agricultural landscape. Wildlife Society Bulletin 31(3):642–660.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Robbins, C.S., D.K. Dawson and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic states. Wildlife Monographs. 103:1–34.

Rodewald, A.M. and R.H. Yahner. 2001. Avian nesting success in forested landscapes: influence of landscape composition, stand and nest-patch microhabitat, and biotic interactions. The Auk 118(4):1018–1028.

Rosenberg, K.V., R.W. Rohrbaugh, Jr., S.E. Barker. J.D. Lowe, R.S. Hames and A.A. Dhondt. 1999. A land manager's guide to improving habitat for scarlet tanagers and other forest-interior birds. The Cornell Lab of Ornithology.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Somershoe, S.G., S.P. Hudman and C.R. Chandler. 2003. Habitat use by Swainson's warblers in a managed bottomland forest. Wilson Bulletin 115(2):148–154.

Swift, B.L., J.S. Larson and R.M. DeGraaf. 1984. Relationship of breeding bird density and diversity to habitat variables in forested wetlands. Wilson Bulletin 96(1):48–59.

Taylor, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in Southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

Twedt, D.J., R.R. Wilson, J.L. Henne-Kerr and R.B. Hamilton. 2001. Nest Survival of forest birds in the Mississippi alluvial valley. Journal of Wildlife Management 65(3):450–460.

Warren, R.J. and C.F. Ford. 1997. Diets, nutrition and reproduction of feral hogs on Cumberland Island, Georgia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:285–296.

Weller, M.W. and J.L. Stegman. 1977. Evaluating and maintaining habitats for fish and wildlife. Trans. Of the 42nd North American Wildlife and Natural Resources Conf. Wildlife Management Institute, Washington, D.C. pp.31–41.

Yates, M.D., S.C. Loeb and D.C. Guynn, Jr. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 51:501–510.

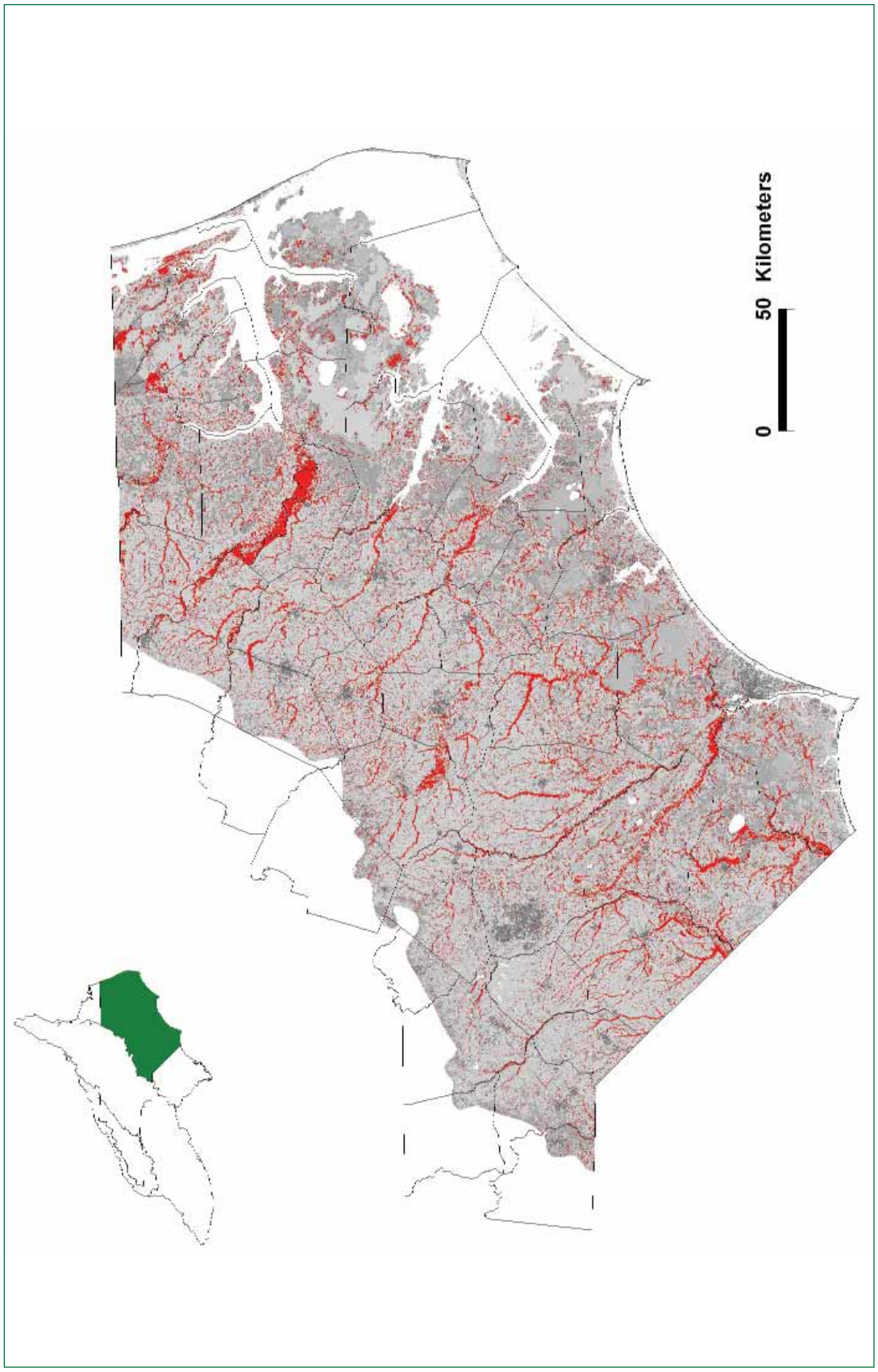


Figure 5A.28. Floodplain forest habitats in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

Mid-Atlantic Coastal Plain Ecoregion

29. **Nonalluvial mineral wetlands** – These wetlands occur on poorly drained areas of the eastern Coastal Plain. Saturation is due to poor drainage and sheet flow from adjoining peatlands. Nonalluvial mineral wetlands are more nutrient-rich than pocosins, but not as rich as floodplain wetlands. In the wettest areas, bald cypress, swamp black gum, and red maple dominate. Where these areas transition to peatland, loblolly pine, pond pine, and Atlantic white cedar may also be present. In less saturated nonalluvial wetlands, trees characteristic of bottomland hardwood systems dominate: cherrybark oak, laurel oak, swamp chestnut oak, tulip poplar, sweetgum, American elm, and red maple.

    Where limestone deposits are near the surface of the ground, the fertility of the soil is improved and a wide variety of trees can occur, including nutmeg hickory, Shumard's oak, Carolina basswood, swamp chestnut oak, water hickory, bitternut hickory, and sweetgum. Pawpaw and redbud may be present in the understory and dwarf palmetto is abundant in the shrub layer (NCNHP 2001).

    Both Nonriverine Wet Hardwood Forest and Nonriverine Swamp Forest communities exist in the outer Coastal Plain and both are seasonally saturated or flooded by high water tables (Schafale and Weakley 1990). Fire was unlikely an important part of these systems naturally, although some Nonriverine Wet Hardwood Forests did support canebrakes historically (Schafale and Weakley 1990). Nonriverine Wet Hardwood Forests are typically drier than Nonriverine Swamp Forests and have more bottomland hardwood species present in their canopy (Schafale and Weakley 1990).

    These sites are important for variety of neotropical migrants during the breeding season and migration periods (Hunter et al. 2000 and Johns 2004), and also several reptiles of conservation concern. The shrubby nature of some of these sites is thought to be related to logging and since they are easy to drain and make excellent farmland, most of these areas have been lost (Schafale and Weakley 1990).

    Examples of this habitat type can be found in Alligator River National Wildlife Refuge, Swanquarter National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, Hoffman Forest, Rocky Point and several swamps in Washington County.

A. Location and condition of habitat (see Map 5A.29):

The condition of nonalluvial mineral wetlands in the Coastal Plain is generally poor due to alternation of hydrology (primarily from draining for farmland and conversion to loblolly pine plantation) and is rather fragmented. Some of the best remaining examples are on public lands such as on Alligator River National Wildlife Refuge, Swanquarter National Wildlife Refuge and the Great Dismal Swamp National Wildlife Refuge. Nonalluvial mineral wetlands tend to be converted for forestry and agriculture more readily since the mineral soils can support heavy equipment better than organic soils, and they are more fertile. Much of this type existed in Beaufort and Pamlico counties until recent years; relatively little remains. A higher percentage of this habitat type has probably been destroyed than any other type in the Coastal Plain, with the exception of dry longleaf pine.

B. Problems affecting species and habitats:

Fire suppression has certainly led to a decline in some of the diversity of these habitats but the alteration of hydrology from ditches associated with farming and forestry practices is the biggest factor impacting this habitat type. Non-native plant species (e.g., Privet, Japanese grass) are also competing with native vegetation in many areas, especially those frequently disturbed. Although little of this quality habitat remains, it can be burned more safely than those sites with organic soils. Therefore the potential still exists to re-establish some high quality nonalluvial mineral wetlands on the Coastal Plain of North Carolina, where it has not already been converted to farmland or ditched for pine plantations.

Priority species associated with coastal plain nonalluvial mineral wetlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Dendroica virens waynei*	Wayne's Black-throated Green Warbler	
	Helmitheros vermivorous	Worm-eating Warbler	
	Limnothlypis swainsonii	Swainson's Warbler	
	Nyctanassa violacea	Yellow-crowned Night-heron	
	Oporornis formosus	Kentucky Warbler	
	Wilsonia citrina	Hooded Warbler	
Mammals	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	T
	Lasiurus intermedius	Northern Yellow Bat	SR
	Lasiurus seminolus	Seminole Bat	
	Myotis austroriparius	Southeastern Bat	SC
	Neotoma floridana	Eastern Woodrat	T
Amphibians	*Desmognathus auriculatus*	Southern Dusky Salamander	
	Pseudacris nigrita nigrita	Striped Southern Chorus Frog	
Reptiles	*Cemophora coccinea copei*	Northern Scarletsnake	
	Crotalus horridus	Timber (Canebrake) Rattlesnake	SC
	Elaphe guttata	Corn Snake	
	Eumeces laticeps	Broad-headed Skink	
	Farancia abacura abacura	Eastern Mudsnake	
	Heterodon platirhinos	Eastern Hog-nosed Snake	
	Lampropeltis calligaster rhombomaculata	Mole Kingsnake	
	Lampropeltis getula getula	Eastern Kingsnake	
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	
	Masticophis flagellum	Eastern Coachwhip	SR
	Ophisaurus mimicus	Mimic Glass Lizard	SC
	Rhadinaea flavilata	Pine Woods Littersnake	
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Tantilla coronata	Southeastern Crowned Snake	
	Virginia valeriae valeriae	Eastern Smooth Earthsnake	

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Determine the status of yellow-crowned night-heron and Wayne's black-throated green warbler, as well as other neotropical migrants and colonial nesting birds that are not well sampled by BBS.
  - Document the status and distribution of priority bat species (e.g., Rafinesque's big-eared bat, northern yellow bat, Seminole bat and southeastern bat) in this habitat.
  - Conduct eastern woodrat surveys and subsequently establish standardized long-term monitoring of the species in this habitat.
  - Determine the status and distribution of canebrake and pigmy rattlesnakes.
  - Survey for other high priority snakes and lizards.
- **Monitoring**
  - Establish long-term monitoring for Wayne's black-throated green warbler and other neotropical migrants that are not well tracked by BBS in this habitat type.
  - Establish MAPS and migration bird banding stations.

  - Following the establishment of surveys to document priority bat use of the habitat, continue with long-term monitoring.
  - Following the establishment of surveys to document priority reptile use of the habitat, continue with long-term monitoring.

- **Research**
  - Conduct home-range and movement research on timber (canebrake) and pigmy rattlesnakes (possibly on other snakes of conservation concern as well).
  - Conduct genetics research to determine if the coastal worm-eating warbler is a separate sub-species.
  - Explore alternatives (herbicides or mechanical) to using fire for the initial restoration of severely fire suppressed non-alluvial wetlands.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Site protection and protection of surrounding areas through land acquisition or easements and cooperation with land trusts are urgently needed, as large acreages (>500 acres) are frequently clearcut all at once for agriculture, pine conversion, or development. Regional land trusts and The Nature Conservancy can be valuable partners in these efforts. Identified funding sources for acquisition include the Clean Water Management Trust Fund, Coastal Wetlands Grants, Natural Heritage Trust Fund, Forest Legacy Grants, and Recovery Land Acquisition Grants. Restoration efforts may be possible in some cases through partnerships with land trusts, the Nature Conservancy, and state and federal agencies.

The use of fire at the remaining unconverted nonalluvial mineral wetland sites is the single most important factor to restore these sites. Plowed firelines along transition zones between habitats should be rehabilitated (smoothed over) where possible. If feasible, fires should be allowed to sweep through the habitat or at least into the edges of the wetland from the adjacent upland sites. New firelines should be constructed when necessary. These areas should be maintained as a permanent narrow opening by discing with a tractor or by wetting with water or foam prior to a burn. The maintenance of contiguous gradients between wetland and adjacent upland sites is critical for seasonal migration and dispersal of herpetofauna. Roads, agriculture, or forestry operations between complimentary sites may still render them ineffective at supporting amphibian and reptile populations. Where fire cannot be introduced back into the site for smoke management or other reasons, the use of a hydro-ax or other chipping machinery should be considered to control midstory (where funds allow).

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

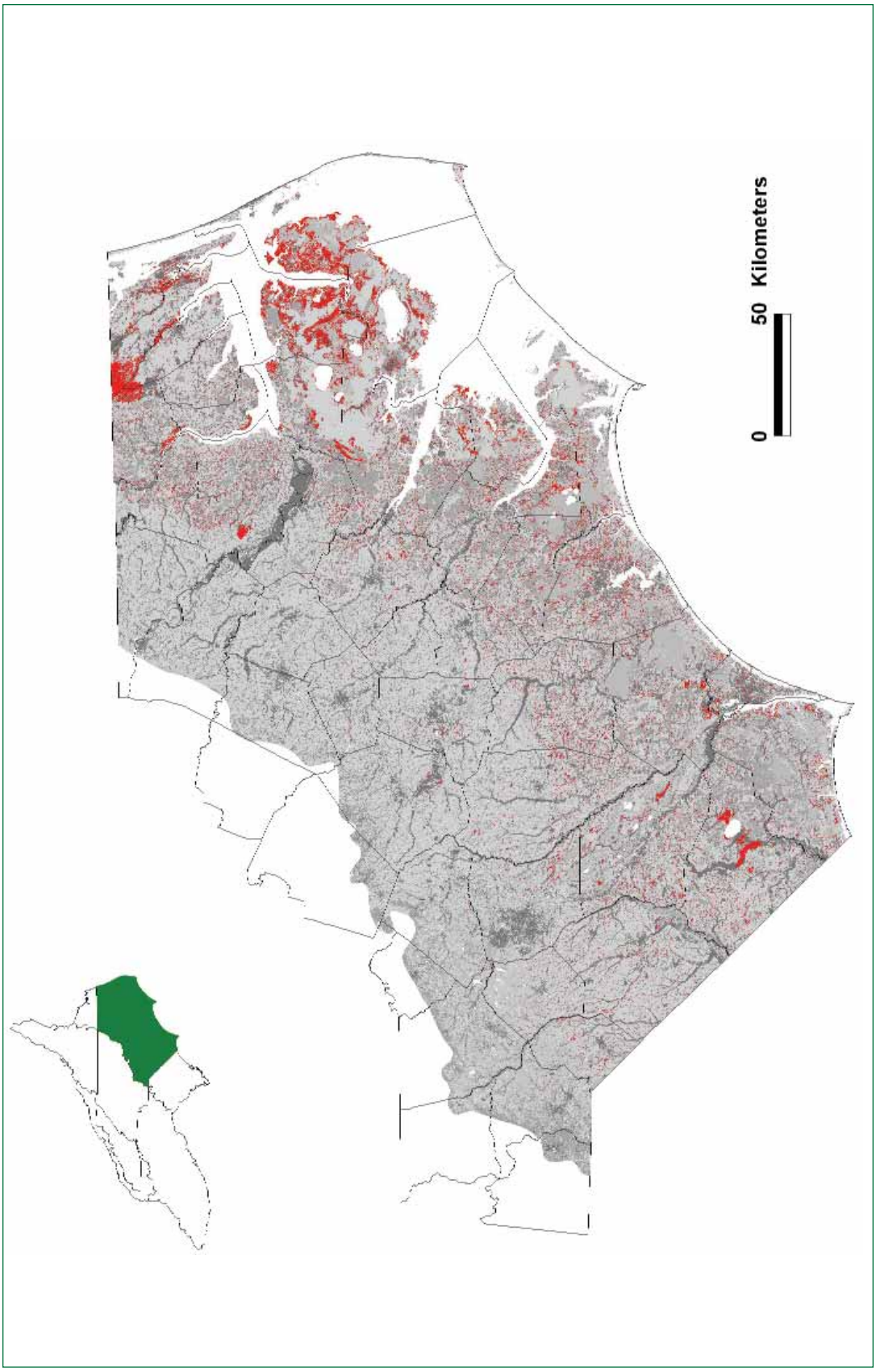


Figure 5A.29. Nonalluvial mineral wetlands in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

30. **Lakes and reservoirs** – There are 22 natural lakes in the Coastal Plain. Basins range from Carolina bays to peatland depressions. Most natural lakes in North Carolina are acidic and therefore have relatively low productivity. Lake Waccamaw is an exception, with neutral pH and a high calcium content. This lake is home to many endemic species and is therefore of extreme importance.

    Reservoirs tend to be quite small on the Coastal Plain since topography is so flat. Millponds, farm ponds, Carolina bays and impoundments are quite common and provide key habitat for lentic aquatic or semi-aquatic wildlife species. These areas (and the immediate shoreline vegetation) are also important areas for many bird species (nesting, roosting, and feeding sites) and provide habitat for fish, reptiles, amphibians, and aquatic or semi-aquatic mammals. *Beaver ponds are discussed in the Small Wetland Communities section.*

    In particular, these sites and immediately adjacent cover (especially the smaller ponds) are habitat for wading birds and shorebirds for foraging, and also important sites for breeding for species such as green heron. Common yellowthroat and red-winged blackbird are typical nesters in vegetation along shorelines, and swallows and swifts often forage over lakes and ponds. Bald eagle and osprey nest and/or forage at these sites, and waterfowl roost, loaf and feed during migration and winter. Double-crested cormorants are becoming common year-round residents at most coastal lakes. Anhinga are sometimes seen during summer, nesting at millponds and/or natural lakes. In addition, these water bodies are popular destinations for human recreational activities such as canoeing, fishing, crabbing and swimming.

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basins portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

Priority species associated with coastal plain lakes and reservoirs:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Anhinga anhinga*	Anhinga	SR
	Egretta caerulea	Little Blue Heron	SC
	Egretta thula	Snowy Egret	SC
	Gallinula chloropus	Common Moorhen	
	Haliaeetus leucocephalus	Bald Eagle	T (T)
	Ixobrychus exilis	Least Bittern	
	Melanerpes erythrocephalus	Red-headed Woodpecker	
	Mycteria americana	Wood Stork	E (E)
	Nyctanassa violacea	Yellow-crowned Night-heron	
Reptiles	*Alligator mississippiensis*	American Alligator	T (T)
	Apalone spinifera aspera	Gulf Coast Spiny Softshell	
	Deirochelys reticularia	Eastern Chicken Turtle	SR
	Farancia abacura abacura	Eastern Mudsnake	
	Farancia erytrogramma erytrogramma	Common Rainbow Snake	
	Kinosternon baurii	Striped Mud Turtle	
	Regina rigida	Glossy Crayfish Snake	SR
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat (see Map 5A.30):

Many of the natural lake communities (e.g., Lake Mattamuskeet) in the Coastal Plain are in public ownership. However, the degree to which the shoreline and water quality are protected varies (NCNHP 2001). Many of these sites are important waterfowl, wading bird and even shorebird wintering and migration stopover areas, especially at National Wildlife Refuges (NWR) like Lake Mattamuskeet NWR and Pocosin Lakes NWR.

Millponds and man-made impoundments provide key habitat for many species of waterfowl, wading birds and other waterbirds throughout the year and are found throughout the Coastal Plain. Impoundments vary with age, water depth and disturbance history; the isolation of these ponds may be an important factor in determining the flora and fauna present (Schafale and Weakley 1990).

B. Problems affecting species and habitats:

Development and loss of associated riparian habitats are primary concerns. Although bald eagles have found additional shorelines to use as perch/foraging sites through the many constructed reservoirs, most of these shorelines are becoming heavily impacted by development.

Changes in hydrology and water chemistry are leading to water quality concerns. Exotic species (e.g., *Hydrilla* and other plants, *Corbicula*, carp) negatively affect native frogs and turtles due to decreased native plant and animal diversity. Avian Vacuolar Myelinopathy (AVM) is a disease that affects birds that use these habitats. It has been known to kill at least 99 bald eagles in the southeast and is associated with a Noval Cyanobacterial species in aquatic plants such as hydrilla. Shorelines are often trampled and shoreline erosion and mowing is a concern in many areas. Point and non-point source pollution sources from residental areas and other sources (e.g., 2-stroke engines) are prevalent, and non-point source pollution from agriculture and logging is possible at several sites, potentially leading to algal blooms and low dissolved oxygen events. Disturbance (boat and personal watercraft wakes and associated noise pollution) by boats and potential Outlying Landing Field aircraft are also a concern relating to some species of wildlife, especially waterfowl. Until regulation changes in 2004, trapping of turtles for the food market was a severe impact on Coastal Plain lakes and ponds.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

- **Surveys**
  - Conduct status and distribution survey work for bald eagle, anhinga, common moorhen, swallows, wood stork, yellow-crowned night-heron (and other ibis, herons and egrets).
  - Document the status and distribution of rails at all times of the year, and least bittern use of marsh areas.
  - Document breeding landbird use of water-filled Carolina bay edges (Mamo and Bolen 1999).
  - Establish survey stations for foraging bats.
  - Document the status and distribution of uncommon or hard to find reptiles (e.g., eastern chicken turtle, eastern mudsnake, glossy crayfish snake); initiate surveys for other reptiles and amphibians using lentic habitats.
  - Establish frog call survey stations at several sites in the Coastal Plain on public lands (and if possible on private lands).
- **Monitoring**
  - Continue long-term monitoring for bald eagles and expand long-term monitoring for nesting ospreys, rails and other marshbirds.
  - Continue surveys and monitoring of heronries.
  - Establish long-term monitoring for all pond turtles (often subject to collection).
  - Conduct monitoring to track impacts of exotics on native wildlife.
- **Research**
  - Track and identify problems associated with avian vacuolar myelinopathy that cause mortality in American coots, other waterfowl, and bald eagles (to continue to follow up on recent research) (Augspurger et al. 2003).
  - Conduct movement research for eastern chicken turtle and some snakes (e.g., eastern mudsnake, common rainbow snake and glossy crayfish snake), using telemetry.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Elimination and control of exotics, especially aquatic plants, is imperative. Native vegetative composition and structure are important to the seasonal migrations of many wetland-related reptiles and amphibians (Bailey et al. 2004). Better buffers surrounding these areas are also needed and lakeshore development needs to be limited to reduce pollution and recreational access impacts on lake communities. Natural structures, in the form of logs, rocks, and snags, should be retained. Development near bald eagle nest trees needs to be controlled.

Conservation of millponds that are being drained due to dike maintenance costs will also be a pressing issue in the coming years. We need to promote techniques for managing beaver damage that minimize loss of quantity and quality of beaver ponds. Beaver ponds are important habitat for many birds, mammals, amphibians and reptiles. Coordination with waterbird working groups should continue and future recommendations from the North American Waterbird Conservation Plan should be followed (Kushlan et al. 2002).

Acquisition and other protection of natural lakes and ponds is a high priority. There are still a few such lakes in the "Bladen Lakes" region that are in private, unprotected ownership. Protection of some millponds is also warranted, though this is a lower priority than protection of natural water bodies.

See the river basin sections for more detailed conservation recommendations regarding aquatic species and habitats.

Supporting References

Augspurger T., J.R. Fischer, N.J. Thomas, L. Sileo, R.E. Brannian, K.JG. Miller, and T.E. Rocke. 2003. Vacuolar myelinopathy in waterfowl from a North Carolina impoundment. Journal of Wildlife Diseases 39:412–417.

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Mamo, L.B. and e.g., Bolen. 1999. Effects of area, isolation and landscape on the avifauna of Carolina bays. Journal of Field Ornithology 70(3):310–320.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

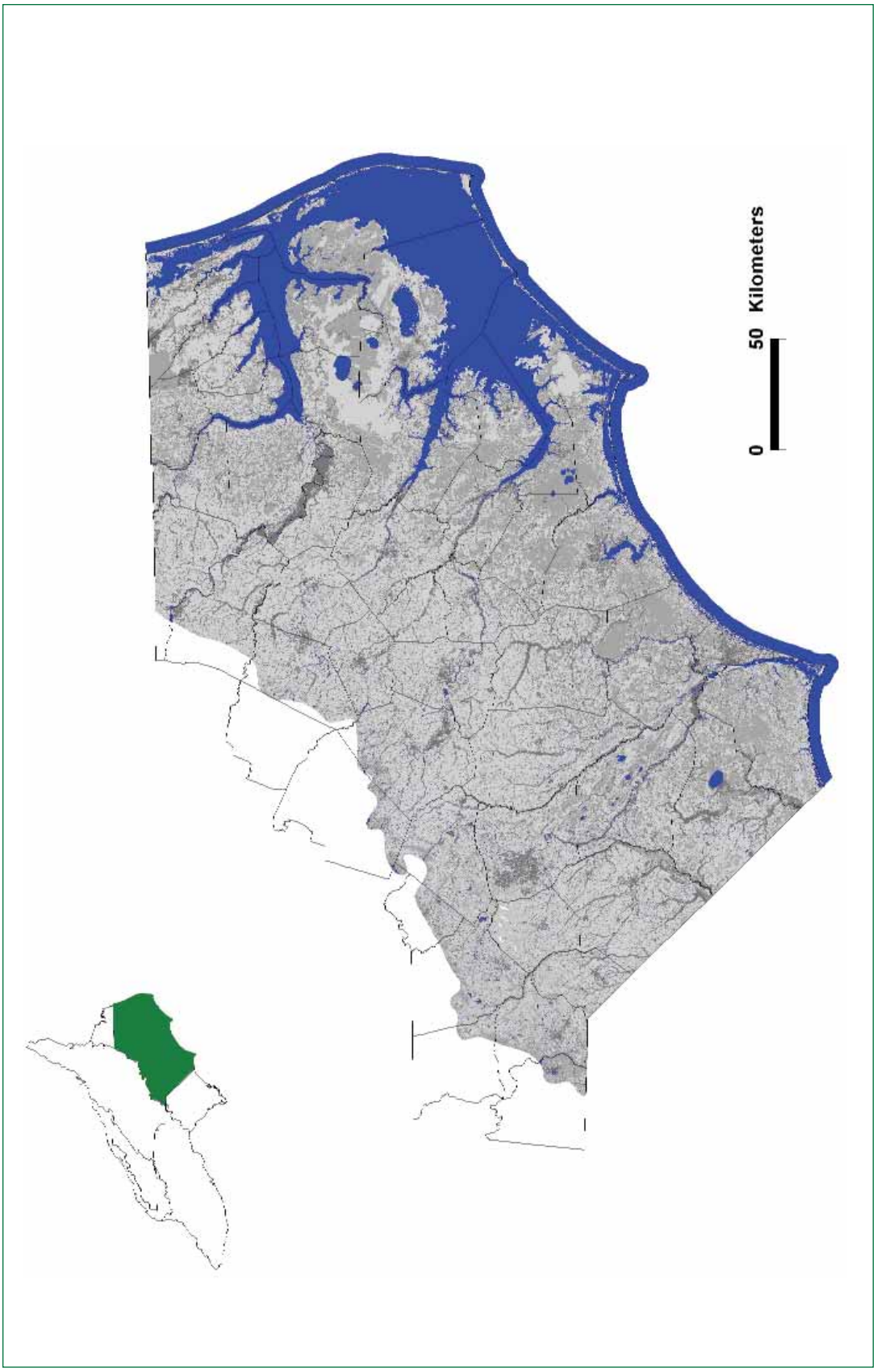


Figure 5A.30. Lakes in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in blue; open water and sounds also shown) (data source: NC GAP, 1992).

31. **Riverine aquatic communities** – Coastal Plain riverine habitats (including streams) are important for a number of wildlife species, especially to herpetofauna that utilize aquatic habitats during part or all of their life cycle, and to aquatic mammals such as the manatee. Examples of birds that utilize river and streams include the Louisiana waterthrush, prothonotary warbler, many waterfowl species, wading birds and some shorebirds. These habitats are also important for a variety of common mammals that are semi-aquatic and/or that have an aquatic food base (e.g., beavers, river otters, certain bats). Many of the issues identified in the floodplain forest section will also have relevance for these taxa (Weller and Stegman 1977).

    Coastal Plain rivers and streams provide a number of important habitat, life cycle, or prey components to a vast assemblage of terrestrial, semi-aquatic, and aquatic wildlife. In addition, the importance of maintaining water quality of riverine habitats cannot be overstated, both in terms of the species that rely upon rivers and streams for habitat, as well as those species which rely indirectly upon the habitat by virtue of provision of habitat for their prey.

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basins portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

Priority species associated with coastal plain riverine aquatic communities:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Anhinga anhinga*	Anhinga	SR
Mammals	*Trichechus manatus*	Manatee	E (E)
Amphibians	*Eurycea guttolineata*	Three-lined Salamander	
	Eurycea sp 1	Sandhills Salamander	
	Necturus lewisi	Neuse River Waterdog	SC
	Rana heckscheri	River Frog	SC
	Siren lacertina	Greater Siren	
	Stereochilus marginatus	Many-lined Salamander	
Reptiles	*Alligator mississippiensis*	American Alligator	T (T)
	Apalone spinifera aspera	Gulf Coast Spiny Softshell	
	Deirochelys reticularia	Eastern Chicken Turtle	SR
	Farancia abacura abacura	Eastern Mudsnake	
	Farancia erytrogramma erytrogramma	Common Rainbow Snake	
	Kinosternon baurii	Striped Mud Turtle	
	Regina rigida	Glossy Crayfish Snake	SR
	Seminatrix pygaea	Black Swamp Snake	SR
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. Location and condition of habitat[1]:

Riverine aquatic communities are found alongside and within all Coastal Plain rivers. Human-influenced alterations have affected much of the coastal plain's riverine and floodplain habitats. Water quality and quantity have been impacted by run-off from municipalities, road construction and poorly managed agricultural operations (originating in the Coastal Plain, and/or from upstream sources in the Piedmont). Dam construction has altered flows and river hydrology and morphology. Removing woody debris from streams after storms has influenced in-stream habitat structure and food webs. The condition of some Coastal Plain rivers is greatly reduced due to these impacts. However, some sections of Coastal Plain rivers are designated High Quality Water and Outstanding Resource Water Management Zones and provide excellent opportunities for maintaining relatively pristine waterways. (*Also see Chowan, Pasquotank, Roanoke, Tar-Pamlico, Neuse, White Oak, Cape Fear, and Lumber River basin sections*).

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

B. *Problems affecting species and habitats:*

Water quality is a primary concern, especially for fully aquatic species. Dams have altered hydrology and stream flows, and have created barriers for movement for species that depend on the rivers and streams for their primary mode of travel. Irregular flooding during the growing and nesting seasons can affect the reproductive success and survival of species that depend on this habitat type. Dams buffer against peak flows that disperse seeds of plants to maintain habitats. Many streams and rivers are heavily laden with sediment, which has disturbed the food webs on which these species depend. Exotic species like *Corbicula* impact nutrient flow and outcompete many native aquatic invertebrates.

Water quality deterioration and loss of habitat are two of the most serious problems affecting wildlife that utilize riverine habitat. Water quality concerns, originating from both point and non-point sources have had, and continue to pose a threat directly to species that occur in riverine habitat, and indirectly through alteration of the food base or habitat. Direct and indirect impacts of decreased water quality upon wildlife associated with riverine habitat are difficult to quantify, and have not been as fully explored as have impacts upon fully aquatic species. However, there is little doubt that clean water is critical to a host of species that live in rivers and streams for a portion of their lives, and that sedimentation, channel scour, and other alterations of the physical habitat can lead to both deterioration of the habitat quality and negative impacts upon aquatic flora and fauna, which form the base of the food web for numerous wildlife species.

A condition with historic roots that still affects riverine habitat and its wildlife is the impoundment of rivers and streams for a variety of purposes including hydroelectric power generation, flood control, water supply, and recreation/aesthetics. Again, the effects have been both direct and indirect, in that lotic habitat has been lost and the food web has shifted, at least in portions of former riverine habitat, to species that do not depend upon flowing water. Other than directly measuring the direct impact of this habitat conversion, we do not know the overall impact upon the wildlife species present from the indirect effects of river or stream impoundment.

Another impact upon riverine habitat that can be construed as habitat loss, at least for some species, is the development of floodplains or riparian areas. River or stream-front development may or may not have a direct negative impact upon water or habitat quality in the stream or river, however in most instances it usually does. The impacts of development adjacent to rivers and streams includes potential problems associated with direct input of contaminants and sediment, alteration of hydrologic patterns and processes, temperature regimes, and loss of critical habitat adjacent to aquatic habitat that may be of equal importance to species that only spend a portion of their lives in the water, like some amphibians.

Most of the listed priority amphibian and reptile species associated with riverine habitat have limited distributions, unknown distributions or widely dispersed but small populations. Isolation or fragmentation of particular habitat stretches occupied by those species could have significant long-term effects upon the sustainability of those populations in the Coastal Plain of North Carolina.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with riverine habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on riverine communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common.
  - Determine the status and distribution of manatees in coastal rivers.
  - Determine the components of foraging bat communities along rivers.
  - Determine the status and distribution for priority herpetofauna associated with Coastal Plain riverine aquatic communities (e.g., river frog, many-lined salamander, sandhills salamander, greater siren, Neuse River waterdog, Gulf Coast spiny softshell, eastern

chicken turtle, striped mud turtle, common rainbow snake, eastern mudsnake, glossy crayfish snake, black swamp snake) and secondarily for other reptiles and amphibians using riverine habitat.
  - Better determine the status and distribution of the American alligator.

- **Monitoring** – Monitoring systems need to be expanded and/or targeted to be able to assess current population status and trend information for the wildlife species associated with riverine habitats. Long-term monitoring for amphibians and reptiles needs to be developed or enhanced (Taylor and Jones 2002) and there is a decided lack of long-term monitoring information on most bat species associated with riverine habitat (Ellis et al. 2002).
  - Establish long-term efforts to monitor the northward range expansion of the manatee.
  - Establish long-term monitoring of bats using riverine habitat for foraging.
  - Establish long-term monitoring for priority amphibian and reptiles.

- **Research**

  Genetics
  - Verify the genetic makeup of the sandhills salamander, which has yet to be formally described.

  Population demographics
  - Collect basic demographics information on riverine-associated reptiles, amphibians and bats.

  Management practices
  - Determine the effect of buffer widths on amphibian and reptile species diversity and productivity.
  - Determine the impacts of "snagging" (removing woody debris after storms) on wildlife populations.
  - Examine the extent and impact of exotic species introductions; conduct research on effective control measures for the most problematic exotics.
  - Investigate the effect of beaver ponds on downstream movement of pollutants (toxins and sediment).

  Habitat use
  - Examine foraging and habitat use patterns of bats, using telemetry.
  - Examine habitat-use patterns of the eastern mudsnake, common rainbow snake, glossy crayfish snake, black swamp snake and eastern chicken turtle, using telemetry.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

The biggest need in Coastal Plain riverine aquatic communities is to increase buffer widths to mitigate impacts from pollution into river systems, and to maintain habitat at the edge of these aquatic communities that will provide cover and foraging areas for many wildlife species using riverine habitat. Immediate and continuing efforts need to be undertaken to limit water quality deterioration from point sources of pollution as well as non-point sources. Toxic chemicals and sediment are entering waterways and having a direct negative impact upon the species in the rivers and streams, but also having significant negative impacts upon the quality of the habitat itself.

Measures to address these issues, some of which are in practice currently, such as regulation of point and non-point sources of pollution, need to be enacted and enforced. Mandatory and incentive-based practices to improve water quality need to be actively pursued with cooperation from agencies and organizations at local, state and federal levels. River and stream ecosystem enhancement and restoration efforts and programs need to be enhanced and supported as well. And finally, within the frameworks afforded by state, local, federal, and private initiatives, riverine habitats need to be permanently protected from the negative impacts of development

through conservation ownership (fee title or easement) of as much habitat as possible. Fee title (linear length protection) and easements acquisition through partnerships with land trusts is essential. Where possible forest patches should be connected along river systems to provide connectivity. The Clean Water Management Trust Fund is an important funding organization for riverine aquatic sites.

Also see the appropriate river basin sections for more detailed conservation recommendations regarding fully aquatic species.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Ellis, A.M., L.L. Patton and S.B. Castleberry. 2002. Bat activity in upland and riparian habitats in the Georgia Piedmont. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56: 210–218.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

N.C. Natural Heritage Program. 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Taylor II, J.D. and J.C. Jones. 2002. Quantifying amphibian richness in Southeastern forests. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 56:301–311.

Weller, M.W. and J.L. Stegman. 1977. Evaluating and maintaining habitats for fish and wildlife. Pages 31–41 in Transactions of the 42nd North American Wildlife and Natural Resources Conf. Wildlife Management Institute, Washington, D.C.

32. **Small wetland communities** – These communities include vernal pools, cypress savanna, small depression ponds, beaver ponds, small depression pocosin, interdune ponds, clay-based Carolina bays and limesink depressions. They are often mimicked by barrow sites along small dirt roads. These depressions may hold water for a significant portion of the year and most are important habitat for many rare or poorly understood reptiles and amphibians. A single small North Carolina vernal pool can contain several species of frogs. Across the landscape, these habitats are widely scattered but provide key breeding sites for amphibians. Small wetlands can also be important breeding habitat for crayfishes (*for more about crayfishes and other aquatic taxa, see the individual river basin sections*).

    Vernal Pools are small sites that flood seasonally and occur throughout the Coastal Plain and Sandhills (Schafale and Weakley 1990). They are dominated by a dense to sparse herb layer and when dry are subject to fires spreading from adjacent uplands. These Vernal Pools are almost always key amphibian breeding sites because they contain no fish.

    Small Depression Ponds are on sites with permanently flooded (at least in the center) sinkholes, Carolina bays and other upland depressions that have complex and irregular zones of vegetation (Schafale and Weakley 1990). Most occur in the lower Coastal Plain, over limestone formations. Scattered trees (pond cypress and swamp blackgum) may be present in both deep and shallow water zones and most ponds are surrounded by a dense shrub layer. These shrubby zones provide breeding habitat for shrub-scrub-nesting birds (Hunter et al. 2000 and Johns 2004) and these sites are used by wading birds for foraging/nesting. The main value of these sites, however, is that they provide critical habitat for reptiles and breeding amphibians.

    Cypress Savannas are rare sites and are found in the southern part of the inner Coastal Plain on wetland soils with a clay hardpan, and include clay-based Carolina bays and other wet clay-like depressions (Schafale and Weakley 1990). They typically dry up during summer, and usually have an open canopy of cypress. Small Depression Pocosin sites are small depressions found throughout the Coastal Plain and seldom distinguished on soil maps. Historically, portions of these depressions likely burned from fires spreading from adjacent uplands (Schafale and Weakley 1990). These are also important amphibian breeding sites since they rarely contain fish.

A. Location and condition of habitat[1]:

Clay-based Carolina bays are particularly abundant in Robeson, Hoke, and Scotland counties; most feature cypress savannas. Small Depression Pocosin examples are found on Croatan National Forest and on Sandhills Game Land, and good examples of Vernal Pools are found on Sandhills Game Land and at Carolina Beach State Park. Small Depression Ponds are primarily found in Brunswick, New Hanover, Onslow, and Carteret counties. All depression habitats have been greatly reduced by development and drainage.

Beaver ponds are a natural community, but result from modification of other community types, and thus there is the potential for human action to mimic them effectively. Beaver ponds vary with age, water depth and disturbance history; the isolation of these ponds may make "accidents of dispersal" important factors in the flora and fauna present (Schafale and Weakley 1990). With stable beaver populations, beaver ponds can be maintained for decades, but dam destruction can shorten their lifespan. A reduction of beaver ponds will place more importance on man-made ponds as the primary habitat for many lentic aquatic species. Dead trees in beaver ponds are important foraging and nesting habitat for woodpeckers (such as the red-headed woodpecker) and for wood duck nesting.

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

Priority species associated with coastal plain small wetland communities:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mammals	*Condylura cristata*	Star-nosed Mole	SC
	Synaptomys cooperi helaletes	Southern Bog Lemming	SR
Amphibians	*Ambystoma mabeei*	Mabee's Salamander	SR
	Ambystoma maculatum	Spotted Salamander	
	Ambystoma opacum	Marbled Salamander	
	Ambystoma tigrinum	Eastern Tiger Salamander	T
	Bufo quercicus	Oak Toad	SR
	Eurycea quadridigitata	Dwarf Salamander	SC
	Hemidactylium scutatum	Four-toed Salamander	SC
	Hyla andersonii	Pine Barrens Treefrog	
	Hyla gratiosa	Barking Treefrog	
	Pseudacris brimleyi	Brimley's Chorus Frog	
	Pseudacris nigrita nigrita	Striped Southern Chorus Frog	
	Pseudacris ornata	Ornate Chorus Frog	SR
	Rana capito	Carolina Gopher Frog	T
	Scaphiopus holbrookii	Eastern Spadefoot	
	Siren intermedia intermedia	Eastern Lesser Siren	
Reptiles	*Clemmys guttata*	Spotted Turtle	
	Deirochelys reticularia	Eastern Chicken Turtle	SR
	Farancia abacura abacura	Eastern Mudsnake	
	Regina rigida	Glossy Crayfish Snake	SR
	Seminatrix pygaea	Black Swamp Snake	SR
	Thamnophis sauritus sauritus	Common Ribbonsnake	

B. Problems affecting species and habitats:

Development and fragmentation has reduced the availability of small wetland communities, impacting breeding amphibians. Increased road densities are correlated with declines in amphibian diversity and abundance (Vos and Chardon 1998, Findlay et al. 2001, Fahrig et al. 1995). Roads can cause heavy mortality for reptiles and amphibians and can effectively isolate breeding populations, or separate wetland habitats from upland habitats that are used during non-breeding portions of amphibian and reptile life cycles.

Many of these habitats are inherently small and are easily impacted by nearby development or drainage. Cutting ditches through wetlands can alter their hydrology and habitat quality. Drainage of many Coastal Plain depressions has occurred, primarily for agricultural or development purposes. Most amphibians are highly sensitive to changes in water quality. Pollution associated with these land uses has altered water quality at some sites. An increase in impervious surfaces due to Coastal Plain development has caused excess stormwater runoff into adjacent seasonal wetlands. Long-term drought and possibly excessive pumping of ground water has caused lowered water tables and lowered pond levels in some areas.

Ephemeral and isolated wetlands are very valuable to amphibians because they typically do not naturally support fish and other predators of amphibian eggs. The introduction of fish, bullfrogs, and other predatory species can devastate the breeding effort of amphibians in small wetlands.

Lastly, the use of all terrain vehicles (ATVs) and other recreational vehicles can cause significant damage around wetland communities. ATVs cause soil disturbance, increase erosion and sedimentation, elevate vehicle related mortality rates, and cause noise-related disruptions of faunal activities.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Conduct surveys on all amphibian species associated with small wetland communities, especially Mabee's salamander, spotted salamander, eastern tiger salamander, oak toad, dwarf salamander, four-toed salamander, ornate chorus frog, Pine Barrens treefrog, and Carolina gopher frog.
  - Determine the status and distribution of the eastern chicken turtle, eastern mudsnake, black swamp snake, and glossy crayfish snake.
  - Initiate frog call surveys (potentially coordinated through NC Partners in Amphibian and Reptile Conservation).
  - Expand cooperative survey efforts for amphibians and reptiles with industrial forest landowners such as Weyerhaeuser and International Paper (small wetlands may be a matrix habitat within larger stands of upland forest).
- **Monitoring**
  - Establish long-term breeding amphibian monitoring in these habitat types.
  - Monitor the long-term quality and quantity of beaver pond habitats in the region.
- **Research**
  - Investigate movements of amphibians and reptiles between small wetlands within a complex and use of adjoining uplands.
  - Investigate the potential to create vernal ponds for the benefit of wildlife, particularly amphibians.
  - Examine small wetlands to determine the importance of foraging and nesting areas for wading birds.
  - Determine the importance of beaver ponds to birds, reptiles and amphibians and document populations of basking turtles in areas with beaver ponds as compared to areas with few or no ponds.

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Protection of sites and surrounding areas through land acquisition or easements and cooperation with land trusts is the most critical conservation need in Coastal Plain small wetland sites. Quite a large number of lime sink (small depression) ponds still remain in private, unprotected status. Regional land trusts and The Nature Conservancy can be valuable partners in these efforts. The maintenance of contiguous gradients between wetland and adjacent upland sites is critical for seasonal migration and dispersal of amphibians; roads, agriculture, or other land use operations between complimentary sites may still render them ineffective at supporting amphibian and reptile populations. However, research has shown that with proper management, herpetofaunal communities can succeed on managed forestland (Leiden et al. 1999; Russell et al. 2002a, Russell et al. 2002b, Ryan et al. 2001). In instances where natural wetlands have been lost or degraded, the construction of artificial wetlands may assist in facilitating dispersal and recolonization of sites (Bailey et al. 2004). Recommendations on how to construct borrow pits during private road construction to benefit amphibians should also be developed.

Wetland restoration efforts should focus on restoring natural hydrology, water quality, and plant communities. The Natural Resources Conservation Service's Wetlands Reserve Program provides a good tool for promoting wetland conservation on private lands. Strategies for the effective removal of introduced aquatic predators need to be developed, and a mechanism for identifying and prioritizing sites for removal should be worked out.

There is a need to promote the adoption of agricultural and forestry best management practices that reduce run-off, erosion, and pollution of small wetland communities. The federal Farm Bill and other cost share programs provide incentives for land stewards to adopt these practices. Technical guidance manpower is needed to proactively promote and facilitate participation in these programs. Allowing prescribed fire in uplands to burn into and/or through depression wetlands during dry seasons or dry years is recommended.

Another critical aspect of small wetland conservation involves the development of outreach materials for the general public, developers, and land-use planners that describe the importance of vernal pools and depression sites for amphibians and reptiles. Better understanding of these seemingly isolated and insignificant sites as critical amphibian breeding areas may lead to more significant consideration of their protection during site design and planning.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Fahrig, L., J. H. Pedlar, S. E. Pope, P. D. Taylor, and J. F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177–182.

Findlay, C. S., J. Lenton, and L. G. Zheng. 2001. Land-use correlates of anuran community richness and composition in southeastern Ontario wetlands. Ecoscience 8:336–343.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Leiden, Y. A., M. E. Dorcas, and J. W. Gibbons. 1999. Herpetofaunal diveristy in coastal plain communities in South Carolina. Journal of the Elisha Mitchell Scientific Society 115:270–280.

Russell, K. R., D. C. Guynn, and H. G. Hanlin. 2002a. Importance of small isolated wetlands for herpetofaunal diversity in managed, young growth forests in the Coastal Plain of South Carolina. Forest Ecology and Management 163:43–59.

Russell, K. R., H. G. Hanlin, T. B. Wigley, and D. C. Guynn. 2002b. Responses of isolated wetland herpetofauna to upland forest management. Journal of Wildlife Management 66:603–617.

Ryan, T. J., T. Philippi, Y. A. Leiden, M. E. Dorcas, T. B. Wigley, and J. W. Gibbons. 2001. Monitoring herpetofauna in a managed forest landscape: effects of habitat type and census techniques. Forest Ecology and Management 167:83–90.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Vos, C. C., and J. P. Chardon. 1998. Effects of habitat fragmentation and road densities on the distribution pattern of the moor frog (Rana arvalis). Journal of Applied Ecology 35:44–56.

33. **Tidal swamp forest and wetlands** – These habitats occur along rivers or sounds in areas where flooding is influenced by lunar or wind tides. Fresh water input may heavily influence the salt content. Vegetation may range from Cypress-Gum swamps, characterized by swamp black gum, water tupelo, and bald cypress, to freshwater marshes containing giant cordgrass, sawgrass, cattails, American threesquare, black needle rush, spike-sedges, southern wildrice, arrowhead, and marsh fern. Regularly flooded herbaceous sites are reported to have high productivity, equivalent to salt marshes (Schafale and Weakley 1990).

    Areas dominated by dense herbaceous vegetation are important for several high priority bird species (Hunter et al. 2000, Johns 2004 and Rich et al. 2004) including rails and bitterns. Invasive *Phragmites* forms dense patches to reduce plant and animal diversity in some places. Fire was likely a natural component of some of these communities (Tidal Freshwater Marsh) and likely reduced dominance of large plant species and increased overall plant diversity (Schafale and Weakley 1990).

    Areas that are forested (Tidal Cypress-Gum Swamp) have a canopy dominated by bald cypress, swamp black gum, water tupelo, a dense to open shrub layer and are influenced by lunar or wind tides with little or no salinity in the water (Schafale and Weakley 1990). Salt-water intrusion during major storm events can cause major disturbance to this community.

Priority species associated with tidal swamp forests and wetlands:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Ammodramus caudacutus*	Saltmarsh Sharp-tailed Sparrow	
	Ammodramus nelsoni	Nelson's Sharp-tailed Sparrow	
	Anhinga anhinga	Anhinga	SR
	Asio flammeus	Short-eared Owl	
	Botaurus lentiginosus	American Bittern	SR
	Circus cyaneus	Northern Harrier	SR
	Cistothorus platensis	Sedge Wren	
	Coturnicops noveboracensis	Yellow Rail	SR
	Egretta caerulea	Little Blue Heron	SC
	Egretta thula	Snowy Egret	SC
	Elanoides forficatus	Swallow-tailed Kite	
	Gallinula chloropus	Common Moorhen	
	Haliaeetus leucocephalus	Bald Eagle	T (T)
	Himantopus mexicanus	Black-necked Stilt	SR
	Ixobrychus exilis	Least Bittern	
	Laterallus jamaicensis	Black Rail	SR
	Mycteria americana	Wood Stork	E (E)
	Nyctanassa violacea	Yellow-crowned Night-heron	
	Plegadis falcinellus	Glossy Ibis	SC
	Porzana carolina	Sora	
	Rallus elegans	King Rail	
	Rallus limicola	Virginia Rail	
Mammals	*Condylura cristata*	Star-nosed Mole	SC
	Cryptotis parva	Least Shrew	
	Sylvilagus palustris	Marsh Rabbit	
Reptiles	*Alligator mississippiensis*	American Alligator	T (T)
	Farancia abacura abacura	Eastern Mudsnake	
	Farancia erytrogramma erytrogramma	Common Rainbow Snake	
	Kinosternon baurii	Striped Mud Turtle	
	Thamnophis sauritus sauritus	Common Ribbonsnake	

A. *Location and condition of habitat (see Map 5A.29):*

This habitat can be found primarily in the northern Coastal Plain surrounding Currituck and Albemarle sounds, but is found sporadically southward at sites along rivers that empty into the sounds and at the upper end of estuaries. The forested habitat is in relatively good condition since it is not suitable for development, though still, little old growth tidal forested wetlands remain. Drainage and reduced burning frequency in both tidal and freshwater marshes has led to reductions in those habitat types. Good remaining examples of the herbaceous variant occur in Currituck, Camden, Chowan and Dare counties.

B. *Problems affecting species and habitats:*

Reduced fire regimes have led to successional changes in marsh habitats. Drainage and conversion of wetlands for development have also been moderate problems. Drainage for mosquito control has been the largest factor changing the characteristics of this habitat. An increase in the amounts of *Phragmites* in these marshlands decreases overall vegetative and animal diversity. Lack of fire in marshes has led to increased shrub and tree growth, especially red maple. The relative lack of old growth forested habitat here has depleted the amount of nest sites for bald eagles, but these sites are still important for a variety of birds that use herb dominated marsh sites.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with these habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on these communities (like rails). Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common. Many bird species associated with these community types are not sampled well or at all by BBS.
  - Conduct marshbird surveys (especially tape playbacks for rails and bitterns) to determine the status and distribution of all marshbirds (Legare et al. 1999, Gibbs and Melvin 1997, Conway et al. 2004).
  - Establish species-specific surveys to improve our knowledge of the status and distribution of least bittern, American bittern, yellow rail, and black rail at all times of the year (Conway et al. 2004).
  - Conduct status and distribution surveys for black-necked stilt, common moorhen, wood stork, northern harrier, short-eared owl, sedge wren and both saltmarsh and Nelson's sharp-tailed sparrows.
  - Establish small mammal surveys to obtain distribution information on the star-nosed mole and least shrew in this habitat, as well as other small mammals.
  - Determine the status and distribution of the marsh rabbit.
  - Determine the status and distribution of the American alligator, eastern mudsnake, common rainbow snake and striped mud turtle.
- **Monitoring**
  - Long-term monitoring, following survey data, is needed for all marshbirds, mammals and reptiles in this habitat type.
  - Continue nest monitoring for colonial waterbirds.
  - Establish mist net stations for passerine birds in this habitat type at all times of the year.
- **Research**
  - Examine habitat use and conduct nesting habitat research on the black rail using telemetry, and then on other marshbirds (Bogner and Baldassarre 2002).
  - Research the relationship between habitat area and the distribution of tidal marshbirds (Benoit and Askins 2002).
  - Conduct research on fire management in marsh habitats to determine optimal frequency, timing, and firing techniques (e.g., flanking fire, back fire) to benefit priority birds.

- Conduct a systematics study to differentiate between the two subspecies of least shrew.
- Explore techniques for restoration of tidal swamp forest and wetlands.
- Investigate the past, current and potential future impact of nutria on tidal wetlands (especially freshwater marshes).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Partnerships with the North Carolina Coastal Land Trust and The Nature Conservancy should be nurtured to acquire more of these types of habitats, particularly marshes in the Currituck Sound region. Identified funding sources for acquisition include the Clean Water Management Trust Fund, Coastal Wetlands Grants, Natural Heritage Trust Fund, Forest Legacy Grants, and Recovery Land Acquisition Grants. Priorities for protection include colonial waterbird nesting sites, eagle nesting sites, wood stork foraging areas, and important black rail habitat once it is better identified. Adjacent nesting habitat for snakes and turtles should also be protected.

Increased burning on sites dominated by herbaceous vegetation needs to be encouraged to retard invasion of maples and other trees and shrubs. This might be pursued through cooperative efforts with the Atlantic Coast Joint Venture, Migratory Bird Committee of the US Fish & Wildlife Service and the South Atlantic Migratory Bird Initiative. Non-native vegetation control (e.g., *Phragmites*) is needed in many areas. Snags, logs, rocks, and other structures that are important for basking reptiles should be retained or restored wherever possible.

Education efforts are needed to emphasize the importance of tidal wetlands. Existing wetland regulations need to be enforced and strengthened. The use of bulkheads should be discouraged when other possibilities are available.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Benoit, L.K. and R.A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114(3):314–323.

Bogner, H.E. and G.A. Baldassarre. 2002. Home range, movement and nesting of least bitterns in western New York. Wilson Bulletin 114(3):297–308.

Conway, C.J., C. Sulzman and B.E. Raulston. 2004. Factors affecting detection probability of California black rails. Journal of Wildlife Management 68(2):360–370.

Gibbs, J.P. and S.M. Melvin. 1997. Power to detect trends in waterbird abundance with call-reponse surveys. Journal of Wildlife Management 61(4):1262–1276.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Legare, M.L., W.R. Eddleman, P.A. Buckley and C. Kelly. 1999. The effectiveness of tape playback in estimating black rail density. Journal of Wildlife Management 63(1):116–125.

N.C. Natural Heritage Program. 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

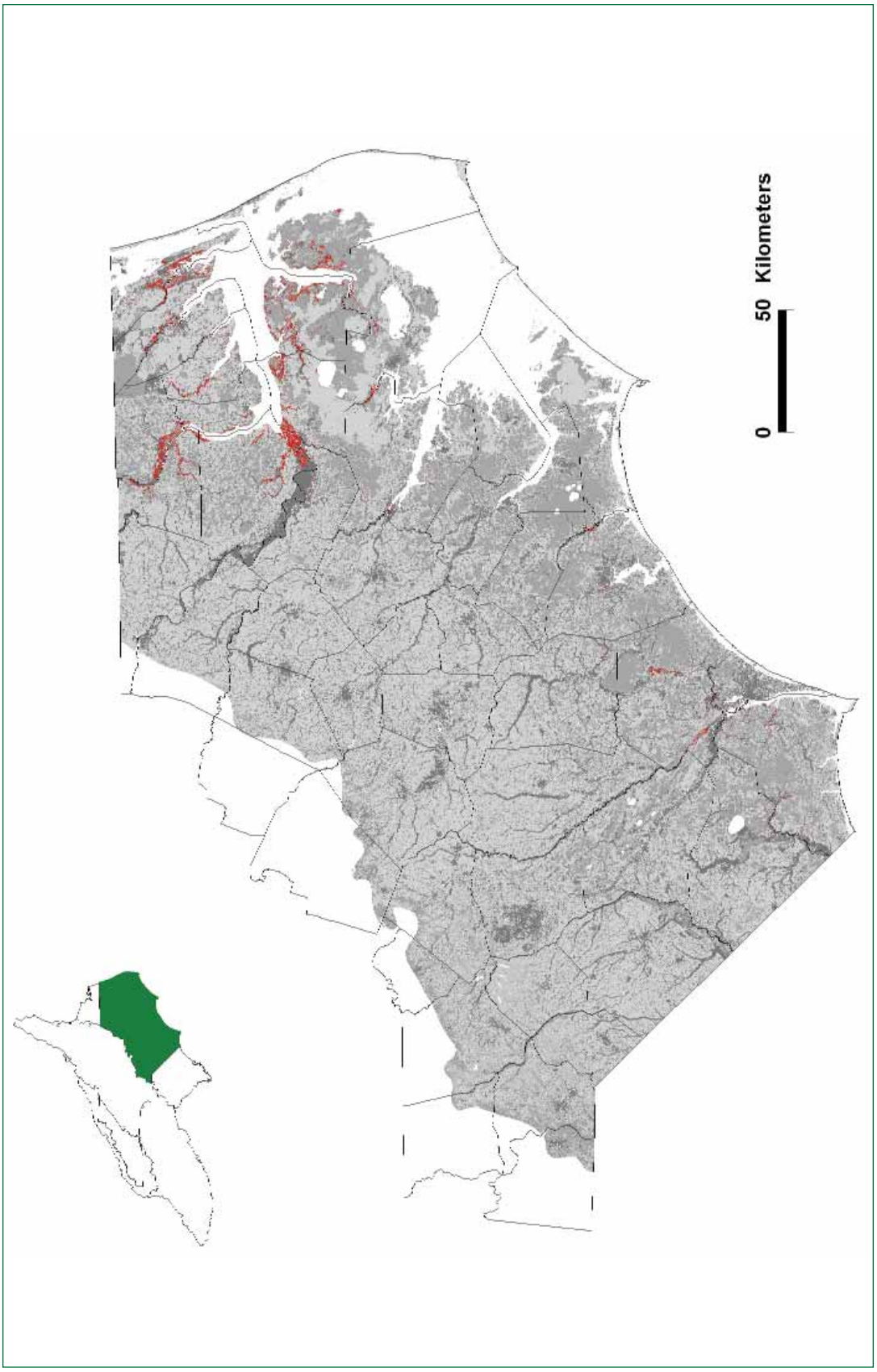


Figure 5A.33. Tidal swamp forest and wetlands in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (in red) (data source: NC GAP, 1992).

34. **Maritime forest/shrub** – Maritime communities are found along barrier islands and the mainland North Carolina coast on stabilized upper dunes and flats protected from salt water flooding and the most extreme salt spray. Hydrology is variable and some of the Maritime Shrub communities are subject to heavy salt spray (Schafale and Weakley 1990). All of the barrier island maritime forest/shrub communities occur in very dynamic environments that are often disturbed or even permanently converted to other community types.

    Maritime Shrub communities are found throughout the barrier islands and are dominated by dense shrubs, especially wax myrtle, yaupon holly, groundsel tree, red cedar and stunted live oak (Schafale and Weakley 1990). There are also often gaps containing grassy areas. Successional shrub communities have become more common on former grass dominated sites due to artificial building of dunes (Schafale and Weakley 1990). The natural community type is not uncommon on the barrier islands, but extensive natural examples are rare.

    Canopies of Maritime Evergreen Forests are dominated by live oak, sand laurel oak, and loblolly pine. Understories are typified by shrubby woody growth, vines are important and common and the herb layer is sparse. These communities occur in sheltered parts of the barrier islands but are still subject to extremes of the maritime environment (Schafale and Weakley 1990). Sites that have been recently logged often are dominated by loblolly pine, and storm disturbance produces canopy gaps. These communities apparently burned historically at irregular intervals and understories have become denser, although natural fire was probably less frequent than in mainland forests (Schafale and Weakley 1990). These communities depend on the canopy for protection from salt spray.

    The rare Maritime Deciduous Forest (Nags Head Woods is the best remaining example) is dominated by beech, American holly, loblolly pine and hickory. Shrubs and vines can be dense and there can be a moderate herb layer present. Maritime vegetation exposed to frequent salt spray during storms is stunted. These are the most sheltered communities of any barrier island sites, and are one of the rarest and most endangered natural communities in North Carolina (Schafale and Weakley 1990).

    Coastal Fringe Evergreen Forests and Coastal Fringe Sandhill communities typically occur on the mainland adjacent to estuaries and barrier islands, although both community types are very rare due to developmental pressures, widespread fire suppression and limited range (Schafale and Weakley 1990).

    These habitats are important breeding and migration stopover points for many migratory birds, and key breeding areas for declining populations of the eastern painted bunting (Hunter et al. 2000, Johns 2004). These communities are also important for some snake species for which we have little status, distribution or demographic information.

Priority species associated with maritime forest/shrub habitats:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Passerina ciris*	Eastern Painted Bunting	
Mammals	*Peromyscus leucopus easti*	White-footed Mouse	SC
Amphibians	*Bufo quercicus*	Oak Toad	SR
	Desmognathus auriculatus	Southern Dusky Salamander	
	Scaphiopus holbrookii	Eastern Spadefoot	
Reptiles	*Cemophora coccinea copei*	Northern Scarletsnake	
	Heterodon simus	Southern Hog-nosed Snake	SC
	Lampropeltis getula getula	Eastern Kingsnake	
	Lampropeltis getula sticticeps	Outer Banks Kingsnake	SC
	Masticophis flagellum	Eastern Coachwhip	SR
	Micrurus fulvius	Eastern Coral Snake	E

A. *Location and condition of habitat*[1]*:*

The condition of these habitats in the state is extremely poor. Maritime forest is one of the most endangered habitat types in North Carolina, primarily due to coastal development, which has literally destroyed much of the maritime habitats. In many places where some assemblage of the habitat remains, houses and other structures are spread throughout.

Only one good example of Maritime Deciduous Forest remains at Nags Head Woods in Dare County; an additional example occurs in nearby Kitty Hawk Woods. Maritime Evergreen Forest is found throughout the barrier islands and good examples can be found at Buxton Woods, Theodore Roosevelt State Natural Area on Bogue Banks, and Bald Head Island. Maritime Shrub is found throughout the barrier islands, but good examples are rare. Some examples exist at Cape Hatteras National Seashore, Shackleford and Core Banks, Bear Island in Onslow County, Fort Macon State Park, Bogue Banks, and Fort Fisher.

B. *Problems affecting species and habitats:*

Residential and commercial coastal development leading to fragmentation and overall reduction of habitat is the single most important factor leading to the loss of this habitat. Almost all this habitat is high ground and suitable for development, and is found in areas close to the beach where human population growth is booming. The creation of numerous small clearings for houses will likely have far-reaching effects on the dynamics of these habitats (Schafale and Weakley 1990).

A lack of fire to maintain some variants of these habitats is also leading to successional changes in many of these sites. Burning is almost impossible to conduct in areas surrounded by homes. There are also feral animal impacts (horses, goats, cows, cats) on some of the barrier islands (e.g., Shackleford Banks). In addition, egg predators such as raccoons and foxes that typically did not inhabit most of the Outer Banks are now widespread because of the increased amount of food available now that people inhabit the area.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys**
  - Conduct migration surveys to determine bird use, especially during the fall.
  - Conduct small mammal surveys on barrier island systems to verify species status, distribution and community composition.
  - Determine the status and distribution of amphibians and reptiles in maritime communities.
- **Monitoring**
  - Continue long-term monitoring and banding work (currently being done by the US Geological Survey) on eastern painted buntings and support the goals and objectives of the Painted Bunting Working Group that involves Florida, Georgia, South and North Carolina.
  - Establish MAPS and migration banding stations in this habitat type.
  - Establish long-term monitoring of amphibians and reptiles, once survey data has been established.
- **Research**

  Genetics
  - Conduct cooperative research with western states to determine the genetic relationships between eastern and western painted buntings.
  - Conduct genetics research on all “kingsnake” species.

  Demographics and habitat use
  - Initiate productivity and habitat use research eastern painted bunting (Norris and Elder 1982, Lanyon and Thompson 1986 and Kopachena and Crist 2000).

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

- Document the habitat selection and competition factors related to indigo bunting and painted bunting in these habitats (Kopachena and Crist 2000).
- Maritime forests in the far southeastern portion of the state historically supported eastern woodrats; consider those habitats as potential reintroduction sites.
- Examine demographics/population dynamics/specific habitat requirements of the white-footed mouse subspecies (listing is almost certain for the subspecies).
- Conduct habitat-use research on southern dusky salamander, eastern spadefoot, southern hog-nosed snake, eastern coachwhip, northern scarletsnake, kingsnakes and eastern coral snake to better determine habitat use patterns.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

In general, there is a need to better track the extent of maritime habitats: *How much is there? What is the condition of each site? How much development pressure is being exerted on each site?* This information should be integrated into our understanding of maritime forest wildlife species current status and distribution and how those distributions may have differed without such extensive coastal development.

Remaining coastal maritime habitats must be a priority for land acquisition efforts. Though coastal uplands are essentially the most costly areas to acquire in the state, it is essential to acquire remaining undeveloped maritime forests, both on barrier islands and on the mainland. In fact, maritime (coastal fringe) forests on the mainland are grossly under-protected. The Atlantic Coast Joint Ventures or South Atlantic Migratory Bird Initiative may be able to help coordinate such projects along with the North Carolina Coastal Land Trusts and The Nature Conservancy. Identified funding sources for acquisition include Coastal Wetlands Grants, Natural Heritage Trust Fund, Forest Legacy Grants, and Recovery Land Acquisition Grants.

Re-establishment of maritime forest habitats should also be pursued, including initiation of prescribed burning of appropriate maritime habitats, where possible. The presence of dense canopies are a key habitat element in maritime forests; many maritime forest-associated herpetofauna, and their prey, are adapted to survive under particular sun and shade regimes (Bailey et al. 2004). An attempt should be made to work with local governments to develop laws or ordinances that require certain amounts of native vegetation be retained, and buffers of vegetation be left along the sounds.

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Kopachena, J.G. and C.J. Crist. 2000. Macro-habitat features associated with painted bunting and indigo bunting in northeast Texas. Wilson Bulletin 112(1):108–114.

Lanyon, S.M. and C.F. Thompson. 1986. Site fidelity and habitat quality as determinants of settlement pattern in male painted buntings. The Condor 88(206–210.

Norris, D.J. and W.H. Elder. 1982. Distribution and habitat characteristics of the painted bunting in Missouri. Transactions of the Missouri Academy of Science 16:77–83.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

35. **Estuarine communities** – These include salt marsh, brackish marsh, salt flat, sand flat, mud flats, algal mats, salt scrub, estuarine island communities, and sounds along coastal North Carolina. Marsh habitats usually develop on the mainland side of the barrier islands after sand is deposited during storm events. They also develop on the mainland side of the sounds and in the lower reaches of our rivers as sea-level rise, salt intrusion or storms kill forested or shrub-scrub habitats.

    Salt marsh communities are often strongly dominated by saltmarsh cordgrass and these areas occur throughout the coastal part of the state, while brackish marsh is dominated by black needlerush and are found throughout the estuarine parts of North Carolina (Schafale and Weakley 1990). Vegetation may include salt meadow cordgrass, glasswort, saw grass, marsh elder, and wax myrtle, as determined by the salinity level of the water.

    Sand flats and mud flats are often created and maintained near one of our 20 inlets as flood tide or ebb tide deltas. These are very dynamic systems and can appear and disappear with each storm event, although most persist for 10–20 years at a time barring major dredging activities. Salt flats and algal mats are either found as shoals within the sounds or on very low stretches of the barrier beaches. These sites are particularly important for foraging shorebirds.

    Salt marsh and brackish marsh habitats are important habitat year-round for a variety of rails, bitterns, wading birds and marsh sparrows, several of which are species of conservation concern according to Partners in Flight (Hunter et al. 2000, Pashley et al. 2000, Rich et al. 2004 and Johns 2004). Waterfowl impoundments created within brackish marshes provide valuable habitat for waterfowl, wading and shorebirds, and furbearers. Estuarine communities also provide important habitat for high priority birds during some stage of their life cycle such as piping plover, Wilson's plover, American oystercatcher, black skimmer, gull-billed tern, bald eagle, peregrine falcon and wood stork. Endangered or threatened sea turtles use these areas and diamond-backed terrapins key in on these habitats. In all these are some of the most important habitats for large numbers and types of immediate coastal wildlife that are federally or state listed, or are experiencing precipitous population declines.

    Estuarine islands can be either natural or created by dredged material. These sites are particularly important for nesting terns, skimmers, pelicans, wading birds, and American oystercatchers. Dredged material islands are not only usually devoid of mammalian predators, but usually have the added advantage of being high enough in elevation that ground nesting birds do not lose their nests during high tides.

    Other fully aquatic taxa (fish, mussels, crayfish, and snails) are referenced in the river basins portion of the report. See the river basin sections (Chapter 5B) for more detailed information on aquatic species and habitats, by basin.

    A focused discussion of coastal and estuarine habitats as they relate to marine species can be found in Chapter 5C (Marine Systems).

A. Location and condition of habitat (see Map 5A.35):

The condition of all these habitats is poor or threatened due to development, fragmentation, wetland ditching and filling, dredging, or a lack of fire, as well as increased human recreational activity. Losses, drastic alteration or disturbance of these habitat types (especially marsh habitats) could have serious consequences for nutrient cycling and for reproduction of marine and estuarine organisms (Schafale and Weakley 1990).

B. Problems affecting species and habitats:

Water quality impacts (pesticide use related to mosquito control, developmental secondary impacts) and water flow impacts (through ditching, canals, etc.) have greatly affected this habitat. Dredging and dredge material placement can also affect these sites through draining of marshes or filling of wetland types. Dredged material placement has been used very effectively in some areas to create marsh or upland bird nesting areas within the estuaries. However, it has become increasingly difficult to direct dredged material to bird nesting islands that need it because of a lack of US Army Corps of Engineer funding for dredging projects and because

Priority species associated with estuarine communities:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Ammodramus caudacutus*	Saltmarsh Sharp-tailed Sparrow	
	Ammodramus nelsoni	Nelson's Sharp-tailed Sparrow	
	Asio flammeus	Short-eared Owl	
	Botaurus lentiginosus	American Bittern	SR
	Calidris alba	Sanderling	
	Calidris canutus	Red Knot	
	Charadrius melodus	Piping Plover	T (T)
	Charadrius wilsonia	Wilson's Plover	SR
	Circus cyaneus	Northern Harrier	SR
	Cistothorus platensis	Sedge Wren	
	Coturnicops noveboracensis	Yellow Rail	SR
	Egretta caerulea	Little Blue Heron	SC
	Egretta thula	Snowy Egret	SC
	Egretta tricolor	Tricolored Heron	SC
	Falco peregrinus	Peregrine Falcon	E
	Haematopus palliatus	American Oystercatcher	SR
	Haliaeetus leucocephalus	Bald Eagle	T (T)
	Himantopus mexicanus	Black-necked Stilt	SR
	Ixobrychus exilis	Least Bittern	
	Laterallus jamaicensis	Black Rail	SR
	Mycteria americana	Wood Stork	E (E)
	Nyctanassa violacea	Yellow-crowned Night-heron	
	Pelecanus occidentalis	Brown Pelican	SR
	Plegadis falcinellus	Glossy Ibis	SC
	Porzana carolina	Sora	
	Rallus elegans	King Rail	
	Rallus limicola	Virginia Rail	
	Rynchops niger	Black Skimmer	SC
	Sterna antillarum	Least Tern	SC
	Sterna caspia	Caspian Tern	SR
	Sterna hirundo	Common Tern	SC
	Sterna nilotica	Gull-billed Tern	T
Mammals	*Cryptotis parva*	Least Shrew	
	Sylvilagus palustris	Marsh Rabbit	
	Trichechus manatus	Manatee	E (E)
Reptiles	*Caretta caretta*	Loggerhead Sea Turtle	T (T)
	Chelonia mydas	Green Sea Turtle	T (T)
	Eretmochelys imbricata imbricata	Atlantic Hawksbill Sea Turtle	E (E)
	Lampropeltis getula getula	Eastern Kingsnake	
	Lampropeltis getula sticticeps	Outer Banks Kingsnake	SC
	Lepidochelys kempii	Kemp's Ridley Sea Turtle	E (E)
	Malaclemys terrapin	Diamond-backed Terrapin	SC
	Nerodia sipedon williamengelsi	Carolina Watersnake	SC
	Thamnophis sauritus sauritus	Common Ribbonsnake	

coastal towns are now competing for the sand for beach nourishment projects. Other beach stabilization projects (e.g., inlet channel relocation and efforts to restrict channel movement) reduce availability of microhabitats such as mud and algal flats around inlets. Development has also taken much of this habitat type and disturbance by humans and their pets is becoming a growing problem, as well as predation by non-native predators on nesting birds. A lack of fire is particularly troublesome in the marsh sites.

Another suite of threats can be found in and on the water. Negative fisheries interactions include diamond-backed terrapins drowning in crab pots and gill nets; trawls and hook and line fisheries impacting endangered sea turtles; red-throated loons and other diving birds getting caught and drowning in gill nets. Recreational boaters may accidentally strike turtles, manatees and birds. There are also now potential impacts related to offshore wind power turbines on both birds and bats (major activity zones for both).

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with these habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk or mainly dependent on these communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common. Many bird species associated with these community types have experienced significant declines according to inventory and survey data.
  - Determine the breeding and wintering status and distribution of the saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow (DiQuinzio et al. 2001, Hodgman et al. 2002) and the seaside sparrow in North Carolina.
  - Determine the status and distribution of sedge wren, northern harrier and short-eared owl.
  - Conduct secretive marshbird surveys for the black rail, American bittern, least bittern, yellow rail and other marsh birds (birds not adequately surveyed by BBS) (Legare et al. 1999).
  - Continue surveys for Wilson's plover and American oystercatcher to assess state-wide trends in abundance and distribution.
  - Determine the status and distribution of priority mammals (e.g., manatee, marsh rabbit).
  - Determine the status and distribution of the diamond-backed terrapin and Carolina watersnake.
- **Monitoring**
  - Continue ongoing all-season piping plover monitoring, as well as other ongoing shorebird and colonial waterbird monitoring.
  - Establish long-term monitoring for all marsh birds (Gibbs and Melvin 1997, Benoit and Askins 2002, Bogner and Baldassarre 2002, Conway et al. 2004).
  - Establish long-term monitoring for passerine birds using marsh habitat; establish bird banding stations at all times of the year in marsh habitats.
  - Continue long-term sea turtle nesting and stranding monitoring; strandings need to be monitored to a greater extent in estuary sites.
  - Establish long-term monitoring for diamond-backed terrapins (post survey work).
- **Research**

  Genetics
  - Conduct systematics studies to differentiate between the two subspecies of least shrew.
  - Explore the genetic relationships among "kingsnake" species.

  Diet, Nutrition
  - Research the nutrition needs of plovers and oystercatchers and the diet niches of terns, skimmers, herons and egrets.

Habitat use/demographics

- Study marsh bird habitat needs and life histories, especially the black rail (Benoit and Askins 2002 and Conway et al. 2004).
- Conduct shorebird foraging studies, wading bird foraging studies, and expanded colonial waterbird research (possible partnerships with Atlantic Coastal Joint Ventures, South Atlantic Migratory Bird Initiative).
- Conduct marsh food productivity/food web research related to shorebirds, rails and wading birds.
- Explore population dynamics related to controlled burns in marshes.
- Examine the reproductive success of beach nesting birds on dredge material islands as compared to success on beaches.
- Explore the use of field readable bands on royal terns and American oystercatchers to attain survivorship information.
- Conduct studies to examine two-egg clutches in royal terns.
- Determine the cause of sharp nesting population declines in snowy egrets.

Predator effects

- Study estuarine predator communities and effects on nesting birds.

Management practices

- Identify causal factors in sea turtle strandings and fishery related mortality issues (using telemetry).
- Conduct diamond-backed terrapin research to better identify causal factors and minimize fisheries related mortality.
- Study the effectiveness of burning marshes, especially brackish marshes, to retard growth of shrubs and stimulate growth of grasses, sedges, and rushes.
- Study the effectiveness of vegetation control measures on dredge material islands for birds that require early successional nesting habitat.
- Determine limiting factors for oystercatchers, plovers, black skimmers, gull-billed, royal, least and common terns and implement management to halt population declines.
- Explore techniques for restoration of estuarine communities.
- Investigate the past, current and potential future impacts of nutria on estuarine wetlands (especially brackish-fresh water marshes).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Many of our brackish marshes, especially on the mainland side of Pamlico Sound, are in private ownership, as are a number of heronries (e.g., Rawls Island, Gull Island). Land acquisition and protection are the primary actions needed. Atlantic Coast Joint Ventures and the North Carolina Coastal Land Trust are partners for these efforts. Coordination with regulatory agencies should be continued and expanded to encourage and enforce wetlands regulations and to enforce the Migratory Bird Treaty Act and the Endangered Species Act. Acquisition targets should include brackish marsh impoundments, which will then require continued management for maintenance. In addition, efforts need to be made to thwart loss of estuarine islands to theft or erosion.

Education and outreach efforts directed at the public, land-use planners, and regulatory agencies such as the NC Department of Transportation and US Army Corps of Engineers are needed to emphasize the ephemeral nature of sand and mud flats so that these habitats will not be destroyed as they are recreated by storms. Other educational needs include increased public awareness concerning potential impacts of boats and recreational fisheries, including ghost fishing line, hooks and bycatch, on wildlife (e.g., sea turtles, diamondback terrapin). Building setback distances should be considered and buffer zones and living sills/marsh should be encouraged. Estuarine bulkheads can destroy adjacent inter-tidal sand or mud flats and marsh

and should be discouraged. The Coastal Habitat Protection Plan (CHPP) (Street et al. 2004) has good details about the negative aspects of bulkheads and we should work to help promote the suggestions/guidelines within the CHPP.

Continued coordination is needed with waterbird working groups such as the North Carolina Waterbird Committee, the Piping Plover Recovery Team, The American Oystercatcher Working Group and the Royal Tern Working Group. Future recommendations from the North American Waterbird Conservation Plan should be implemented (Kushlan et al. 2002). Promotion of and support for oyster restoration programs (e.g., NC Coastal Federation), which would in-turn enhance food sources and ecosystem functioning in estuarine systems, should also be encouraged.

Supporting References

Benoit, L.K. and R.A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114(3):314–323.

Bogner, H.E. and G.A. Baldassarre. 2002. Home range, movement and nesting of least bitterns in western New York. Wilson Bulletin 114(3):297–308.

Conway, C.J., C. Sulzman and B.E. Raulston. 2004. Factors affecting detection probability of California black rails. Journal of Wildlife Management 68(2):360–370.

DiQuinzio, D.A., P. W.C. Paton and W.R. Eddleman. 2001. Site fidelity, philopatry and survival of promiscuous saltmarsh sharp-tailed sparrows in Rhode Island. The Auk 118(4):888–899.

Gibbs, J.P. and S.M. Melvin. 1997. Power to detect trends in waterbird abundance with call-reponse surveys. Journal of Wildlife Management 61(4):1262–1276.

Hodgman, T.P., W.G. Shriver and P.D. Vickery. 2002. Redefining range overlap between the sharp-tailed sparrows of coastal New England. Wilson Bulletin 114(1):38–43.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Legare, M.L., W.R. Eddleman, P.A. Buckley and C. Kelly. 1999. The effectiveness of tape playback in estimating black rail density. Journal of Wildlife Management 63(1):116–125.

Pashley, D.N., C.J. Beardmore, J.A. Fitzgerald, R.P. Ford, W.C. Hunter, M.S. Morrison, K.V. Rosenberg. 2000. Partners in Flight: Conservation of the land birds of the United States. American Bird Conservancy, The Plains, VA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A.Kennedy, A.M. Martell, A.O. Panajabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Mid-Atlantic Coastal Plain Ecoregion

Figure 5A.35. Estuarine habitats (mapped as tidal marsh in light blue) in the Mid-Atlantic Coastal Plain ecoregion of North Carolina (data source: NC GAP, 1992). *As defined in the Plan, this habitat would also include the shallow bays, estuaries and sounds along the coast.*

36. **Beach/dune** – Upper beach vegetation includes sea rocket, Dixie sandmat, seaside sandmat, Russian thistle, and seabeach amaranth. Dune vegetation is characterized by sea oats grass and American beach grass. These habitats are also well imitated by dredged material islands within our sounds that are often devoid of the predators that have invaded the barrier beaches. Overwash, salt spray, and erosion contributes to ever-changing beach/dune dynamics. The beach/dune habitat is particularly important to sea turtles, beach nesting birds and shorebirds. Many of the bird species rely on the dynamic nature of the beach, and need storms to recreate wide beaches with bare sand and shell overwash areas. The swash zone (the area between high and low tide) is particularly important to beach invertebrates which are used as a food source by fish and waterbirds.

    A focused discussion of coastal and estuarine habitats as they relate to pelagic and marine species can be found in Chapter 5C (Marine Systems).

Priority species associated with beach and dune habitats:

Group	Scientific Name	Common Name	State Status (Federal Status)
Birds	*Calidris alba*	Sanderling	
	Calidris canutus	Red Knot	
	Charadrius melodus	Piping Plover	T (T)
	Charadrius wilsonia	Wilson's Plover	SR
	Chordeiles minor	Common Nighthawk	
	Falco peregrinus	Peregrine Falcon	E
	Haematopus palliatus	American Oystercatcher	SR
	Pelecanus occidentalis	Brown Pelican	SR
	Rynchops niger	Black Skimmer	SC
	Sterna antillarum	Least Tern	SC
	Sterna caspia	Caspian Tern	SR
	Sterna hirundo	Common Tern	SC
	Sterna nilotica	Gull-billed Tern	T
Mammals	*Peromyscus leucopus easti*	White-footed Mouse	SC
Reptiles	*Caretta caretta*	Loggerhead Sea Turtle	T (T)
	Chelonia mydas	Green Sea Turtle	T (T)
	Dermochelys coriacea	Leatherback Sea Turtle	E (E)
	Lepidochelys kempii	Kemp's Ridley Sea Turtle	E (E)
	Malaclemys terrapin	Diamond-backed Terrapin	SC
	Masticophis flagellum	Eastern Coachwhip	SR

A. Location and condition of habitat[1]:

These habitats occur all along coastal North Carolina, but are restricted to the immediate coastline. The condition of these habitats is probably among the worst of all habitats within the state. Development has exploded on the coast. Beach houses, motels, and other structures, and the infrastructure to support them, have caused a significant stabilization effect on the beaches that will be very difficult to reverse.

B. Problems affecting species and habitats:

Development of our beaches is the primary cause for the depletion in the beach/dune habitat. Several of the bird species we are most concerned about require early successional habitat for nesting and these habitats have been destroyed or severely altered. Predators (native and non-native) have increased many-fold. Many of these species (cats, herring and great black-backed

[1]A map of this habitat is not provided, due to scale and sensitivity issues.

gulls, raccoons, foxes) were not present before the beach became populated with people and their associated trash. These predators have caused significant problems for beach-nesting birds and sea turtles. Vehicle use has also created disturbance issues as well as direct impacts to nesting turtles and birds. Chronic human disturbance is becoming a problem at many sites. People are now able to access even the most remote beaches via shallow draft boats and personal watercrafts. Direct and indirect disturbance, not only by humans but also by their pets, causes problems for nesting and non-nesting birds. Artificial dune stabilization, associated with the protection of homes and infrastructure (roads, powerlines, waterlines), prevents the natural re-creation of wide beaches and overwash areas. Beach renourishment and beach bulldozing can cover or destroy macro-invertebrates in the swash zone and on the beach that foraging shorebirds and surf fishes depend upon. These activities can also destroy sea turtle nests when conducted between May and November. Even under the best survey conditions, all sea turtle nests can not be found and marked or relocated to prevent take from these activities. Beach renourishment can also lead to more development and possibly decrease washover and increase vegetation, thus decreasing the amount of suitable nesting habitat for beach nesting birds. Landscaping choices (e.g., introduced species such as *Vitex*) can also strongly affect the dune system.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

- **Surveys** – Surveys are needed to document the distribution, relative abundance and status of many wildlife species associated with these beach/dune habitats. Priorities for conducting surveys need to focus on species believed to be declining, at risk, or mainly dependent on these communities. Secondary priority for surveys should be for species for which current distribution information is already available or for species that are considered common.
  - Conduct shorebird surveys throughout the year to better understand population fluctuations for breeding, wintering and migratory birds (especially piping plover, American oystercatcher, Wilson's plover).
  - Determine distribution and status of wintering shorebirds (Sprandel et al. 2000).
- **Monitoring**
  - Monitor status and reproductive success of gull-billed tern, common tern, least tern, black skimmer, piping plover, and Caspian tern.
  - Continue support for regular colonial waterbird surveys (currently conducted coast wide roughly every three years).
  - Determine seasonal numbers and distribution of shorebirds (Dinsmore et al. 1998).
  - Continue sea turtle nest and stranding monitoring.
  - Monitor introduced non-native species effects (especially plants and invertebrates) on native coastal wildlife, including sea turtles.
- **Research**

  Predator impacts
  - Identify causal factors responsible for low beach nesting bird reproductive success; initiate predator impact studies (e.g., ghost crabs, fire ants, gulls, foxes, raccoons, feral cats) (Wolcott and Wolcott 1999).

  Life history/demography
  - Conduct American oystercatcher and Wilson's plover reproductive success research (more important for Wilson's plover reproductive success since studies are already underway looking at oystercatcher success).
  - Conduct foraging strategies and energy budget allocations of migrating shorebirds (Davis and Smith 2001).
  - Conduct life history studies of colonial waterbirds (Wambach and Emslie 2003).
  - Study the demographics/population dynamics/specific habitat requirements of the white-footed mouse subspecies (listing is almost certain for the subspecies).

Management practices

- Evaluate impacts of beach renourishment on sea turtle reproduction.
- Examine the effectiveness of vegetation control for beach nesting birds that require early successional habitat.
- Examine the effectiveness of trapping or other predator control measures (potentially for native and non-native species alike).
- Work with owners and managers of buildings containing nesting least terns to increase reproductive success while allowing owners/managers to maintain good public relations.

Telemetry

- Conduct habitat use and time allotment studies on sea turtles.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Building setback distances need to be reevaluated and lengthened. This should prevent much of the need for beach renourishment and stabilization projects. Although coastal development can not be fully controlled, there are a few areas of great importance that can still be purchased fee title or as an easement (South Topsail near New Topsail Inlet, North Topsail near New River Inlet, Lee and Hutaff islands, parts of Masonboro Island, north end of Carolina Beach). These purchases should remain at the top of the list of priorities.

Coordination needs to continue to influence where dredged material is placed to be most beneficial/least detrimental to beach nesting birds, foraging shorebirds, and sea turtles. Reducing disturbance from off road vehicles, people and their pets on coastal beach and dune systems is needed. Continued support for and enhanced coordination among coastal management agencies regarding existing restrictions and programs aimed at regulating beach activities is also critical.

Continued coordination is needed with waterbird working groups such as the North Carolina Waterbird Committee, the Piping Plover Recovery Team, The American Oystercatcher Working Group and the Royal Tern Working Group. Future recommendations from the North American Waterbird Conservation Plan should be implemented (Kushlan et al. 2002).

Predators (not limited to exotic species) must be controlled through education efforts, trapping or other means to increase sea turtle and beach nesting bird reproductive success.

To better manage sea turtle populations, mortality factors must be reduced. In addition, continued efforts need to address beach lighting, sand fencing, sand pushing and beach stabilization issues, so that sea turtles have a better chance for nesting success. Another educational need includes increasing public awareness of potential impacts of tourists and visitors on beach/dune associated species. Recently, there have been severe public conflicts regarding keeping beach access areas open despite conservation agencies recommendations for closure to protect beach-nesting birds and turtles (e.g., Fort Fisher, 2004).

See the Coastal Habitat Protection Plan (Street et al. 2004) for an in-depth discussion of issues pertaining to coastal fisheries habitat protection. Also see Chapter 5C (Marine Systems).

Supporting References

Bailey, M. A., J. N. Holmes, and K. A. Buhlmann. 2004. Habitat management guidelines for amphibians and reptiles of the southeastern United States (DRAFT). Partners in Amphibian and Reptile Conservation.

Davis, C.A. and L.M. Smith. 2001. Foraging strategies and niche dynamics of coexisting shorebirds at stopover sites in the southern Great Plains. The Auk 118(2):484–495.

Dinsmore, S.J., J.A. Collazo and J.F. Walters. 1998. Seasonal numbers and distribution of shorebirds on North Carolina's Outer Banks. Wilson Bulletin 110(2):171–181.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M.E. 2004. North Carolina Bird Species Assessment. N.C. Partners in Flight.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC.

Sprandel, G.L., J.A. Gore and D.T. Cobb. 2000. Distribution of wintering shorebirds coastal Florida. J. Field Ornithol. 71(4):708–720.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Wambach, E.J. and S.D. Emslie. 2003. Seasonal and annual variation in the diet of breeding, known-age royal terns in North Carolina. Wilson Bulletin 115(4):448–454.

Wolcott, D.L. and T.G. Wolcott. 1999. High mortality of piping plovers on beaches with abundant ghost crabs: correlation, not causation. Wilson Bulletin 111(3):321–329.

B. Aquatic Systems

The overall richness of North Carolina's aquatic fauna is directly related to the geomorphology of the state, which defines the major drainage divisions and the diversity of habitats found within them. Seventeen major river basins are designated in North Carolina (Figure 5B.1). The headwaters of 11 of these basins begin in North Carolina, but only four basins are contained entirely within the state (Cape Fear, Neuse, White Oak, Tar-Pamlico). Five western basins are part of the Interior Basin and drain to the Mississippi River and the Gulf of Mexico (Hiwassee, Little Tennessee, French Broad, Watauga, and New). The other 12 basins are part of the Atlantic Slope and flow to the Atlantic Ocean. The long history of separation between these major drainage basins has apparently lead to significant differentiation of their respective faunas. Distinct aquatic communities are found on each side of the Eastern Continental Divide with relatively few native species in common.

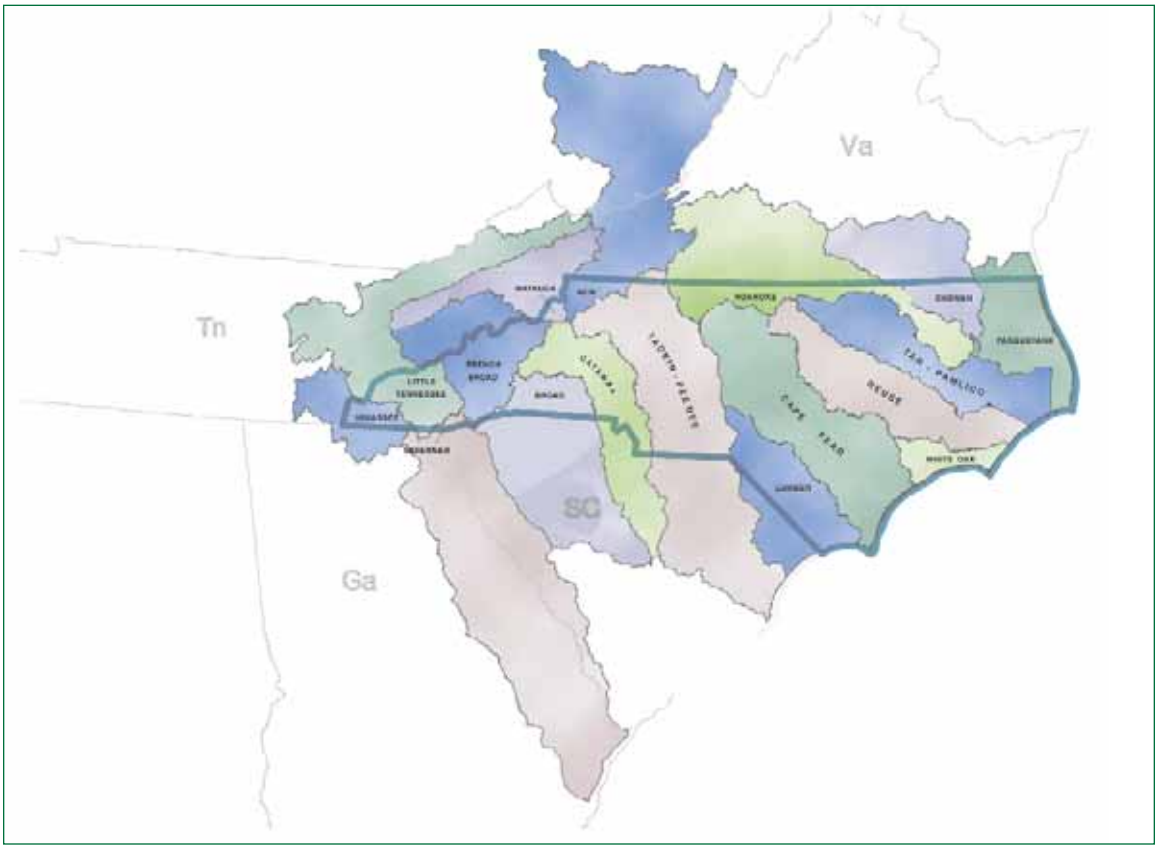


Figure 5B.1. North Carolina's river basins (source: NC Wildlife Resources Commission).

Within each major drainage basin, individual river basins drain broadly diverse terrain and a wide variety of aquatic habitats exist among them. In an assessment of southeastern states, North Carolina ranked third highest in overall diversity of stream-types (Warren et al. 1997). The mountains of the Blue Ridge physiographic province dominate the western third of the state. Generally, streams in the Blue Ridge are relatively high gradient, cool, have boulder and cobble-gravel bottoms, and are of low to moderate fertility; however, the larger streams and rivers have historically supported exceptionally diverse warm-water communities. The five river basins of the Interior Basin, along with the Savannah, are entirely within the Blue Ridge in North Carolina. The headwaters of the Broad, Catawba, and Yadkin-PeeDee river basins drain the eastern slopes of the Blue Ridge. These river systems continue toward the sea through the rolling topography of the Piedmont, where all but three of the remaining river basins arise. The Piedmont is a mosaic of broad valleys interspersed with highlands of varying topography and geology. Streams in the Piedmont are generally warm, have cobble-gravel and sand bottoms, and are of intermediate gradient and fertility. The Fall Line demarks a change in topography from the Piedmont to the flat terrain of the Atlantic

Coastal Plain. The White Oak, Chowan, and Pasquotank basins are entirely within the Coastal Plain in North Carolina. Low gradient, warm water, sand and mud bottom, and high fertility generally characterize freshwater Coastal Plain streams. Natural lakes and extensive wetlands are important aquatic habitats found only in the Coastal Plain in North Carolina.

Biodiversity in Aquatic Ecosystems

The southeast region has the highest aquatic species diversity in the entire United States (Burr and Mayden 1992, Taylor et al. 1996, Warren et al. 2000, Williams et al. 1993). Southeastern fishes make up 62% of the United States fauna, and nearly 50% of the North American fish fauna (Burr and Mayden 1992). Molluscan diversity in the region is 'globally unparalleled', with 91% of all United States mussel species found in the southeast (Neves et al. 1997). Crayfish diversity and global importance in the region rivals that of mollusks (Taylor et al. 1996). Crayfish in the southeast comprise 95% of the total species found in all of North America (Butler 2002a). North Carolina freshwaters support a significant proportion of that diversity with at least 240 fish, 125 mollusk, and 45 crayfish species.

Unfortunately, patterns of imperilment are similar. Greater than two-thirds of the nation's freshwater mussel and crayfish species are extinct, imperiled, or vulnerable (Williams et al. 1993, Neves et al. 1997, Master et al. 1998). The majority of these at-risk species are native to the southeast. The number of imperiled freshwater fishes in the southeast (84) is greater than any other region in the country and the percentage of imperiled species is second only to the western United States (Minckley and Deacon 1991, Warren and Burr 1994). Twenty-eight percent of southeastern freshwater and diadromous fishes have a status of extinct, endangered, threatened, or vulnerable, which represents a 125% increase in 20 years (Warren et al. 2000). North Carolina ranks third among southeastern states in number (21) and percentage (11.5%) of imperiled fishes (Warren et al. 1997). Freshwater mollusks are suffering even greater declines. Thirty-six mussel species and 26 snail species that formerly occurred in the southeast (13% of all United States mussel species and 8% of southeastern snails) are presumed extinct (Neves et al. 1997). By state, between 34% and 71% (mean = 58%) of mussel species, or populations of species, are imperiled in the southeast, which represents 98% of all rare mussel species in the United States (Neves et al. 1997). Fifty-nine percent of freshwater mussel species in North Carolina are imperiled (Neves et al. 1997). Assessments of North Carolina mussel populations in the 1990's reported 62 of 147 known populations (42%) to be "in poor or very poor condition" (Rader 1994) and only 51 populations (35%) are likely to maintain viable populations over the next 30 years (Alderman et al. 1992). Among crustaceans listed as endangered or threatened in the United States, 54% are from the southeast (Schuster 1997). Twelve species (26%) of North Carolina crayfish are listed as species of concern or rare in the state (Clamp 1999, LeGrand et al. 2004).

Causes of declines among all aquatic taxa are widely attributed to habitat destruction and degradation, and the introduction of nonindigenous species (Williams et al. 1993, Taylor et al. 1996, Etnier 1997, Warren et al. 1997). Fishes inhabiting medium-sized rivers and creeks rely on coarse substrates that are relatively silt-free; however, these streams are often heavily impounded and have altered substrates. Habitat alteration from nonpoint source pollution and flow alteration (i.e., impoundments) are the primary cause of population declines for 72% of southeastern fishes considered imperiled (Etnier 1997). Not surprisingly, nonpoint source pollution and the effects of dams and impoundments are also the leading historic and current threats to freshwater mollusks (Bogan 1993, Neves et al. 1997, Richter et al. 1997). The complex life cycles and habitat requirements of mussels make them especially vulnerable to these perturbations (Adams 1990, Bogan 1993, Neves et al. 1997). The small native range of many crayfish species is a primary factor in their vulnerability to habitat loss and competition (Clamp 1999, Taylor et al. 1996). Threats to crayfish include pollution and impoundment, but competition with nonindigenous species is also a primary threat to many species (Taylor et al. 1996).

In North Carolina, threats to biodiversity are similar to those listed above and include point and nonpoint source pollution, hydrologic alteration, physical habitat manipulation, and biological pollution. In recent decades, water quality has improved in many waters that were historically polluted primarily by point-source discharges; however, overall habitat degradation continues to

threaten the health of aquatic communities. Increased development and urbanization, poorly managed crop and animal agriculture, and mining impact aquatic systems with point and nonpoint source inputs. Impoundments on major rivers and tributaries drastically alter the hydrologic regime of many North Carolina waterways and result in habitat fragmentation, blockage of fish migration routes, and physical habitat alterations.

Assessments of Aquatic Conservation Priorities and Strategies

Over the past decade or so, increased attention has been focused on analysis of aquatic biodiversity, patterns of imperilment, and threats to distill priorities for proactive management and/or conservation triage. A few efforts have gone beyond (or bypassed) identifying specific priorities to propose strategies to address long-term aquatic conservation needs and actions to address these priorities. To the greatest extent possible and where applicable, the guidance provided by these important efforts have been incorporated into this Plan. The following is a brief review of some of the more influential literature that applies to aquatic conservation priorities and strategies in North Carolina.

Priorities

Broad assessments of aquatic conservation priorities were recently completed by two private conservation organizations, each addressing freshwater biodiversity conservation needs at a different scale. These assessments largely built upon existing information to identify significant regions and priority areas for freshwater conservation. The World Wildlife Fund conducted a conservation assessment of freshwater ecoregions of North America (Abell et al. 2000). The Nature Conservancy assessed smaller-scale watersheds across the country (Master et al. 1998), and subsequently identified priority areas within four freshwater ecoregions in the southeast (Smith et al. 2002). Predictably, all three efforts identify the southeast as a key region for freshwater conservation efforts. Many of the most critical areas identified in those efforts overlap North Carolina's borders.

Abell et al. (2000) identified the entire South Atlantic freshwater ecoregion (southern Virginia through central Georgia) as a key region in which to focus aquatic conservation efforts in North America.

Out of 327 key small watershed areas identified across the country by Master et al. (1998), 21 are found in North Carolina (Figure 5B.2).

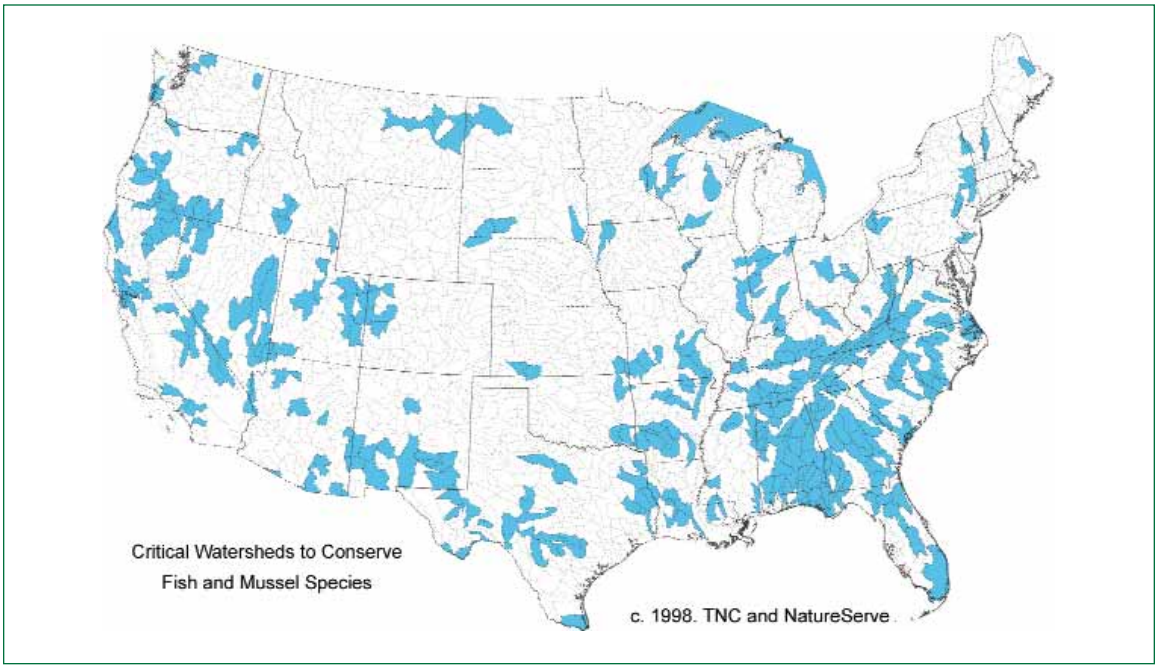


Figure 5B.2. Key watersheds for freshwater conservation in the United States (source: Master et al. 1998).

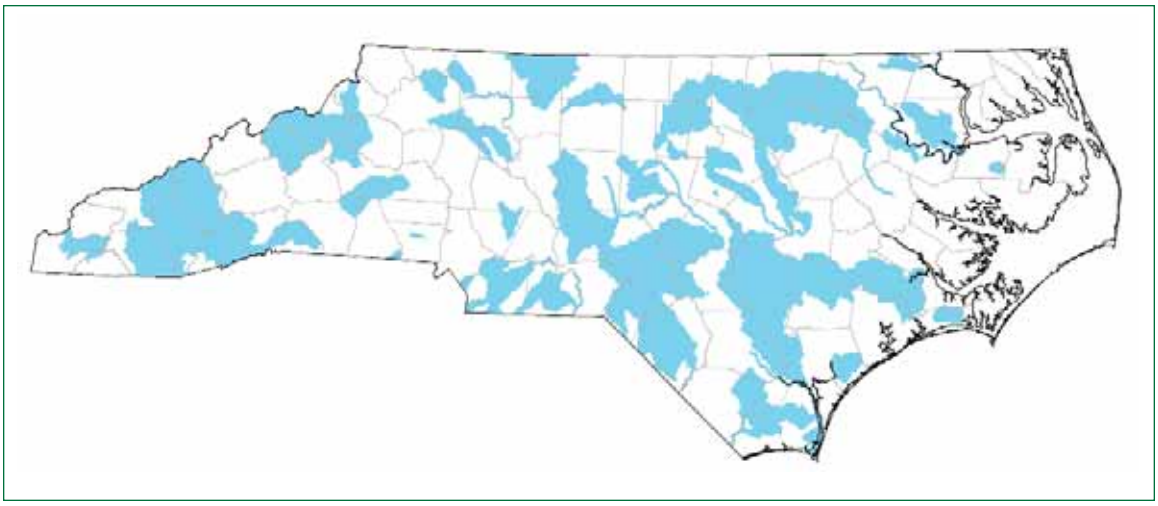


Figure 5B.3. Priority sites for freshwater conservation in North Carolina (data source: Smith et al. 2002).

A number of other studies (results of some were synthesized in the broader assessments cited above) focused on other aspects and scales that are useful in determining conservation priorities. Etnier (1997) and Warren et al. (1997) identified patterns of imperilment among southeastern fishes by family and major habitat preference. Medium-sized rivers and creeks (not including first and second order headwaters) support the greatest number of species (90 and 248, respectively), the highest number of jeopardized species (36 and 32), and the greatest proportion of jeopardized species overall (75% total). The fish families Percidae (darters) and Cyprinidae (minnows) contain the highest numbers of species (152 and 155, respectively) and jeopardized species (46 and 18). However, the greatest percentage of jeopardized species within family were among the Acipenseridae (sturgeons, six of seven species: 86%), the Elassomatidae (pygmy sunfishes, three of six species: 50%), the Percidae (31%), and the Ictaluridae (catfishes [specifically, madtoms], eight of 33 species; 24%). These families are characteristically dependent on benthic habitats or vegetated, isolated wetlands (Warren et al. 1997).

Butler (2002b) assessed conservation priorities for fishes in the Southern Appalachian Ecoregion (SAE, as defined by the US Fish & Wildlife Service). In North Carolina, the SAE includes all Tennessee River tributary basins, as well as the New, upper Roanoke, Yadkin-PeeDee, Catawba, and Savannah basins in the Blue Ridge and eastern foothills. That effort prioritized stream systems having extant populations of imperiled fishes, identified fishes with a relatively high potential for imperilment and deemed to have the greatest need for conservation status assessment, and proposed critical research and conservation needs for those fishes. While federally-listed species were obviously high priorities, emphasis was placed on the non-federally listed fish fauna of the SAE with the intent of preventing further declines. The Little Tennessee and Hiwassee river systems (primarily in North Carolina) were identified among the highest priority stream systems in the SAE for fish conservation.

While we know of no work to date that has specifically focused on prioritizing mollusk species or habitats for conservation priority, priorities are implicit (and addressed explicitly in some cases) in federal and state protection and conservation lists (e.g., LeGrand et al. 2004), and reviews of conservation status and patterns of imperilment (e.g., Williams et al. 1993, Neves et al. 1997). Representatives from federal and state resource management agencies and universities are presently attempting to prioritize mussel species and specific conservation actions in the Cumberlandian region (Tennessee and Cumberland river systems in TN, VA, NC, AL, MS, and KY), analogous to the document produced for the Mobile Basin (Hartfield 2003). This effort will be completed in mid-2005 and should provide guidance useful in refining priorities in western North Carolina.

Similar to the case with mollusks, Taylor et al. (1996) identified conservation status of North American crayfishes and hotspots of diversity and threats that implies conservation priorities. In a more regionally-focused document, Butler (2002a) identified the upper Little Tennessee and Hiwassee river basins in North Carolina and Georgia as the highest priorities for crayfish conservation in the SAE. That effort also identified 12 crayfish taxa "deemed to have the greatest need for current conservation status assessment," five of which occur in North Carolina, and two of which are endemic to the state.

By state statute, the NC Wildlife Resources Commission maintains a Nongame Wildlife Advisory Committee to help guide nongame wildlife management policies and actions. This body, in turn, relies on taxa-specific Scientific Advisory Councils to make recommendations for policies and actions. Specific to aquatic taxa, these councils recommend fish, mollusk, and crustacean species for state listing as endangered, threatened, and species of concern, as well as potentially injurious non-native species. Publications, bulletins, and informal communications are periodically produced by these bodies that contain these and other recommendations (e.g., Adams et al. 1990, Menhinick and Braswell 1997, Clamp et al. 1999).

Strategies

Shute et al. (1997) provided an excellent historical perspective of, and recommendations for, aquatic resource management and conservation strategies. Historically, aquatic conservation and management strategies have typically focused on a few commercially or recreationally significant game fish species, with stock enhancement as a primary goal. The passage of the 1973 Endangered Species Act and 1977 Clean Water Act stressed ecosystem protection and allowed for focused attention on all species and their habitats. Ecosystem management is likely the most effective strategy for conserving rare aquatic species because it factors in ecological relationships, land-use patterns, and threats to habitat and water quality. It is a complicated and often costly approach and relies heavily on cooperation among federal and state agencies, local governments, private organizations, and individual citizens. However, its holistic approach can benefit all species within the watershed.

The US Fish & Wildlife Service has led in the development of detailed conservation strategies for mussels in the United States (Biggins et al. 1997) and fishes in the southeast (Bibb et al. 2002). Both of these important documents identified specific goals and detailed strategies for achieving them. Interestingly, in listing seven major issues impacting southeastern fishes that the strategic goals were designed to address, the first two issues were not directly related to threats to the species or their habitats. They were: "1) Insufficient coordination among existing and potential partners and stakeholders, and; 2) A lack of concern, awareness, and understanding of the values (e.g., ecological, scientific, aesthetic, economic) of our native fish fauna and healthy aquatic ecosystems and the human related impacts to them" (Bibb et al. 2002). In addition to the National Strategy (Biggins et al. 1997), Jenkinson and Todd (1997) provided an historical perspective of mollusk management in the United States and proposed general strategic guidance for habitat protection, population enhancement, harvest controls, public appreciation, and invasive species control and prevention.

Conservation efforts have only recently been focused on crayfish. Schuster (1997), and to some extent Taylor et al. (1996), identify the present state of crayfish management (and crustaceans in general) and the challenges that face developing adequate management plans.

The Commission prepared a draft Wildlife Diversity Plan that identified a number of general needs and objectives for wildlife management, conservation education, and recreation in the state (NCWRC 1999). That draft was prepared in anticipation of passage of the Conservation and Reinvestment Act and was generally a precursor of this Plan. Primary objectives stated in that document were to protect and enhance native wildlife populations and to enhance public awareness and appreciation of wildlife through education, outreach, and recreation opportunities. A list of general priority actions to meet the general objectives was identified; however, no specific priorities or strategies were identified.

Biological Needs: Knowledge Gaps and Ubiquitous Concerns

In order to address species and habitat conservation needs, it is important to first acknowledge our current state of understanding about the target species groups. While the Species Prioritization process (described in Chapter 2) was used to identify aquatic species most in need of conservation attention, basic taxonomy and distribution remains unresolved for a number of crayfish, snails and mussels. Indeed, molecular taxonomists and systematists predict sizeable increases in the numbers of species for most groups, thus sizable decreases in range with concomitant increases in the number of species deemed endangered or threatened (Agapow et al. 2004). It is important that these yet-undescribed species be considered in future conservation planning.

Even for many aquatic species that are relatively well-known taxonomically, information is still lacking on distributions, and population strength and trends. These gaps are especially pronounced among mollusks and crustaceans. While considerable knowledge gaps exist for freshwater mussels, they are even greater for snails and pea clams. Likewise, information vital to effective management of crayfish is lacking; such information for microcrustaceans (e.g., water fleas, seed shrimp, scuds) is practically non-existent.

Filling all knowledge gaps for every taxonomic group is arguably not necessary to achieve effective conservation. Effective monitoring and management of aquatic communities can generally be achieved through focused attention on key elements of those communities among the more well-known fish, mollusks, and crayfishes. Even this, however, is a daunting challenge. Realistically, all necessary tasks cannot be accomplished by the Commission alone. Sharing and consolidation of data from various sources to more completely assess information gaps and help meet vital goals for inventory and monitoring must be improved. The existing Commission aquatics database and the NC Natural Heritage Program database are important tools to meet these goals. Improvements should be made in sharing data between these two databases and broadening the scope of data captured between them. Other state and federal agencies (e.g., NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, Tennessee Valley Authority), universities and museums, private consultants, and certain industries (e.g., hydropower and forestry) are engaged, to various degrees and purposes, in monitoring aquatic communities. These and other sources of data should be exploited to the greatest practical extent that their quantity and quality will allow.

Cooperation and coordination is also essential to fulfill research needs for basic life history and ecology, resolve taxonomic problems, vulnerability to specific threats, restoration techniques, etc. Opportunities to partner and leverage limited funds should be explored and pursued to the maximum extent possible.

Freshwater Fishes

Fairly complete distribution information exists for most fish species in the state. Most spatial and temporal fish distribution data is collected by the NC Division of Water Quality's Basinwide Monitoring Program, which samples fish communities in all 17 basins on a 5-year rotation. The Tennessee Valley Authority also monitors fish communities at numerous sites throughout the western Tennessee River tributary basins. But basin level surveys and monitoring need to be expanded, as there are over 60 species listed as significantly rare or higher within the state status listings. A great percentage of tributaries are rarely to never sampled, except for incidental/specific studies. In addition, main stem river habitats are only spottily sampled in conjunction with various projects (e.g., Federal Energy Regulatory Commission relicensing). So at any given time, while we have a decent idea of what fish distribution was in the state, based on records compiled over decades, contemporary status and distribution of a given species is harder to assess with a real degree of certainty. Under-sampled habitats occur in every region, though the Coastal Plain basins likely lead, due to the difficulty of habitat sampling (i.e., inability to find small, flowing wadeable streams; W. Starnes, pers. comm., B. Tracy, pers. comm.). Other issues of great importance are non-native species introductions and the redistribution of regionally native species via human introductions. Each year, instances of non-native species introductions and inter-basin transfers grow in number. The resultant impacts on native species, which are inevitable given past examples, will take time to assess.

Freshwater Mussels

Compared to other invertebrate taxa, we have decent knowledge levels and data regarding freshwater mussels. However, accurate distribution information is still lacking for many species, as is work related to fish host identification, ecology (both of individual species and among communities of organisms), and basic systematics (genetics, taxonomy, and morphology). Extensive monitoring of populations is generally lacking. There are endemism concerns associated with many species, both throughout the Tennessee River Basin tributaries, as well as concerns about the distribution of some species with rather restricted ranges within the South Atlantic rivers. Taxonomic difficulties have yet to be resolved for several genera, most notably *Elliptio*. There is an extreme knowledge deficit regarding the pea clams; attaining information on their distributions should be pursued whenever possible.

Freshwater Crayfish

Though we have basic information about crayfish fauna distribution by major hydrologic units (river basins), we have relatively low knowledge levels and understanding of crayfish conservation status. Impeding our knowledge of crayfish conservation status is a general lack of biologists that actively study them. Existing collections, maintained by the NC Museum of Natural Sciences, are more extensive for some basins than for others. Distribution information is limited and based on records from specific survey efforts; we know next to nothing about distribution changes. Except for the rare occasion of collections being made at the same sites over a period of years (e.g., NC Division of Water Quality, Basinwide Monitoring Program), not a great deal can be ascertained about population trends. Additional information on crayfish distribution and threats is necessary in order to ascertain status. Extensive monitoring is lacking, in part because it is difficult to impossible to identify most species in the field. Taxonomists that can reliably identify specimens and effective river basin keys are needed[1], along with extensive field surveys and voucher specimens. Endemism concerns are high; there is a strong need to identify and protect areas of endemism (perhaps in conjunction with fish, mussels, and snails).

Freshwater Snails

We have extremely low knowledge levels and understanding of our freshwater snails, especially South Atlantic coastal slope species. As with crayfish, a major challenge is simply the lack of biologists dedicated to the study of freshwater snails. Basic survey and distribution information is lacking for most species. Endemism concerns are high. Extensive survey efforts are needed. There is particular need to focus on the very small and highly endemic snails within family Hydrobiidae. The NC Division of Water Quality (Basinwide Monitoring Program) collects some data on freshwater snails; though spotty, it is a good starting point.

Other Invertebrates

The NC Natural Heritage Program tracks species within all the aforementioned taxa, in addition to rare species in the following invertebrate groups: terrestrial gastropods, arachnids, other crustaceans (e.g., ostracods), millipedes, mayflies, stoneflies, caddisflies, dragonflies, damselflies, flies, moths, butterflies, grasshoppers and katydids, beetles, true bugs, and annelids. Much of the aquatic insect data is provided by the Biological Monitoring group of the NC Division of Water Quality. However, the Commission does not have jurisdiction over most of these taxa, and there is a scarcity of biologists focused on these groups. Knowledge levels and data availability for insects, terrestrial gastropods, and arachnids are the lowest of any animal groups in the state. However, these taxa are an integral part of the ecosystems they share with other invertebrate and vertebrate species. Opportunities to expand our knowledge and understanding of these groups should be taken when possible, as should the establishment of habitat-based projects that are mutually beneficial to these groups and to higher taxa. For more information on invertebrate conservation needs, see Appendix D.

[1] As of 2005, John Cooper of the NC Musuem of Natural Sciences is developing 'basin-specific' field keys that are being tested by agency field biologists (J. Cooper, pers. comm.).

Organization and Content

The following sections are organized by river basins, as designated by the NC Division of Water Quality for their Basinwide Water Quality plans. Each section offers a more detailed view of the threats, needs, and conservation priorities of the individual basins. Priority species found within each basin are listed in a table at the start of each section. (Also see Appendix H for basin distributions for all priority aquatic species). Map Series 5B (following each basin section) identifies geo-political information and priority conservation areas for each basin. Supporting references are included to direct readers towards other information sources that might be useful to review for conservation planning in the basin.

References

Abell, R. A., D. M. Olsen, E. Dinerstein, P. T. Hurley, J. T. Diggs, W. Erichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America. A conservation assessment. Island Press, Washington, D.C.

Adams, W.F., J.M. Alderman, R.G. Biggins, A.G. Gerberich, E.P. Keferl, H.J. Porter, and A.S. Van Devender. 1990. A report on the conservation status of North Carolina's freshwater and terrestrial molluscan fauna. N.C. Wildlife Resources Commission, Raleigh, NC.

Agapow, P., O. R. P. Bininda-Emonds, K. A. Crandall, J. L. Gittleman, G. M. Mace, J. C. Marshall, and A. Purvis. 2004. The impact of species concept on biodiversity studies. The quarterly review of biology 79:161–179.

Alderman, J.M., W.F. Adams, S. Hall, and C. McGrath. 1992. Status of North Carolina's state listed freshwater mussels. N.C. Wildlife Resources Commission, Raleigh, NC.

Bibb, K. A., S. J. Walsh, R. G. Biggins, V. A. Mudrak, and N. M. Burkhead. 2002. Strategy for the conservation of southeastern imperiled fishes. Developed from the Proceedings of a workshop held by a Southeastern Imperiled Fishes Working Group Oct 26–28, 1999, Chattanooga, TN.

Biggins, R. G., Neves, R. J., and Dohner, C. K. 1997. National strategy for the conservation of native freshwater mussels. U S Fish & Wildlife Service, Asheville, N.C.

Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): A search for causes. American Zoologist 33:599–609.

Burr, B. M., and R. L. Mayden. 1992. Phylogenetics and North American freshwater fishes. Pages 18–75 *in* R. L. Mayden, editor. Systematics, historical ecology, and North American freshwater fishes. Stanford University Press, Stanford, CA.

Butler, R. S. 2002a. Crayfishes of the Southern Appalachian ecosystem, with emphasis on the imperiled fauna. US Fish & Wildlife Service, Asheville, NC.

Butler, R. S. 2002b. Imperiled fishes of the Southern Appalachian ecosystem, with emphasis on the non-federally listed fauna. US Fish & Wildlife Service, Asheville, NC.

Clamp, J.C., W.F. Adams, J.W. Reid, A.Y. Taylor, J.E. Cooper, C. McGrath, D.J. Williams, D.J. DeMont, W.O. McLarney, G. Mottesi, and J. Alderman. 1999. A report on the conservation status of North Carolina's freshwater and terrestrial crustacean fauna. N.C. Wildlife Resources Commission, Raleigh.

Etnier, D. A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pages 87–104 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Hartfield, P.W. 2003. Freshwater mussels and snails of the Mobile River Basin: plan for controlled propagation, augmentation, and reintroduction. US Fish & Wildlife Service, Jackson, MS.

Jenkinson, J.J. and R.M. Todd. 1997. Management of native mollusk resources. Pages 283-305 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Master, L. L., S. R. Flack, and B. A. Stein, editors. 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, VA.

Menhinick, E.F., and A.L. Braswell, eds. 1997. Endangered, threatened, and rare fauna of North Carolina. Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey, No. 11.

Minckley, W. L., and J. E. Deacon. 1991. Battle against extinction. Native fish management in the American West. University of Arizona Press, Tuscon, AZ.

Neves, R. J., A. E. Bogan, J. D. Williams, S. A. Ahlstedt, and P. W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pages 43–86 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

N.C. Wildlife Resources Commission (NCWRC). 1999. North Carolina wildlife diversity plan. Division of Wildlife Management, Raleigh, NC.

Rader, D. 1994. Programs to protect aquatic biodiversity in North Carolina. Pages 81–100, *in* D.S. Wilcove and M.J. Bean, editors. The big kill: Declining biodiversity in America's lakes and rivers. Environmental Defense Fund, Washington, D.C.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11(5):1081–1093.

Schuster, G.A. 1997. Resource management of freshwater crustaceans in the southeastern United States. Pages 269–282. *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Shute, P.W., R.G. Biggins, and R.S. Butler. 1997. Management and conservation of rare aquatic resources: A historical perspective and recommendations for incorporating ecosystem management. Pages 445–466. *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Taylor, C. A., M. L. Warren, J. F. Fitzpatrick, H. H. Hobbs, R. F. Jezerinac, W. L. Pflieger, and H. W. Robison. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21:25–38.

Whalen, J.K. 2004. A risk assessment for crayfish conservation on National Forest lands in the eastern United States. Unpublished thesis, James Madison University, Harrisonburg, VA.

Warren, M. L., and B. M. Burr. 1994. Status of freshwater fishes of the United States: overview of an imperiled fauna. Fisheries 19:6–18.

Warren, M. L., P. L. Angermeier, B. M. Burr, and W. R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pages 105–164 *in* G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Decatur, GA.

Warren, M.L., B.M. Burr, S.J. Walsh, H.L. Bart, R.C. Cashner, D.A. Etnier, B.J. Freeman, B.R. Kuhajda, R.L. Mayden, H.W. Robison, S.T. Ross, and W.C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25(10):7–31.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18:6–22.

1. Hiwassee River Basin

Priority aquatic species in the Hiwassee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Clinostomus funduloides ssp.*	"Smoky" Dace[1]	SC
	Erimystax insignis	Blotched Chub	SR
	Etheostoma sp.cf. blenniodes	"Hiwassee" Greenside Darter[1]	
	Etheostoma sp.cf. rufilineatum	"Hiwassee" Redline Darter[1]	
	Ichthyomyzon greeleyi	Mountain Brook Lamprey	
	Moxostoma sp 1	Sicklefin Redhorse	SR
	Notropis photogenis	Silver Shiner	
	Percina aurantiaca	Tangerine Darter	
	Percina squamata	Olive Darter	SC
	Pimephales notatus	Bluntnose Minnow	
Mussels	*Elliptio dilatata*	Spike	SC
	Fusconaia barnesiana	Tennessee Pigtoe[2]	E
	Fusconaia subrotunda	Longsolid[2]	SR
	Lampsilis fasciola	Wavyrayed Lampmussel	SC
	Pegias fabula	Littlewing Pearlymussel[3]	E (E)
	Pleurobema oviforme	Tennessee Clubshell[2]	E
	Villosa iris	Rainbow[2]	SC
	Villosa trabalis	Cumberland Bean	SR (E)
	Villosa vanuxemensis	Mountain Creekshell[2]	T
Crayfish[4]	*Cambarus acanthura*	Spinytail Crayfish	SR
	Cambarus hiwaseensis	Hiwassee Crayfish	
	Cambarus nodosus	Knotty Burrowing Crayfish	SR
	Cambarus parrishi	Hiwassee Headwaters Crayfish	SC
Snails	*Elimia christyi*	Christy's Elimia[5]	E
	Leptoxis virigata	Smooth Mudalia[6]	SR

A. Location and condition of basin (see Maps 5B.1a, 5B.1b):

The Hiwassee River basin is located in the southwestern corner of North Carolina in Cherokee and Clay counties. The headwaters begin in Georgia and the Hiwassee River flows generally to the northwest into Tennessee where it joins the Tennessee River. The Hiwassee River is part of the Tennessee/Ohio/Mississippi River System. The North Carolina portion of the Hiwassee basin is entirely within the Blue Ridge physiographic province and covers approximately 625 sq. miles. Major tributaries in the basin include the Hiwassee River, Valley River, Nottely River, and Brasstown Creek.

[1] Potential taxonomic revision, may be described as new species.
[2] Taxonomy of *Fusconaia*, *Pleurobema*, and *Villosa* spp. in western North Carolina is presently unclear
[3] Apparently extirpated from the basin.
[4] At least two additional putative taxa are presently under review and will likely be described as new species. The known range of these is limited and they will be considered as priority species.
[5] Also known as Knotty elimia (*Elimia interupta*).
[6] Occurrence record in basin may be result of misidentification.

Land use in the basin is 70% forested, 3% urban/built-up, and 27% agriculture/pasture (NCDWQ 2002). Impoundments total 10,850 acres, including Appalachia, Hiwassee, Chatuge (Tennessee Valley Authority), and Mission (Duke Energy). Major landownership in the basin is private, but other significant holdings include Nantahala National Forest and the Tennessee Valley Authority (primarily around their reservoirs). The Eastern Band of the Cherokee Indians also controls some large tracts of land in the basin (primarily within the Hanging Dog Creek watershed). Much of the higher elevations are within the National Forest and developed land is primarily in the valleys; however, there are substantial private holdings in the middle and higher elevations. Development is increasing in these areas, including steeply sloped mountainsides.

There are no designated impaired waters in the basin (74% fully supporting, 26% not rated) (NCDWQ 2002). Two streams are designated as Outstanding Resource Waters (Gipp Creek and Fires Creek) and one stream is designated as High Quality Water (Tusquitee Creek). Higher elevation cold water streams are generally in good to excellent condition. Impacts from non-point sources (primarily erosion) generally increase as streams flow into the more developed valleys and merge into larger streams.

Species diversity is potentially greatest in large and medium-sized rivers, especially in riffle and run habitats. The Valley River and Brasstown Creek are the largest unimpounded streams in the basin in North Carolina and remain in relatively good shape. These streams support most of their historically known fauna; however, at least a few species are extirpated and some have evidently declined. The mainstem Hiwasssee and Nottely rivers are either impounded or regulated throughout their lengths in North Carolina. In these rivers, habitats for native species are variously degraded.

B. Problems affecting species and habitats:

Impacts from hydropower development in the basin have altered and degraded a substantial portion of habitat for most native aquatic species, primarily in large streams and rivers. The mainstem Hiwassee and Nottely rivers are significantly altered by direct and indirect impacts from impoundment. Fifty-seven miles of historically free-flowing riverine habitats are now either seasonally or permanently flooded by Chatuge, Mission, Hiwassee, and Appalachia reservoirs or are affected by indirect impacts from impoundment. The unimpounded reaches of the Nottely and Hiwassee rivers are affected by cold water, altered hydrologic regimes, and periodic low levels of dissolved oxygen due to hypolimnetic and peaking power production releases from Chatuge and Nottely dams. Impoundment and thermal alteration may further affect native species by fragmenting available suitable habitat and isolating historically contiguous populations in tributaries.

As is common throughout the state, erosion and sedimentation are the primary forms of non-point source pollution affecting the Hiwassee Basin. Impacts are evident in Brasstown Creek, Peachtree Creek, lower Valley River, and other smaller watersheds. Sources of erosion are primarily ground disturbance from development activities (e.g., residential, commercial, transportation, and utility construction) and agriculture. Stream bank and other erosion from poorly managed cattle pastures (primarily caused by lack of fenced buffers along streams) and erosion from row crops contribute most of the sediment from agriculture. Timber harvest with insufficient erosion controls may be another source of sediment in the basin. Other non-point sources of pollution include the quantity and quality of runoff from built-up areas and roadways.

Point-source discharges do not appear to be a major source of pollution in the basin at present. Sewage treatment plants and light industry make up most of the presently permitted discharges (see NCDWQ 2002). A large landfill along the Valley River, just upstream from Murphy, appears to be leaching directly to the river. Any specific impacts from this are unknown, but it may warrant investigation.

Non-native species also pose potential threats to native aquatic species in the Hiwassee basin. The blueback herring, Asian clam, striped bass, snail bullhead, rainbow trout, and brown trout are known to be established in the basin. Blueback herring appear to be having impacts on game species in Hiwassee Reservoir and Hiwassee River (i.e. walleye, Wheeler et al. 2004), but impacts to nongame species are unknown at present. Specific impacts from Asian clam and the introduced game fishes are unclear. Other species not presently known from the basin, but known to have invaded surrounding areas include the zebra mussel and rusty crayfish. Other potential problems are indirect affects from invasive plant species and exotic pathogens that can significantly alter riparian vegetation (e.g., Japanese knotweed, hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, NC Museum of Natural Sciences; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency)

- Sicklefin redhorse – complete distribution surveys, identify important spawning areas.
- Crayfish – complete primary inventories and determine status of rare species.
- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids, complete distribution surveys for Christy's elimia.
- Determine distribution of non-native species (e.g., blueback herring).

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Sicklefin redhorse – support completion of species description (cooperate with Roanoke College).
- "Hiwassee" greenside and redline darters – support resolution of taxonomic problems and species descriptions (if required) (potential cooperators include Southeastern Louisiana University, St. Louis University, and NC Museum of Natural Sciences).
- Mussels in the genera *Villosa*, *Pleurobema*, and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Sciences and NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least two putative undescribed species are presently known (cooperate with NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to Commission permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Sicklefin redhorse – support completion of life history studies (partners: Roanoke College, NC State University, and Duke Power).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques) (cooperate with NC State University; other potential cooperators include Virginia Tech. and Tennessee Tech.).

- All other priority species:
  - Review available information and support life history investigations where lacking.
  - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
  - Support determination of specific factors that limit populations downstream from dams, and in the Valley River.
  - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Hiwassee basin cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, US Fish & Wildlife Service, US Forest Service, Hiwassee Watershed Coalition, Duke Energy, Eastern Band of the Cherokee Indians, NC Museum of Natural Science; interstate, intrabasin cooperators include the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
  - Basin specific priorities include the sicklefin redhorse, blotched chub, Christy's elimia, all priority mussel species.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
  - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
  - Basin specific priority: blueback herring.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Hiwassee Basin include: Hiwassee Watershed Coalition, Natural Resources Conservation Service, Ecosystem Enhancement Program, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, Duke Energy, Eastern Band of Cherokee Indians, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the Hiwassee basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.1b):
    - Valley River
    - Brasstown Creek
    - Hiwassee River
    - Hanging Dog Creek
    - Tusquitee Creek
    - Fires Creek

- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations (cooperators include: Hiwassee Watershed Coalition, Natural Resources Conservation Service, Ecosystem Enhancement Program, Tennessee Valley Authority, US Forest Service).
  - Support Hiwassee Watershed Coalition restoration efforts in Brasstown Creek and Valley River watersheds.
  - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
- Investigate potential for priority mollusk (esp. Christy's elimia) and fish population restoration in restored or improved habitats as opportunities become available. Restoration of species that are known or believed to be extirpated from the basin should be considered.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Hiwassee basin.
  - Compile and post species accounts to fish atlas for federal and state listed fishes from the Hiwassee basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
  - Produce materials focused on Hiwassee basin species richness and conservation goals (especially in the Valley River).
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
  - Work through the Federal Energy Regulatory Commission (FERC) relicensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts in Hiwassee and Nottely rivers. Work with Duke Energy to fulfill relicense settlement agreements at Mission project (Tennessee Valley Authority projects are outside FERC jurisdiction).

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - Cooperate with US Fish & Wildlife Service to evaluate the status of sicklefin redhorse as a Candidate for federal listing as Threatened or Endangered, and explore opportunities for Candidate Conservation Agreements.
  - Assess other species in the Hiwassee basin for recommendation for state listing (e.g., longsolid, "Hiwassee"redline and greenside darters).
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Landowner Incentive Program, Safe Harbor).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Butler, R.S. 2002. Crayfishes of the Southern Appalachian Ecosystem, with emphasis on the imperiled fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

Butler, R.S. 2002. Imperiled fishes of the Southern Appalachian Ecosystem, with emphasis on the non-federally listed fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

Cooper, J. E. 2004. Guide to crayfishes of the Hiwassee River basin, North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Hampson, P.S., M.W. Treece, Jr., G.C. Johnson, S.A. Ahlstedt, and J.F. Connell. 2000. Water quality in the Upper Tennessee River Basin, Tennessee, North Carolina, Virginia, and Georgia, 1994–1998. U.S. Geological Survey Circular 1205.

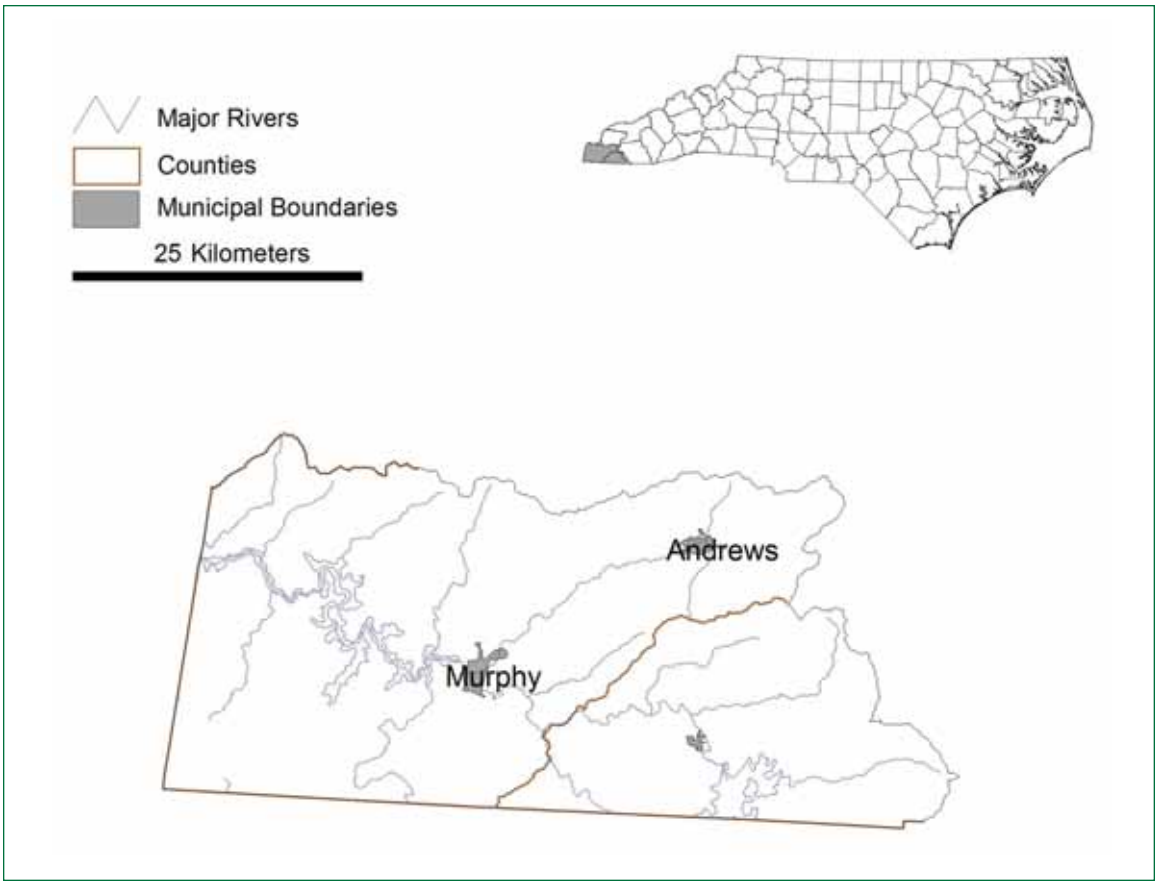
Loftis, C.S. and C.C. Willard. 2001. Fisheries and wildlife management plan for the Hiwassee River Basin. N.C. Wildlife Resources Commission, Raleigh, NC.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

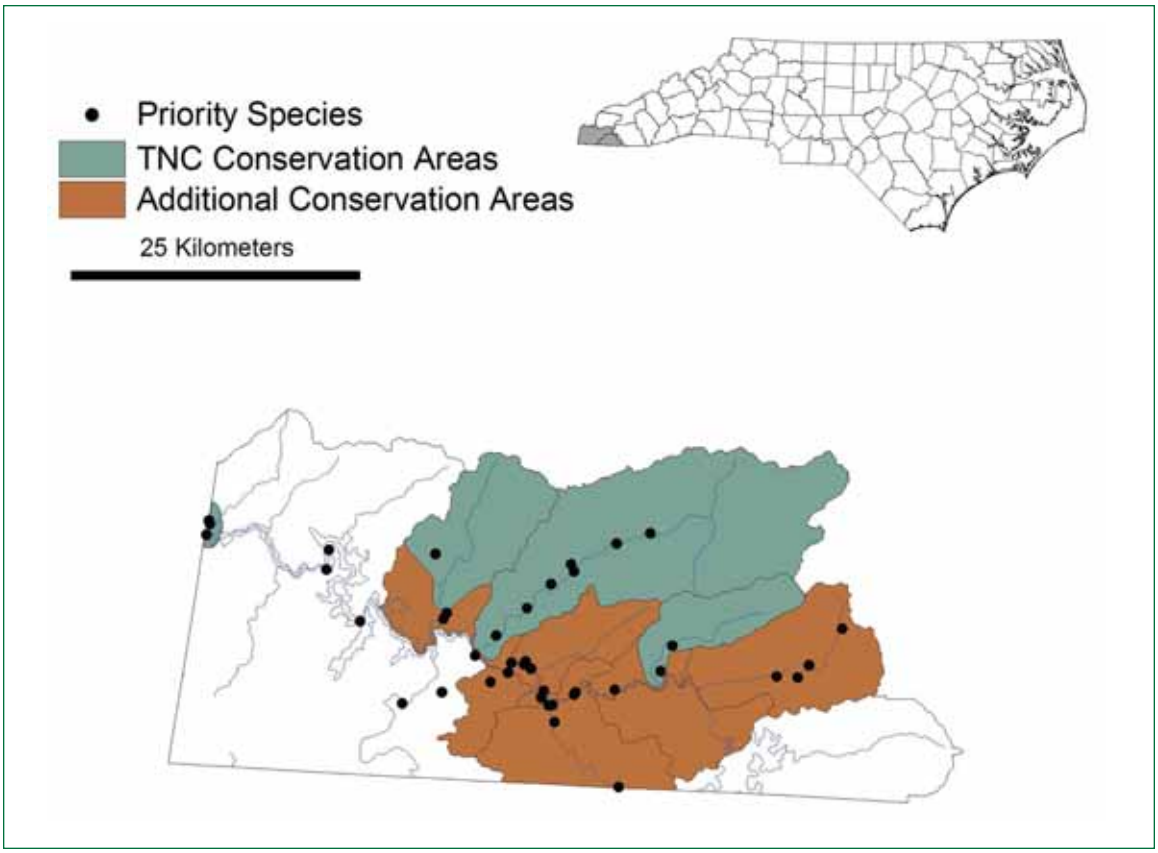
N.C. Division of Water Quality (NCDWQ). 2002. Hiwassee River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Wheeler, A. P., C. S. Loftis, and D. L. Yow. 2004. Hiwassee Reservoir walleye survey, 2000–2003. N.C. Wildlife Resources Commission, Raleigh, NC.



Map 5B.1a. Hiwassee River basin, political information.



Map 5B.1b. Hiwassee River basin, priority species occurrences and priority areas for freshwater conservation.

2. Little Tennessee River Basin

Priority aquatic species in the Little Tennessee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish[1]	*Clinostomus funduloides sp.*	"Smoky" Dace[2]	SC
	Cyprinella monacha[3]	Spotfin Chub	T (T)
	Etheostoma vulneratum	Wounded Darter	SC
	Ichthyomyzon greeleyi	Mountain Brook Lamprey	
	Labidesthes sicculus	Brook Silverside[4]	
	Moxostoma sp 1	Sicklefin Redhorse	SR
	Notropis photogenis	Silver Shiner	
	Notropis volucellus	Mimic Shiner	
	Noturus flavus	Stonecat	E
	Percina aurantiaca	Tangerine Darter	
	Percina burtoni	Blotchside Logperch	E
	Percina squamata	Olive Darter	SC
Mussels	*Alasmidonta raveneliana*	Appalachian Elktoe	E (E)
	Alasmidonta viridis	Slippershell Mussel	E
	Elliptio dilatata	Spike	SC
	Fusconaia barnesiana	Tennessee Pigtoe[5]	E
	Fusconaia subrotunda	Longsolid[4]	SR
	Lampsilis fasciola	Wavyrayed Lampmussel	SC
	Lasmigona holstonia	Tennessee Heelsplitter[6]	E
	Pegias fabula	Littlewing Pearlymussel	E (E)
	Pleurobema oviforme	Tennessee Clubshell[4]	E
	Villosa iris	Rainbow[4]	SC
Crayfish	*Cambarus georgiae*	Little Tennessee River Crayfish	SC
	Cambarus reburrus	French Broad River Crayfish	SR
	Cambarus tuckasegee	Tuckasegee Stream Crayfish	SR
	Orconectes sp. cf. spinosus	No common name until status finalized	SR

A. Location and condition of basin (see Maps 5B.2a, 5B.2b):

The Little Tennessee River basin drains part of southwestern North Carolina in Graham, Macon, Swain, Jackson, and Clay counties in the Blue Ridge physiographic province. The headwaters of the Little Tennessee River are in northeastern Georgia where it flows for seven miles before entering North Carolina. The mainstem Little Tennessee River flows 125 miles through North Carolina before entering Tennessee where it joins the Tennessee River. It is part of the Tennessee/Ohio/Mississippi river system. Total watershed area in North Carolina: 1,797 sq. miles, including 2,565 stream miles and 21,158 reservoir acres. Major tributaries include the Cullasaja, Nantahala, Tuckasegee, Oconaluftee, and Cheoah rivers.

[1] Yellowfin shiner (*Notropis lutipinnis*) is a native priority fish species in the adjacent Savannah basin, but is an introduced non-native in the Little Tennessee.
[2] Potential taxonomic revision, may be described as new species.
[3] Currently know by *Erimonax monachus* (as of 2005).
[4] Native only in Little Tennessee, non-native in Yadkin-PeeDee, Lumber rivers.
[5] Taxonomy of *Fusconaia*, *Pleurobema*, and *Villosa* spp. in western North Carolina is presently unclear.
[6] Occurrence record in basin may be result of misidentification.

Land use in the basin is 89% forested, 5% urban/built-up, 6% pasture (NCDWQ 2002). Impoundments include Fontana, Nantahala, Calderwood, Cheoah, Santeetlah, Glenville, Bear Creek, Cedar Cliff, Wolf Creek, Tanasee Creek, Dillsboro, Ela, Emory, and Sequoyah. Land ownership is >50 % publicly owned. Portions of the basin lie within the boundaries of the Great Smoky Mountains National Park and Nantahala National Forest. The Needmore Tract (~4600 acres) is a recently acquired Commission Game Land along the Little Tennessee River in Macon and Swain counties. The Qualla Boundary Cherokee Indian Reservation covers portions of the Oconaluftee and Tuckasegee watersheds. Much of the higher elevations are within the National Forest and National Park; however, development on private holdings in the higher elevations is increasing. Development is presently greatest and is increasing in the valleys and along the major waterways. The mainstem Little Tennessee River from the Georgia state line to Franklin, much of the Tuckasegee River from Cullowhee to Bryson City, and the Oconaluftee River from the National Park boundary to the Tuckasegee confluence are experiencing increasing disturbance and development.

Water quality ratings in the basin are generally good with 97% of streams rated as fully supporting; however, 2.4% of streams are impaired and 0.6% are not rated (NCDWQ 2002). The upper headwaters of the East Fork Tuckasegee and Nantahala rivers are designated Outstanding Resource Waters and multiple higher elevation streams are designated High Quality Waters. As is generally true throughout the Mountain Region, habitats with greatest potential for species diversity are in the larger, cool-warm water streams and rivers at lower elevations.

The 24 mile-long reach of the Little Tennessee River between Franklin and Fontana Reservoir supports the greatest diversity and abundance of native aquatic species in the region. Strong populations of Appalachian elktoe, spotfin chub, sicklefin redhorse and most other priority species generally thrive in the high quality habitat conditions. Good habitat conditions and native aquatic communities also exist in the lower Tuckasegee. Instream habitat conditions in the upper Little Tennessee River are severely impaired by excessive sedimentation. Habitat for sensitive aquatic species within this reach is presently marginal to totally lacking. Impacts from hydropower development substantially impair and limit native aquatic communities in the upper Tuckasegee, Nantahala, and Cheoah river systems. However, recognition needs to be given to the upper Little Tennessee basin's role as a key migratory flyway for birds, given its north-south orientation into the mountains and its large concentration of wetland habitat.

B. *Problems affecting species and habitats:*

The major problems affecting species and habitats in the Little Tennessee basin are impoundment (dams) and associated impacts, and excessive erosion and stream sedimentation. Of the entire 144 miles of the mainstem Little Tennessee River (in Georgia, North Carolina, and Tennessee), only 47 miles in Georgia and North Carolina remain unimpounded. Much of the Tuckasegee River is either impounded or altered by cold water releases and peaking flow regulation from dams. The Cheoah River is entirely altered by diversion of practically all flow from the remaining nine mile reach downstream from Santeetlah Dam. Loss of habitat due to impoundment, thermal and hydrologic alteration, as well as population fragmentation are the primary impacts from hydropower development.

Potentially high-quality habitats are further degraded from non-point source pollution, primarily from erosion and sedimentation from disturbance related to development and agriculture. Water and habitat quality upstream from Lake Emory at Franklin (upper Little Tennessee River, Cullasaja River, Cartoogechaye Creek, and tributaries) varies considerably (see Little Tennessee Watershed Association 2003 for further information). Portions of the Cullasaja River and Cartoogechaye Creek are presently in relatively good shape. While some tributaries in this area contribute significantly to the problem, substantial amounts of sediment result from bank erosion along the upper Little Tennessee mainstem. Erosion and sedimentation are also problems in the Tuckasegee River watershed, especially in the larger tributaries between Cullowhee and Bryson City (e.g., Savannah and Scott creeks). Impaired Waters in the basin include: Cullasaja River, Mill Creek, upper Little Tennessee River, Beech Flats Prong, and West Buffalo Creek arm of Santeetlah Reservoir (NCDWQ 2002).

Invasive, non-native species are a potential problem. The yellowfin shiner has apparently been introduced to the upper Little Tennessee River and is expanding downstream from Franklin. Other non-native fish species (e.g., bluehead chub and yellow perch) also inhabit portions of the basin. The Asian clam is established in the Little Tennessee and Tuckasegee rivers. Chinese mystery snails have been found in Cowee Creek and could spread to the mainstem Little Tennessee River (M. Cantrell, pers. comm). The rusty crayfish is apparently established in at least one stream downstream from Fontana Reservoir (Cooper 2005). Zebra mussels are not yet known from North Carolina, but are known from Tellico Reservoir (Little Tennessee River) in Tennessee. Exotic pathogens and parasites may also present threats. Spotfin chubs from the Little Tennessee River were recently discovered to be infested with a tapeworm native to Asia (N. Heil, pers. comm.). Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Park Service (Great Smoky Mts National Park), NC Museum of Natural Science; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency)

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Sicklefin redhorse – complete distribution surveys; identify important spawning areas.
- Tennessee heelsplitter – determine distribution and status.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species (e.g., yellowfin shiner, Chinese mystery snails, rusty crayfish).
- Conduct distribution surveys in the Tuckasegee River for the blotchside logperch.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Sicklefin redhorse – support completion of species description (cooperate with Roanoke College).
- Mussels in the genera *Villosa*, *Pleurobema*, and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Science, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least two putative undescribed species are presently known (cooperate with NC Museum of Natural Science).
- "Smoky" dace – support taxonomic resolution and species description (if required).
- Stonecat – support taxonomic resolution of the species in the basin.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine

vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Sicklefin redhorse – support completion of life history studies, identify critical spawning habitat, identify seasonal habitat use (cooperate with Roanoke College, NC State University, and Duke Power).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques). Determine feasibility, appropriate species, and techniques for reintroduction to Cheoah River (cooperate with US Fish & Wildlife Service, US Forest Service, and NC State University, with support from the NC Resource Management and Enhancement Fund- provided through Alcoa Power Federal Energy Regulatory Commission [FERC] settlement).
- Spotfin chub – support investigation of potential for reintroduction to Cheoah River (cooperate with US Fish & Wildlife Service, US Forest Service; other potential cooperators include the University of Tennessee, Conservation Fisheries, Inc., with support from NC Resource Management and Enhancement Fund- provided through Alcoa Power FERC settlement).
- All other priority species:
  - Review available information and support life history investigations where lacking.
  - Support investigation of potential for reintroduction of priority species to Cheoah River.
  - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
  - Support investigations of population response to stream restoration projects (especially in priority areas).
  - Support research to improve habitat conditions in regulated rivers.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, US Fish & Wildlife Service, US Forest Service, National Park Service (Great Smoky Mountains National Park), Duke Energy, Eastern Band of the Cherokee Indians, NC Museum of Natural Science; interstate, intrabasin cooperators are the Georgia Department of Natural Resources, Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
  - Basin specific priorities include the Appalachian elktoe, littlewing pearly mussel, spotfin chub, sicklefin redhorse, stonecat.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
    - o Monitor aquatic community response to remediation of hydropower impacts in Cheoah River (partners include: US Fish & Wildlife Service, US Forest Service, with support from NC Resource Management and Enhancement Fund- provided through Alcoa Power FERC settlement).
  - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
  - Basin specific priorities include the spotfin chub parasites, yellowfin shiner, bluehead chub, yellow perch, Chinese mystery snail, Asian clam, rusty crayfish.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Little Tennessee River basin include: Little Tennessee Watershed Association, Land Trust for the Little Tennessee, Watershed Association for the Tuckasegee River, Natural Resources Conservation Service, Ecosystem Enhancement Program, county-based soil and erosion control efforts, US Forest Service, US Fish & Wildlife Service, TVA, Duke Energy, Alcoa Power, NC Resource Management and Enhancement Fund, Eastern Band of Cherokee Indians, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the Little Tennessee River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.2b):
    - Little Tennessee River
    - Tuckasegee River
    - Cheoah River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations (e.g., Land Trust for the Little Tennessee, Little Tennessee Watershed Association).
  - Support conservation and restoration efforts in the Little Tennessee River through participation in the Little Tennessee Watershed Association Technical Advisory Committee and through support of implementation of the "Upper Little Tennessee River Basin: A conservation assessment and strategy" (Desmond 2003).
  - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.
  - Incorporate management goals for aquatic community conservation and enhancement into management plan for Needmore Game Lands.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for priority mollusk and fish population restoration in Cheoah River. As appropriate, support and participate in specific activities to restore populations in the Cheoah River.
- Investigate potential for priority mollusk and fish population restoration in restored or improved habitats as other opportunities become available.
- Support captive propagation of spotfin chubs from Little Tennessee River for various purposes, including restoration efforts.
- Support development of propagation techniques and production capacity for augmentation and reintroduction of other priority fish and mollusk species.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Little Tennessee basin.
  - Compile and post species accounts to fish atlas for federal and state listed fishes from the Little Tennessee basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
    o Participate in "Kids in the Creek" program for Macon County schools.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
  - Support adoption of site specific water quality standards for waters that support federally listed species in the Little Tennessee basin (cooperate with NC Division of Water Quality, US Fish & Wildlife Service, and local governments).
  - Coordinate efforts with Georgia to reduce point and non-point sources of pollution in upper Little Tennessee River.

- Work through the FERC re-licensing process and other opportunities to mitigate negative impacts from hydropower development. Specific basin priorities include:
  - Cooperate with Duke Energy, FERC, and resource agency cooperators to assess potential for removing Dillsboro Dam on the Tuckasegee River and minimizing potential impacts of removal.
  - Work with Duke Energy, Alcoa Power, FERC, and resource agency cooperators to fulfill relicense settlement agreements for Little Tennessee basin projects (Tennessee Valley Authority projects are outside FERC jurisdiction).
  - Investigate potential for removing Cullhowhee Dam on the Tuckasegee River.
  - Support practicable mitigation and restoration for hydropower impacts throughout the Little Tennessee basin.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - Cooperate with US Fish & Wildlife Service to evaluate the status of sicklefin redhorse as a Candidate for federal listing as Threatened or Endangered, and explore opportunities for Candidate Conservation Agreements.
  - Assess other species in the Little Tennessee basin for recommendation for state listing (e.g., longsolid).
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service to:
    - Plan and align activities for Appalachian elktoe, littlewing pearly mussel, and spotfin chub with recovery plan goals,
    - Better track and record activities that apply to recovery plan objectives, and
    - Plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Safe Harbor agreements). (Potential partners include: US Fish & Wildlife Service, NC Natural Heritage Program, Duke Power, The Nature Conservancy, Little Tennessee Watershed Association, Land Trust for the Little Tennessee, Watershed Association of the Tuckasegee River, local governments, private landowners, Eastern Band of the Cherokee Indians, Natural Resources Conservation Service, Coweeta Hydrological Laboratory).
    - Investigate opportunities to utilize any available and applicable program (especially Habitat Conservation Planning) to conserve habitat and recover the federally listed species in the Little Tennessee basin (e.g., Appalachian elktoe, littlewing pearly mussel, and spotfin chub).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Borawa, J.C. 2001. Fisheries and wildlife management plan for the Nantahala River basin. N.C. Wildlife Resources Commission, Raleigh, NC.

Butler, R.S. 2002. Crayfishes of the Southern Appalachian Ecosystem, with emphasis on the imperiled fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

Butler, R.S. 2002. Imperiled fishes of the Southern Appalachian Ecosystem, with emphasis on the non-federally listed fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

Cooper, J.E. 2004. Guide to crayfishes of the Little Tennessee River basin, North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Cooper, J.E. 2005. A report on adventive crayfishes in North Carolina. Unpublished report, N.C. Museum of Natural Sciences, Raleigh, NC.

Desmond, D. 2003. The Upper Little Tennessee River Basin: A conservation assessment and strategy. Land Trust for the Little Tennessee, Franklin, NC.

Hampson, P.S., M.W. Treece, Jr., G.C. Johnson, S.A. Ahlstedt, and J.F. Connell. 2000. Water quality in the Upper Tennessee River Basin, Tennessee, North Carolina, Virginia, and Georgia, 1994–1998. U.S. Geological Survey Circular 1205.

Little Tennessee Watershed Association. 2003. The state of the streams in the upper Little Tennessee watershed: A report on water quality and habitat trends, 1990–2002. Franklin, NC.

Loftis, C.S. 2001. Fisheries and wildlife management plan for the Little Tennessee River Basin. N.C. Wildlife Resources Commission, Raleigh, NC.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

N.C. Division of Water Quality (NCDWQ). 2002. Little Tennessee River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2000. Fisheries and wildlife management plan for the Cheoah River Basin and the Lower Little Tennessee River. Raleigh, NC.

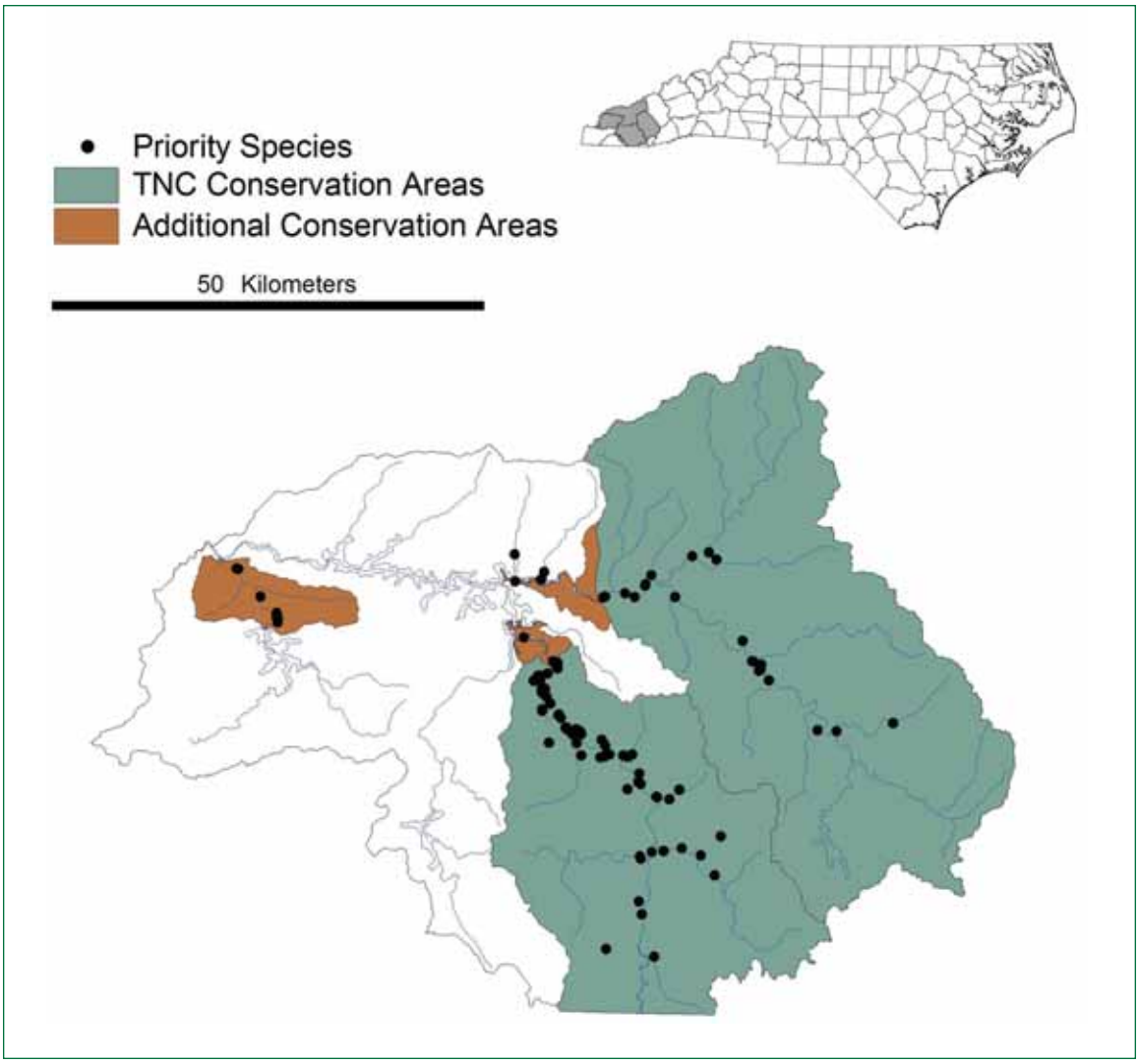
Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

US Fish & Wildlife Service. 1977. Final threatened status and critical habitat for five southeastern fishes. Federal Register, 42(175): 45526–45530.

US Fish & Wildlife Service. 2002. Endangered and threatened wildlife and plants; designation of critical habitat for the Appalachian elktoe. Federal Register, 67(188):188

Yow, D.L. and J.C. Borawa. 2001. Fisheries and wildlife management plan for the Tuckasegee River basin. N.C. Wildlife Resources Commission, Raleigh, NC.

Map 5B.2a. Little Tennessee River basin, political information.



Map 5B.2b. Little Tennessee River basin, priority species occurrences and priority areas for freshwater conservation.

3. French Broad River Basin

Priority aquatic species in the French Broad River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Carpiodes carpio*	River Carpsucker	SC
	Carpiodes cyprinus	Quillback	
	Erimystax insignis	Blotched Chub	SR
	Etheostoma acuticeps	Sharphead Darter	T
	Etheostoma jessiae	Blueside Darter[1]	SC
	Etheostoma vulneratum	Wounded Darter	SC
	Ichthyomyzon greeleyi	Mountain Brook Lamprey	
	Ictiobus bubalus	Smallmouth Buffalo[2]	
	Lampetra appendix	American Brook Lamprey	T
	Luxilis chrysocephalus	Striped Shiner	T
	Notropis photogenis	Silver Shiner	
	Notropis volucellus	Mimic Shiner	
	Noturus eleutherus	Mountain Madtom[1]	SC
	Noturus flavus	Stonecat	E
	Percina aurantiaca	Tangerine Darter	
	Percina burtoni	Blotchside Darter	E
	Percina caprodes	Logperch	T
	Percina macrocephala	Longhead Darter[1]	SC
	Percina squamata	Olive Darter	SC
	Pimephales notatus	Bluntnose Minnow	
Mussels	*Alasmidonta raveneliana*	Appalachian Elktoe	E (E)
	Alasmidonta viridis	Slippershell Mussel	E
	Fusconia subrotunda	Longsolid	SR
	Lampsilis fasciola	Wavyrayed Lampmussel	SC
	Lasmigona holstonia	Tennessee Heelsplitter[3]	E
	Pleurobema oviforme	Tennessee Clubshell	E
	Strophitus undulatus	Creeper (Squawfoot)	T
	Villosa trabalis	Cumberland Bean[1]	SR (E)
Crayfish	*Cambarus reburrus*	French Broad River crayfish	SR

A. Location and condition of basin (see Maps 5B.3a, 5B.3b):

The French Broad river basin in North Carolina is composed of three major sub-basins, each of which individually flow northwest into Tennessee: French Broad River, Pigeon River, and Nolichucky River.

- The **French Broad River** sub-basin can be divided further into three more or less geomorphologically distinct units.
  - *Upper mainstem and headwater streams*
    Major tributaries: North, West, and East Forks of French Broad River

[1]Possibly extirpated.
[2]Native only in French Broad basin, non-native in Catawba, Yadkin-PeeDee, Neuse basins.
[3]Occurrence record in basin may be result of misidentification.
[3]Questionable records in the basin

  - *Middle mainstem and tributaries*
    Major tributaries: Little River, Mills River, Davidson River. Swannanoa River; Mud Creek, Cane Creek, and Hominy Creek,
  - *Lower mainstem and tributaries*
    Major tributaries: Sandymush Creek, Big Ivy River; Big Laurel and Spring Creeks

- **Pigeon River**
  Major tributaries: East and West Forks Pigeon River; Jonathan, Richland, Cataloochee, and Big creeks

- **Nolichucky River**
  Major tributaries: North and South Toe Rivers, Cane River, and Big Rock Creek.

The French Broad river watershed in North Carolina encompasses 2,830 sq. miles, including 4,136 stream miles in Haywood, Madison, Buncombe, Transylvania, Henderson, Yancy, Mitchell, and Avery counties, and is entirely within the Blue Ridge physiographic province. The headwaters are entirely within North Carolina. The basin drains the north and western slopes of the Black Mountains, the highest range in the eastern United States. The upper mainstem French Broad River system drains the high mountains of the Blue Ridge and flows through the broad, flat valley of the Asheville Basin. Within the Asheville Basin, the French Broad and tributaries are relatively low gradient and share many habitat characteristics with streams in the Valley and Ridge physiographic province. Consequently, a number of aquatic species more typical of the Valley and Ridge are known from this part of the French Broad and virtually nowhere else in the Blue Ridge. Near the city of Asheville, the French Broad flows out of the Asheville Basin and descends a relatively steep, narrow gorge before entering Tennessee. The topography of the Pigeon River watershed is similar, with high gradient headwaters, a relatively flat midsection, and a steep gorge near the Tennessee border. The midsection of the Nolichucky River watershed lacks substantial flat areas and remains more high-gradient and gorge-like throughout its length in North Carolina.

Approximately 50% of the basin is forested. Much of the forested land is at the higher elevations and lies within the boundaries of Pisgah National Forest, Blue Ridge Parkway, and a portion within the Great Smoky Mountains National Park. Most agricultural and developed lands are concentrated within the river valleys; however, residential development is increasing on steeper slopes. Between 1982 and 1992, cultivated and uncultivated croplands decreased by ~67%, while urban and developed lands increased by 42%. Agriculture covers 17% of the land area in the basin and 10% of the basin is considered urban (NCDWQ 2000).

Dams on the French Broad River and tributaries include: Craggy, Capitola, and Redmon (run of river with small detention pool). Impoundments include Lake Julian, Burnett Reservoir, Beetree Reservoir, Busbee Reservoir, Enka Lake, and many other small impoundments throughout the watershed, especially in the upper portion in Henderson and Transylvania counties. Dams and impoundments in the Pigeon River sub-basin include Walters Dam/Waterville Lake (with a 12 mile bypassed reach downstream), Lake Junaluska, Allen Creek Reservoir, and Lake Logan. While there are a few small impoundments on minor tributaries, there are no dams on the Nolichucky River and its major tributaries.

Water quality ratings in the basin include 77% fully supporting waters, 2% impaired waters, 21% not rated (NCDWQ 2000). Overall, water quality is good throughout most of the basin. The middle and lower French Broad River and tributaries are impacted by agriculture, dairy farms, and urbanization. In 2000, there were 16 streams designated as Impaired Waters. Almost half of these (seven) are within the Asheville Basin portion of the middle French Broad River sub-basin. Outstanding Resource Waters in the basin include Cataloochee Creek, the upper South Toe River watershed, and South Fork Mills River. Significant watersheds with High Quality Waters designation include Big Creek and the upper Davidson River. Some significant watershed areas are also designated Water Supply I and II and they include the North Fork Mills River, and the upper portions of Ivy, Cane, and Swannanoa rivers (see NCDWQ 2000 and http://h2o.enr.state.nc.us/bims/Reports/reportsWB.html for further stream designations).

B. Problems affecting species and habitats:

Habitat degradation resulting from non-point source pollution is the most widespread problem in the basin. Large-scale development and urbanization, as well as agriculture are significant sources of non-point source pollution and sedimentation. Nutrient enrichment is a greater problem in the French Broad basin than in any other Interior Basin drainage in the region (Hampson et al. 2000). Highway construction and associated indirect and secondary impacts are a significant concern in many parts of the basin. Poorly managed development on steep slopes and within riparian areas along tributaries apparently contributes much of the sedimentation from development activities. Threats from hydrologic modifications resulting from increased urbanization (i.e. increased impervious surfaces, flood plain development and filling, stream channel alterations) are apparently increasing throughout the basin, with some areas experiencing greater impacts than others. Habitat degradation from point sources of pollution is also a significant problem in portions of the basin, if not as widespread as non-point sources. Compared to other basins in the region (e.g., Hiwassee, Little Tennessee, and Catawba) impacts from impoundments are relatively minor in the French Broad basin; however, some significant problems exist in portions of the basin.

Problems associated with non-native and invasive species are unclear at present; however, the native long-ear sunfish has apparently been displaced entirely throughout the basin by the non-native redbreast sunfish. The Atlantic Slope native White River crayfish and white catfish are established in the Pigeon sub-basin. Other non-native fishes, such as common carp, goldfish, rainbow trout, and brown trout, are long established in the basin with apparently minimal impacts on native non-game communities. A number of exotic tropical fish species (e.g., tilapia, armored catfish, pacu) are established in Lake Julian, but over winter survival is apparently restricted to the warm waters of a power plant discharge. The Asian clam is known from the French Broad sub-basin, but its extent throughout the basin is not fully documented. As identified in previous basin accounts, non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

French Broad River sub-basin

Habitat for priority aquatic species in the French Broad River subbasin is affected by impacts related to development and urbanization, agriculture, and point sources. Sedimentation and turbidity are more or less chronic problems in most of the larger streams in the lower elevations of the Asheville Basin and surrounding area, including the mainstem French Broad River. Point source pollution, including both present problems and residual effects from much more severe pollution of the past, contributes significantly to habitat degradation and the extirpation of priority species.

Very few high-quality habitats for cool-warm water priority species in medium to large streams have remained intact through the 20th century. The mainstem French Broad River and tributaries from the confluence of the Davidson River downstream to the Tennessee border have lost a substantial portion of their aquatic species. Habitat appears to remain unsuitable for some of these species; however recovery of some of these species may be possible due to relatively recent incremental improvements in water quality. The Upper French Broad River, Little River, Mills River, and Ivy River have been the primary refuges for most of the priority species that are still extant in this subbasin. However, increased development and chance events are ever-present threats in such fragmented refugia. For example, a tanker truck accident dumped toxic chemicals in the upper California Creek and Ivy River watershed in 2002, which killed aquatic life to the confluence with the French Broad River. High quality habitat for priority mussels in the Little River is limited to a short reach between Cascade Lake and confluence of Crab Creek, where sedimentation from agriculture and development in the watershed degrades habitat. Runoff from large-scale agriculture and development threaten the lower Mills River.

Dams on the mainstem French Broad River (Craggy, Capitola, Redmon) are run of river and impacts appear to be minimal. Barrier effects and population fragmentation (at least isolation of upstream populations) may have some impact on extant riverine fishes (especially potadromous species) and potential for restoration of extirpated species (e.g., lake sturgeon, sauger).

Pigeon River sub-basin

The Pigeon River has experienced significant degradation from point source pollution and impoundment, as well as non-point sources. A paper mill at Canton (Blue Ridge Paper Products, formerly Champion Paper) discharged toxic wastes directly to the Pigeon River for much of the 20th century. Many priority species were eliminated from the mainstem Pigeon River by this pollution. Improvements in waste water treatment that began in the early 1990's have improved habitat conditions and prospects for recovery of many native species appear to be good.

The most significant impacts from impoundment in the French Broad basin are at the Walters Dam (Progress Energy) and bypass reach on the Pigeon River. Approximately 5 miles of the river is impounded in Walters Reservoir and 12 miles downstream from Walters Dam is dewatered (except for some leakage at the dam and tributary inflow) by bypassing water from the reservoir through a penstock to a powerhouse near the Tennessee state line. Restoration of minimum flows to the bypassed reach is tied to improvements in upstream water quality (per Federal Energy Regulatory Commission [FERC], Article 414). Improvements in the paper mill's impacts to the reservoir must meet certain thresholds defined by chemical and biological criteria before water can be released.

The Pigeon River and short reaches of the East and West forks of the Pigeon upstream from Canton have remained relatively high-quality cool-warm water habitat and has provided refuge for most of the priority species that are still extant in the sub-basin. Increasing development could potentially degrade this important habitat. Other tributaries, such as Jonathans Creek, Richland Creek, Fines Creek, and Crabtree Creek are variously degraded by non-point source pollution. Poorly managed agriculture and increasing development are the primary factors.

Nolichucky River sub-basin

Historically, sedimentation and pollution from several mining operations throughout the subbasin (primarily in the North Toe watershed) significantly degraded cool-warm water habitats. Encouragingly, improvements that began in the 1970's have apparently helped reduce these impacts. Recent bioassessments indicate improving conditions (NCDWQ 2000; TVA and NCWRC unpublished data). Habitat in the North Toe River between Spruce Pine and the South Toe River confluence continues to be degraded, apparently from discharges and runoff from mining operations and the town of Spruce Pine. Floodplain gravel mining in the upper Cane River watershed poses a potential threat to long-term channel stability and habitat quality. Development is increasing throughout much of the sub-basin and erosion and sedimentation may also be on the rise. Major highway projects are planned for the area and the direct, indirect, and secondary impacts could threaten the recent improvements in habitat conditions.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, Little Tennessee Watershed Association, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Parks Service (Great Smoky Mts National Park), NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency)

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary distribution and status surveys.

- Mussels – complete primary distribution and status surveys in a few remaining areas; periodic surveys in areas where potential for expansion of existing populations is possible.
- Fish – distribution surveys in Nolichucky River system for blotchside logperch, stonecat, blotched chub, and sharphead darter; mainstem French Broad river for appropriate priority fish species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Strophitus*, *Pleurobema* and *Fusconaia* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least one putative undescribed species is presently known (cooperate with NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support research projects applicable to improving success and efficiency of Pigeon River fish re-introduction project (cooperators include: Blue Ridge Paper Products, University of Tennessee, Western Carolina University, and the NC Division of Water Quality).
- Priority mollusk species – support research to facilitate population augmentation and restoration (e.g., translocation and propagation techniques) (cooperators include: NC State University and Virginia Tech.).
- Extirpated priority species (including spotfin chub) – determine measurable habitat requirements and monitor conditions in the basin for potential reintroduction opportunities, support development of propagation techniques (cooperators include: US Fish & Wildlife Service, University of Tennessee, and Conservation Fisheries Incorporated).
- All other priority species:
  - Review available information and support life history investigations where lacking.
  - Support investigation of potential for reintroduction of priority species to upper French Broad River.
  - Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
  - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, US Fish & Wildlife Service, US Forest Service, National Park Service (Blue Ridge Parkway), Haywood Waterways Association, Blue Ridge Paper, University of Tennessee, Progress Energy, Pigeon River Fund, NC Museum of Natural Science; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
  - Basin specific priorities include the Appalachian elktoe, slippershell, stonecat, blotched chub, and sharphead darter
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
    - Monitor progress of Pigeon River fish restoration project (partners include: Blue Ridge Paper Products, University of Tennessee, NC Division of Water Quality).
  - Performance of hydropower remediation.
  - Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
  - Basin specific priorities include the Asian clam and White River crayfish.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the French Broad River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Fish & Wildlife Service, Haywood Waterways Association, Riverlink, Mud Creek Watershed Association, Carolina Mountain Land Conservancy, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the French Broad River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.3b):
    - Upper Nolichucky/Cane/Toe Rivers
    - Little River
    - Mills River
    - Upper French Broad River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
  - Support conservation and restoration efforts in the Pigeon River sub-basin through participation in the Haywood Waterways Association Technical Advisory Committee.
  - Encourage conservation of existing good riparian and stream conditions in priority areas.
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
  - Pigeon River fish reintroduction project – Facilitate and cooperate with partners to reintroduce common and priority fish species extirpated from Pigeon River between Canton and Walters/Waterville reservoir; support associated propagation efforts for augmentation and reintroductions of rare species.
  - Investigate potential for priority mollusk population restoration in restored or improved habitats as other opportunities become available (upper mainstem French Broad River- reintroduce and/or augment Appalachian elktoe, longsolid, Tennessee clubshell, oyster mussel, Cumberland moccasin shell; upper North Toe River – augment Appalachian elktoe and wavy-rayed lampmussel populations).
  - Support development of propagation techniques and production capacity for augmentation and reintroduction of other priority fish and mollusk species.
  - Spotfin chub – Support investigation of potential for reintroduction to suitable habitats in the French Broad basin (cooperate with US Fish & Wildlife Service and US Forest Service; other potential cooperators include: University of Tennessee, Conservation Fisheries, Inc.).

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  - Update crayfish and mussel atlases with presently known species occurrence and distributions in the French Broad basin.
  - Compile and post species accounts to fish atlas for federal and state listed fishes from the French Broad basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
    o Participate in “Kids in the Creek” program for Haywood County schools.
- Seek opportunities for direct outreach throughout the basin, especially in the Nolichucky sub-basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service.) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
  - Support adoption of site specific water quality standards for waters that support federally listed species in the French Broad basin (cooperate with the NC Division of Water Quality, US Fish & Wildlife Service, and local governments).
- Work through the FERC relicensing process and other opportunities to mitigate negative impacts from hydropower development (Partners include: Progress Energy, Metropolitan Sewerage District of Buncombe County, US Fish & Wildlife Service, NC Division of Water Resources, NC Division of Water Quality).
  - Work with Progress Energy, FERC, and resource agency cooperators to fulfill relicense settlement agreements for Walters/Waterville hydropower project on the Pigeon River.
  - Support practicable mitigation and restoration for hydropower impacts throughout the French Broad basin.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
  - Assess species in the French Broad basin for recommendation for state listing (e.g., longsolid).

- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service Asheville Field Office to:
    - Plan and align activities for Appalachian elktoe and spotfin chub with recovery plan goals.
    - Better track and record activities that apply to recovery plan objectives, and
    - Plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Safe Harbor agreements). (Potential partners include: US Fish & Wildlife Service, NC Natural Heritage Program, The Nature Conservancy, Riverlink, Carolina Mountain Land Conservancy, local governments, private landowners).
    - Investigate opportunities to utilize any available and applicable program (especially Habitat Conservation Planning) to conserve habitat and recover the federally listed species in the Little Tennessee basin (Appalachian elktoe, littlewing pearly mussel, and spotfin chub).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Butler, R.S. 2002. Crayfishes of the Southern Appalachian Ecosystem, with emphasis on the imperiled fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

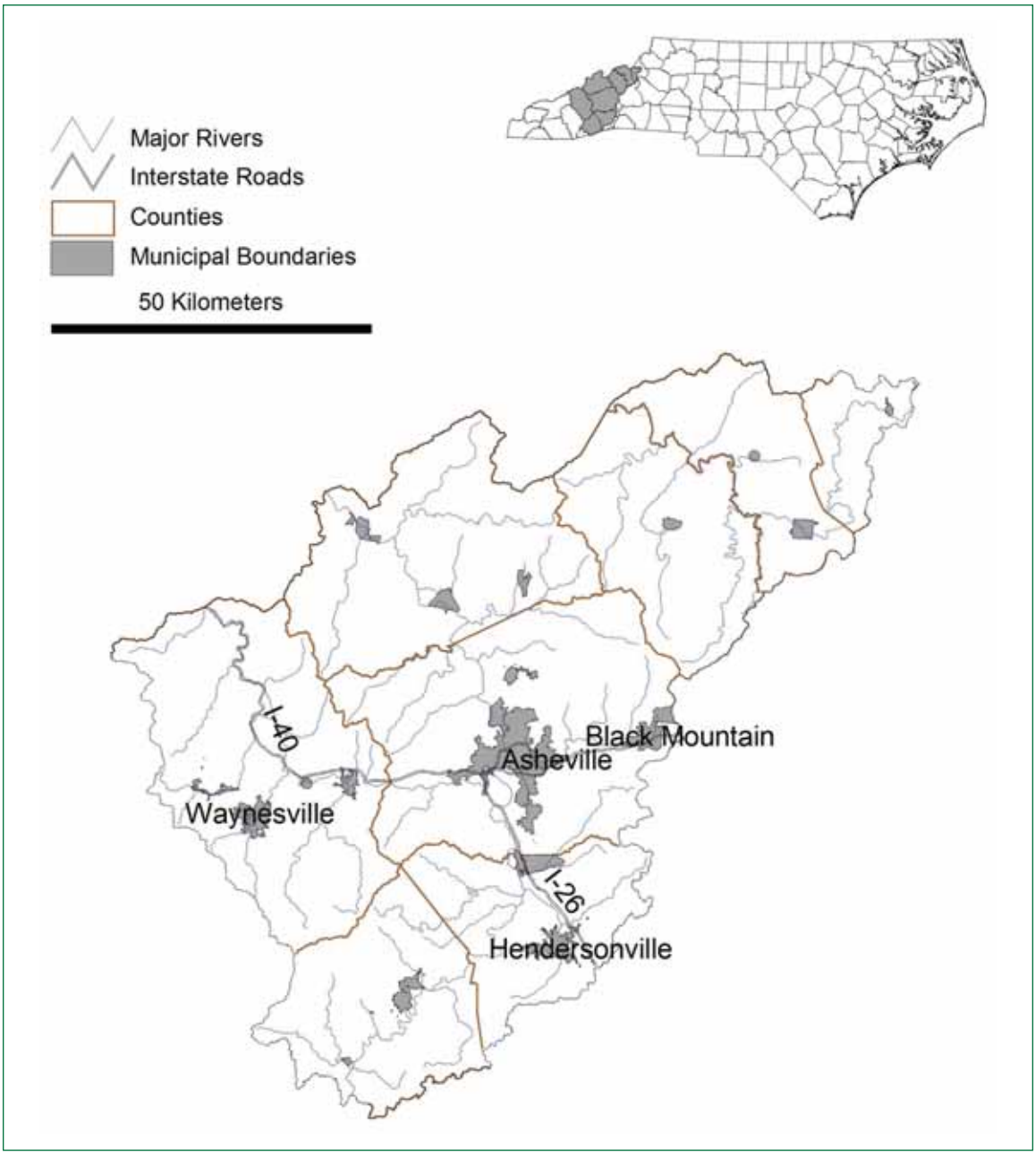
Butler, R.S. 2002. Imperiled fishes of the Southern Appalachian Ecosystem, with emphasis on the non-federally listed fauna. Prepared for the Southern Appalachian Ecosystem Team of the US Fish & Wildlife Service. US Fish & Wildlife Service, North Carolina Field Office, Asheville, NC.

Cooper, J.E. 2005. A report on adventive crayfishes in North Carolina. Unpublished report, N.C. Museum of Natural Sciences, Raleigh, NC.

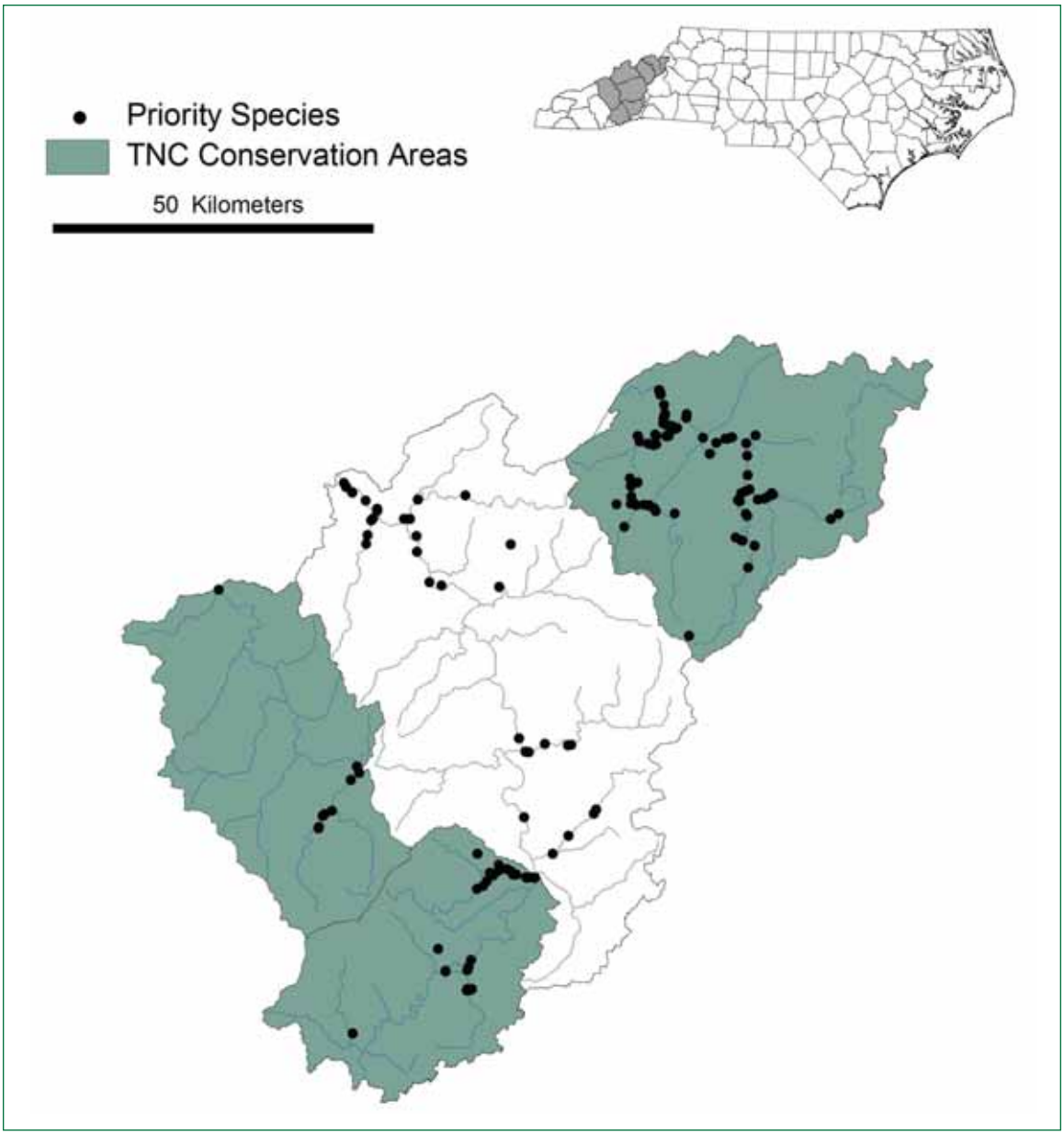
Hampson, P.S., M.W. Treece, Jr., G.C. Johnson, S.A. Ahlstedt, and J.F. Connell. 2000. Water quality in the Upper Tennessee River Basin, Tennessee, North Carolina, Virginia, and Georgia, 1994–1998. U.S. Geological Survey Circular 1205.

N.C. Division of Water Quality (NCDWQ). 2000. French Broad River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.3a. French Broad River basin, political information.



Map 5B.3b. French Broad River basin, priority species occurrences and priority areas for freshwater conservation.

4. Watauga River Basin

Priority aquatic species in the Watauga River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	Notropis photogenis	Silver Shiner	
	Percina aurantiaca	Tangerine Darter	
	Pimephales notatus	Bluntnose Minnow	
Mussels	Lasmigona subviridis	Green Floater	E

A. Location and condition of basin (see Maps 5B.4a, 5B.4b):

The Watauga River watershed drains northwest into Tennessee where it flows into Watauga Reservoir. The Watauga River is a tributary of the Holston River, which is a major tributary of the Tennessee River. The Watauga River watershed in North Carolina encompasses 205 sq. miles, including 270 stream miles in Avery and Watauga counties, and is entirely within the Blue Ridge physiographic province. The Elk River is a major tributary.

Land use in the basin is 87% forest/wetland, 13% pasture/managed herbaceous, and >1% urban (NCDWQ 2002). Most development and agricultural activities are located in the valleys due to abundance of steep slopes within the watershed. However, development (primarily home construction) is rapidly increasing on steeper slopes. Major land ownership is private with <10% in public lands (Pisgah National Forest and the Blue Ridge Parkway). There are no major impoundments within the North Carolina portion of the basin. There is one run of the river hydro-electric facility on the Watauga River (Ward Mill Dam). There are several small impoundments on tributaries, including Beech Mountain Reservoir on Buckeye Creek (drinking water reservoir).

There are no designated impaired waters within the basin (83% fully supporting, 17% not rated) (NCDWQ 2002). Overall, water quality in the Watauga basin is very good. The primary water quality concerns stem from non-point inputs, primarily siltation

B. Problems affecting species and habitats:

While water quality conditions are generally very good at present, past pollution events may have had a profound effect on the extant aquatic fauna in the Watauga River. Local accounts indicate that a tannic acid factory near Valle Crucis caused severe pollution in the early 20th century and may have lead to the extirpation of many native species. Apparently, no extensive surveys for aquatic species were made prior to this period of degradation and the extent of species loss is unknown. Presently, excessive erosion and sedimentation from non-point sources is the primary problem affecting species and habitats. Narrow riparian corridors or total lack of riparian vegetation along portions of the Watauga River and many tributaries have lead to excessive stream bank erosion and loss of habitat to sediment deposition and over-widening of channels. Impacts from row-crop agriculture and poorly managed livestock pasture (sedimentation from runoff and stream bank erosion) are also significant. As residential development increases (vacation homes, golf courses, etc.) stormwater run-off is a major contributor to sedimentation and other non-point problems. The area appears to be experiencing an acceleration of development and threats to water and habitat quality are increasing. Christmas tree farming is also increasing in the basin. Relatively large amounts of herbicides and pesticides are used in this form of silviculture. Impacts of runoff from tree farms is unclear, but should be monitored for potential effects. Impacts from non-native species (e.g., margined madtom) are unknown, but could be a negative impact on native fish communities.

Little is known of the extent to which non-native aquatic species have become established in the Watauga basin in North Carolina. Non-native trout species (rainbow and brown trout) are well established. As identified in previous basin accounts, non-native vegetation can also negatively

impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Partners include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University).

- Review existing data and determine information needs for all taxa (cooperate with NC Museum of Natural Sciences).
- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary distribution and status surveys.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Crayfish – support description and species diagnosis of all crayfish species in the basin. At least one putative undescribed species is presently known (cooperate with NC Museum of Natural Science).
- Snails – support identification and description of all species in the basin.

. **Research to facilitate appropriate conservation actions** – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support life history and habitat requirement studies for green floater, especially focused on factors that may limit populations in the Watauga River.
- Continue cooperation with Appalachian State University to investigate potential impacts of seasonal delayed harvest trout stocking on native cool-warm water communities in Watauga River.
- Support investigations into potential impacts to aquatic systems from intensive silvicultural applications of pesticides.
- All other priority species:
  - Review available information and support life history investigations where lacking.
  - Support investigation of potential for reintroduction of priority species to Watauga River.
  - Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include: NC Division of Water Quality, Tennessee Valley Authority, NC Department of Transportation, US Fish & Wildlife Service, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University; an interstate, intrabasin cooperator is the Tennessee Wildlife Resources Agency).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  – Performance of stream restoration projects.
  – Performance of hydropower remediation.
  – Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
  – Basin specific priority: margined madtom.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Watauga River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Fish & Wildlife Service, county-based soil and erosion control efforts, US Forest Service, Tennessee Valley Authority, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  – Priority watersheds for freshwater conservation in the Watauga River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.4b):
    o Watauga River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
  – Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.
- Investigate potential for reintroduction of common upper Tennessee River basin species (i.e. wavy-rayed lampmussel, rainbow) to the upper Watauga River, as habitat conditions dictate. No stocks for reintroduction are available from the basin in North Carolina—these would have to come from elsewhere in the upper Holston River system in Tennessee or Virginia.

Data collection, management, and dissemination

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships

  – Coordinate sampling with other resource groups.
  – Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.

- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  – When available, update crayfish and mussel atlases with presently known species occurrence and distributions in the Watauga basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  – Deliver oral presentations.
  – Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
  – Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  – Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  – Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  – When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

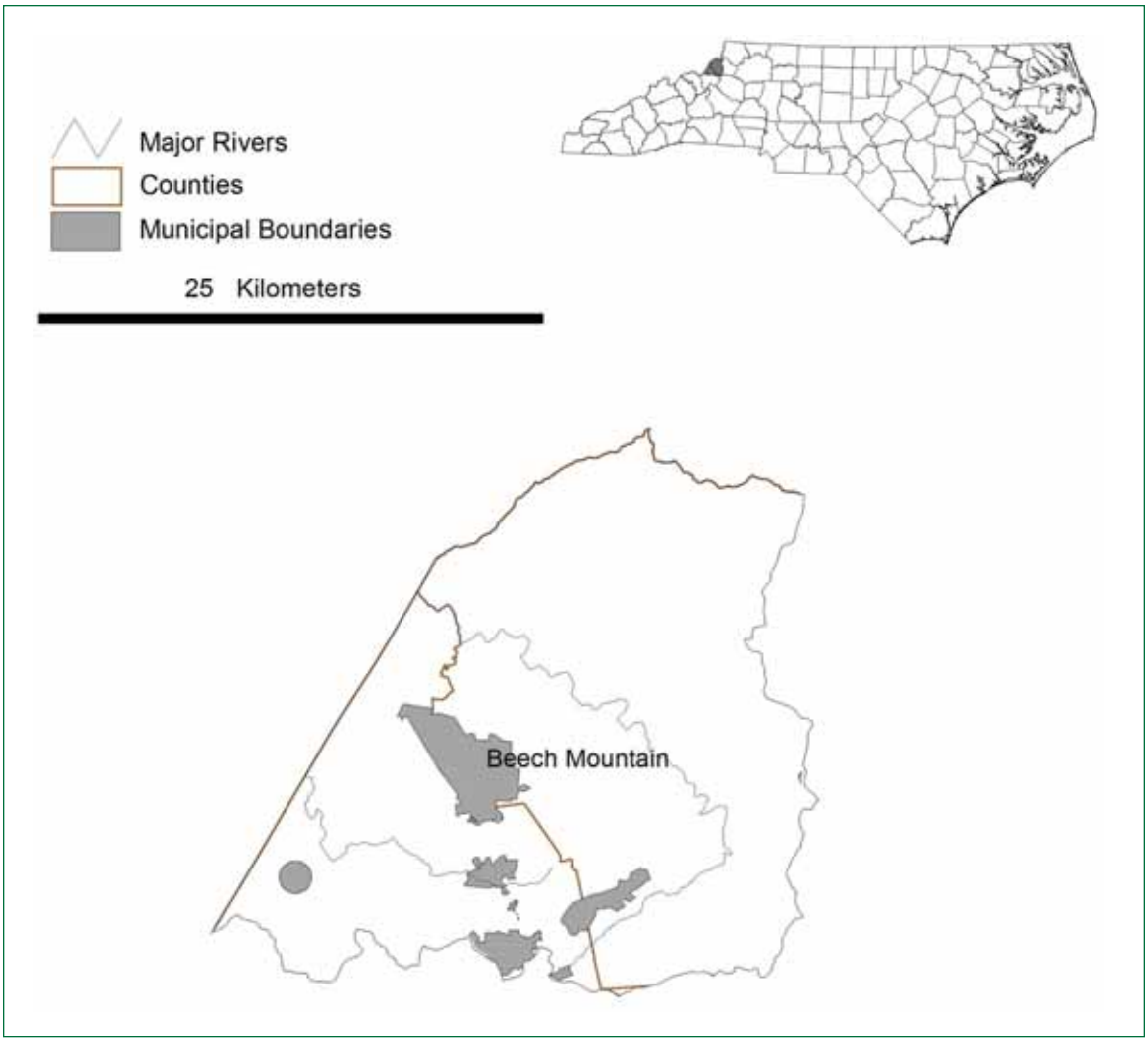
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

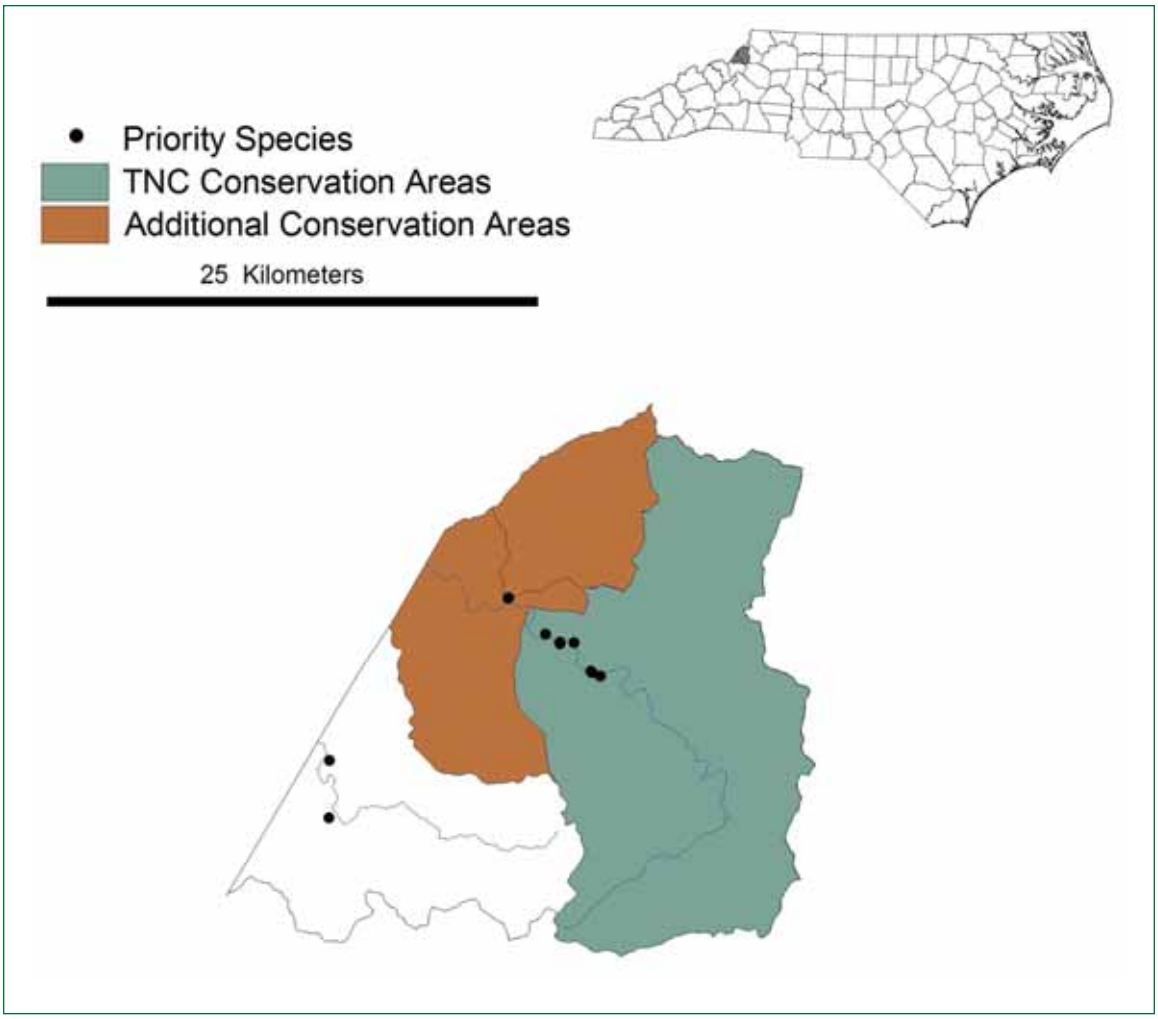
Hampson, P.S., M.W. Treece, Jr., G.C. Johnson, S.A. Ahlstedt, and J.F. Connell. 2000. Water quality in the Upper Tennessee River Basin, Tennessee, North Carolina, Virginia, and Georgia, 1994–1998. U.S. Geological Survey Circular 1205.

N.C. Division of Water Quality (NCDWQ). 2002. Watauga River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.4a. Watauga River basin, political information.



Map 5B.4b. Watauga River basin, priority species occurrences and priority areas for freshwater conservation.

5. New River Basin

Priority aquatic species in the New River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Etheostoma kanawhae*	Kanawha Darter	SR
	Exoglossum laurae	Tonguetied Minnow	SR
	Notropis photogenis	Silver Shiner	
	Notropis rubellus	Rosyface Shiner	
	Notropis volucellus	Mimic Shiner	
	Percina caprodes	Logperch	T
	Percina oxyrhynchus	Sharpnose Darter	SC
	Phenacobius teretulus	Kanawha Minnow	SC
	Pimephales notatus	Bluntnose Minnow	
Mussels	*Cyclonaias tuberculata*	Purple Wartyback	E
	Elliptio dilatata	Spike	SC
	Lasmigona subviridus	Green Floater	E
Snails	*Leptoxis dilatata*	Seep Mudalia	T

A. Location and condition of basin (see Maps 5B.5a, 5B.5b):

The New River basin in North Carolina is located in the northwest corner of the state in Ashe, Alleghany, and Watauga counties. The basin drains 753 sq. miles in North Carolina and includes approximately 801 stream miles. It is part of the Kanawha/Ohio/Mississippi River system and is the only Interior Basin drainage in North Carolina that does not flow into the Tennessee River. It is entirely within the Blue Ridge physiographic province and is comprised of three sub-basins:

- **North Fork New River** tributaries –- Roaring, Brush, and Hoskin Forks; Helton, Silas, Buffalo, Three Top, Big Laurel, and Long Hope Creeks
- **South Fork New River** tributaries –- Meadow, Piney, East and Middle Forks; Cranberry, Peak, Howard, Meat Camp, Roan, Naked, and Winkler Creeks.
- **Little River** tributaries – Brush Creek and Laurel Branch; Elk, Glade, Bledsoe, and Pine Swamp Creeks.

Land use in the basin is 53% forested, 33% pasture/cropland, 6% urban, and 8% other (NCDWQ 2000). The North Carolina portion of the New River basin is mountainous and rural. Most agriculture and development is concentrated in the valleys with the exception of Christmas tree farms; however, development on steeper slopes is increasing. Impoundments include Appalachian State University Lake (18 acres) on Norris Branch in the South Fork New River watershed (water supply reservoir), one hydroelectric facility at Sharpe Falls (run-of-the-river), North Fork New River. The headwaters of Laurel Branch in the Little River sub-basin contain three impoundments for irrigation to Olde Beau Golf Course Community. Public land ownership in the basin includes New River State Park (1,300 acres along the South Fork New River), Mount Jefferson State Natural Area, Three Top Mountain Game Land, and relatively small areas within the Blue Ridge Parkway (National Parks Service). Recently, 300 acres of Sparta Bog was purchased by the NC Department of Transportation for mitigation. All other land is private.

Water quality is generally good in the New River Basin. Water quality ratings include 95% fully supporting, 2% impaired, 3% not rated (NCDWQ 2000). Impaired waters within the New River Basin include Naked Creek, Little Buffalo Creek (waste water treatment plant discharge, non-point sources-sedimentation), Peak Creek, Ore Knob Branch, and Little Peak Creek (acid mine drainage). Trout waters are abundant and many streams are classified as High Quality or Outstanding Resource Waters. The 26.5 miles of the lower South Fork New River and the entire

portion of the New River in North Carolina are designated as both a National Scenic River and a state Natural and Scenic River. This reach is also classified as Outstanding Resource Waters. The entire New River was named an American Heritage River in 1998. Most of the middle reach of the South Fork New River is designated as High Quality Waters, as is the lower Little River.

B. Problems affecting species and habitats:

While water quality is generally good overall, there are localized problems and general habitat degradation in many cool-warm water habitats for priority species throughout the basin. The factors affecting aquatic habitat degradation (primarily through erosion and sedimentation) are development and land clearing, poorly managed livestock grazing (run-off and stream bank degradation), unpaved rural roads along streams, and general loss of riparian vegetation.

Development (primarily new home construction) is increasing throughout the basin, especially on steeper slopes. Impacts from sedimentation appear to be quite severe in some localized areas and generally degrade habitats in larger tributaries and in the mainstem New River. Increasing population is also placing greater demand on drinking water supplies. Increases in water withdrawals from streams primarily in the upper South Fork New sub-basin, is a potential problem.

Water quality is variously degraded by acid mine drainage, impacts from urban runoff, and waste water treatment plant discharge. Christmas tree production is a major agricultural enterprise in the basin and large amounts of pesticides and herbicides are used. Impacts from this on aquatic systems are largely unknown.

Numerous non-native aquatic animal species are established in the basin. As identified in previous basin accounts, non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid). Impacts on populations of native species are unclear at present, but should be a focus of long-term monitoring and specific investigations.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Partners in North Carolina include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, National Parks Service (Blue Ridge Parkway), Appalachian State University, National Committee for the New River, New River State Park; an interstate, intrabasin partner is the Virginia Department of Game and Inland Fisheries).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish, mussels, and fish – update status surveys.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Snails – support identification and description of all species in the basin.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Support life history and habitat requirement studies for green floater, especially focused on factors that may limit populations in the New River.
- Support investigations into potential impacts to aquatic systems from intensive silvicultural applications of pesticides.
- All other priority species:
  – Review available information and support life history investigations where lacking.
  – Support investigation of potential for reintroduction of extirpated species to New River.
  – Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Potential partners in North Carolina include: NC Division of Water Quality, Appalachian State University, New River State Park, National Committee for the New River, US Fish & Wildlife Service, US Forest Service, and the National Parks Service (Blue Ridge Parkway); an interstate, intrabasin cooperator is the Virginia Department of Game and Inland Fisheries).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
  – Basin specific priorities include the green floater, Kanawha darter, Kanawha minnow, tongue-tied minnow, sharpnose darter, seep mudalia.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  – Performance of stream restoration projects.
    o Continue to cooperate with US Army Corps of Engineers to assess stream restoration projects on South Fork New River.
  – Performance of hydropower remediation.
  – Performance of species restoration projects.
- Assess non-native species impacts – monitor populations of potentially injurious non-native species and impacts on priority species:
  – Monitor spread of multiple introduced fish species and potential impacts to native communities.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the New River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, National Committee for the New River, New River State Park, US Fish & Wildlife Service, US Forest Service, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  – Priority watersheds for freshwater conservation in the Watauga River River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.5b):
    o Mainstem New River
    o South Fork New River
    o Lower North Fork New River
    o Little River

- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
  – Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  – When available, update crayfish and mussel atlases with presently known species occurrence and distributions in the New basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  – Deliver oral presentations.
  – Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission [FERC], US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
  – Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.

  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.

- Work through the FERC re-licensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts throughout the New River basin

Land-use planning efforts – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.
- Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Landowner Incentive Program, Safe Harbor).

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

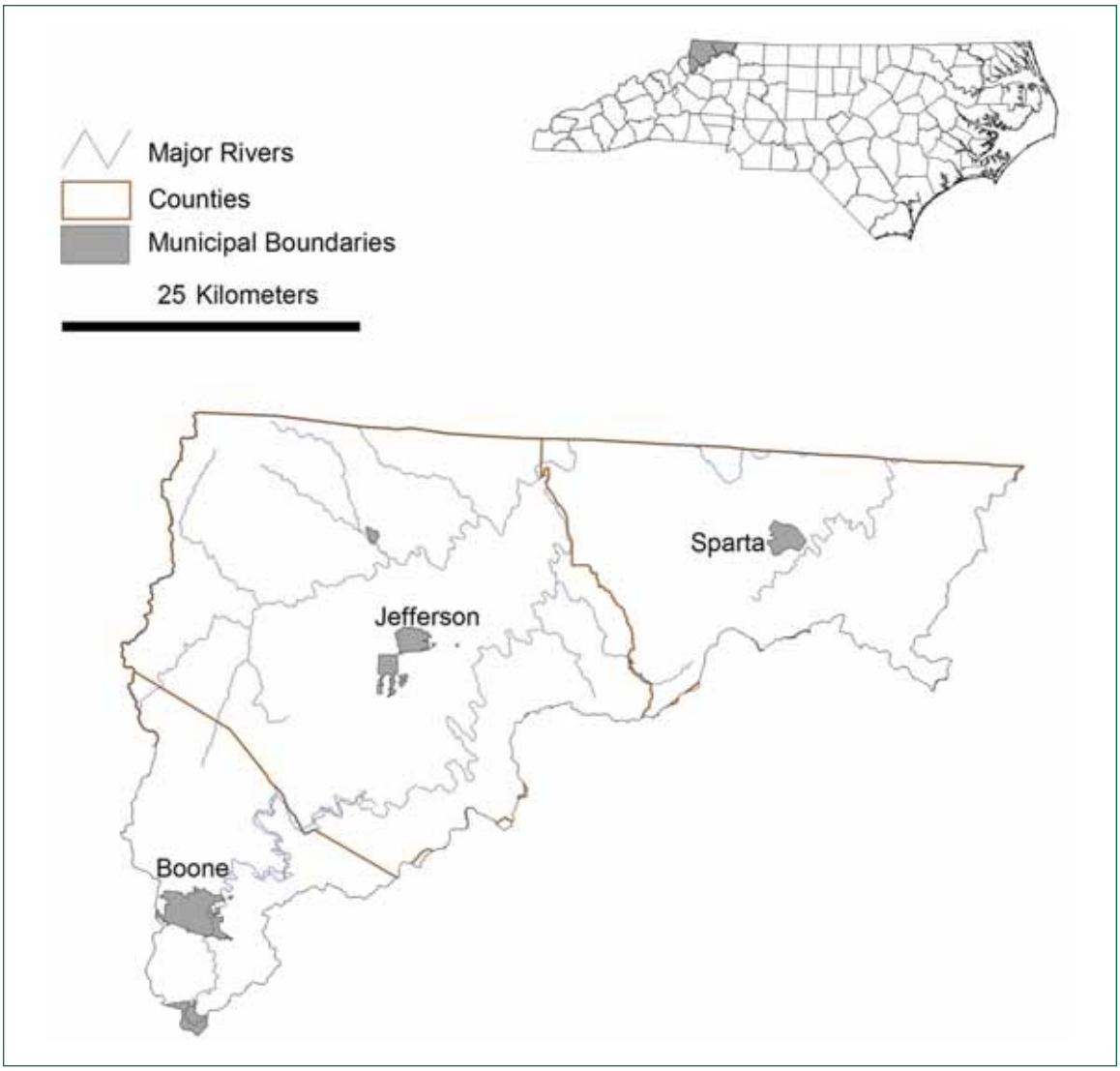
Supporting References

McGrath, C. 1998. New River basin aquatic inventory. Nongame Project Report, N.C. Wildlife Resources Commission, Raleigh, NC.

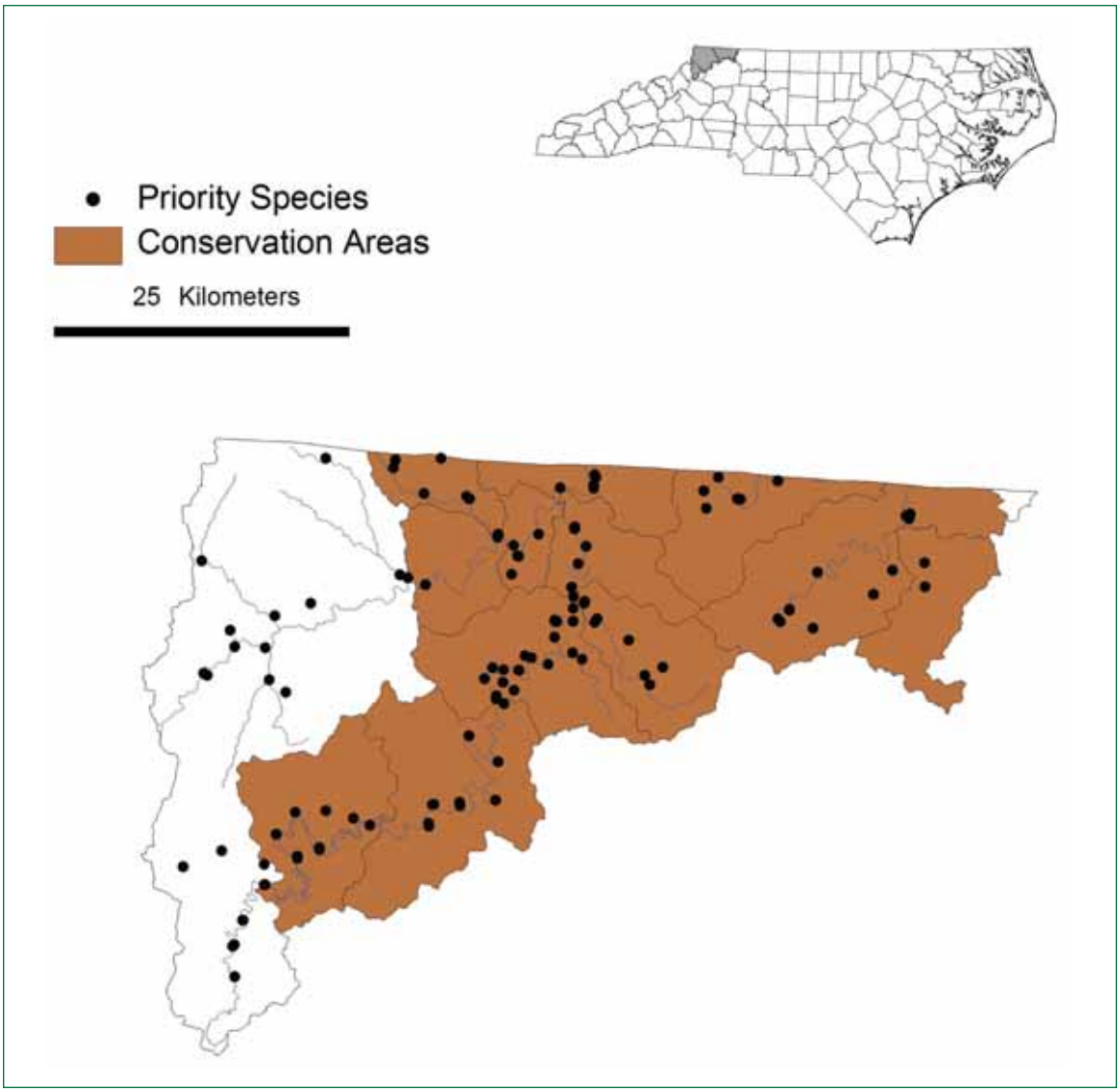
N.C. Division of Water Quality (NCDWQ). 2000. New River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.5a. New River basin, political information.



Map 5B.5b. New River basin, priority species occurrences and priority areas for freshwater conservation.

6. Savannah River Basin

Priority aquatic species in the Savannah River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Ameiurus brunneus*	Snail Bullhead	
	Etheostoma inscriptum	Turquoise Darter	SC
	Hybopsis rubifrons	Rosyface Chub	T
	Notropis lutipinnis	Yellowfin Shiner	SC
	Percina nigrofasciata	Blackbanded Darter	
Crayfish	*Cambarus chaugaensis*	Oconee Stream Crayfish	SC
	Cambarus reburrus	French Broad River Crayfish	SR

A. Location and condition of basin (see Maps 5B.6b[1]):

The headwaters of the Savannah River basin begin along the eastern slopes of the Blue Ridge Mountains. The river flows south through Georgia and South Carolina and empties into the Atlantic Ocean. Only 2% of the total Savannah River basin is in North Carolina, encompassing 172 sq. miles in small portions of Macon, Jackson, Transylvania, and Clay counties. The North Carolina portion of the basin is entirely within the Blue Ridge physiographic province and consists of 176 miles of streams and 1,366 reservoir acres. Streams in North Carolina are part of the Tugaloo River and Seneca River sub-basins; however, both of these named rivers begin outside the state. Major tributaries of the Tugaloo in North Carolina are the Overflow and Big creeks, and the Chattooga River. Major tributaries of the Seneca River in North Carolina include the Toxaway, Horsepasture, Thompson, and Whitewater rivers.

Land use in the basin is 96% forest/wetland, 2.1% pastureland, and <1% urban (NCDWQ 2002). Much of the basin is publicly owned, including portions of Nantahala National Forest, 3,000 acres of Commission lands, and 7,000 acres within NC Gorges State Park. There are a few small reservoirs, include Cashiers Reservoir, Fairfield Reservoir, and Toxaway Reservoir. Many ponds associated with golf courses and second home developments in the Cashiers/Highlands area contribute to habitat fragmentation, temperature pollution and a source of non-native introductions.

There are no impaired waters within the basin (62% fully supporting, 38% not rated) (NCDWQ 2002). Water quality in this basin is excellent in major streams and most small headwater streams. Some small headwater streams are being impacted by runoff from construction in developing areas. Most of the Tugaloo River tributaries in North Carolina are designated Outstanding Resource Waters, including the Chattooga River, Big Creek, and Overflow Creek. The Whitewater River and lower Bear Wallow Creek are designated High Quality Waters in the Seneca River sub-basin.

B. Problems affecting species and habitats:

While much of the basin in North Carolina is in National Forest and State Park lands, development is increasing on private lands. Non-point source problems (primarily erosion and sedimentation) from land clearing, removal of riparian vegetation, and rural roads are potential problems. Numerous small impoundments fragment headwater habitats. All of the major tributaries in North Carolina are upstream from major impoundments in Georgia and South Carolina that isolate them from the rest of the basin. Short reaches of the Horsepasture and Toxoway rivers are impounded just inside the North Carolina border (Lake Jocassee, Duke Power).

[1]There is no political map ('5B.6a') for the Savannah River basin because the basin occupies such a small portion of North Carolina.

Little is known of the extent to which non-native aquatic species have become established in the Savannah basin in North Carolina. Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need) (Potential partners in the Savannah basin include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, Gorges State Park; interstate, intrabasin partners include the South Carolina Department of Natural Resources and the Georgia Department of Natural Resources).

- Review existing data and determine information needs for all taxa.
- Inventory and status surveys per identified needs (especially primary distribution of crayfish and snails).
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Snails – support identification and description of all species in the basin.
- Collect specimens of redhorse suckers for taxonomic study (cooperate with Roanoke College).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Potential partners in North Carolina include: NC Division of Water Quality, NC Department of Transportation, US Forest Service, Gorges State Park; interstate, intrabasin partners include the South Carolina Department of Natural Resources and the Georgia Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
  - Performance of species restoration projects.

- Assess non-native species impacts :
  - Monitor populations of potentially injurious non-native species and impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Savannah River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, US Forest Service, Gorges State Park, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the Savannah River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.6b):
    - o Chattooga River
    - o Toxaway River
    - o Whitewater River
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
  - Coordinate sampling with other resource groups.
  - Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
  - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Savannah basin.

- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, etc.) and processes to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the Federal Energy Regulatory Commission relicensing process and other opportunities to mitigate negative impacts from hydropower development.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
- Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
  - Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

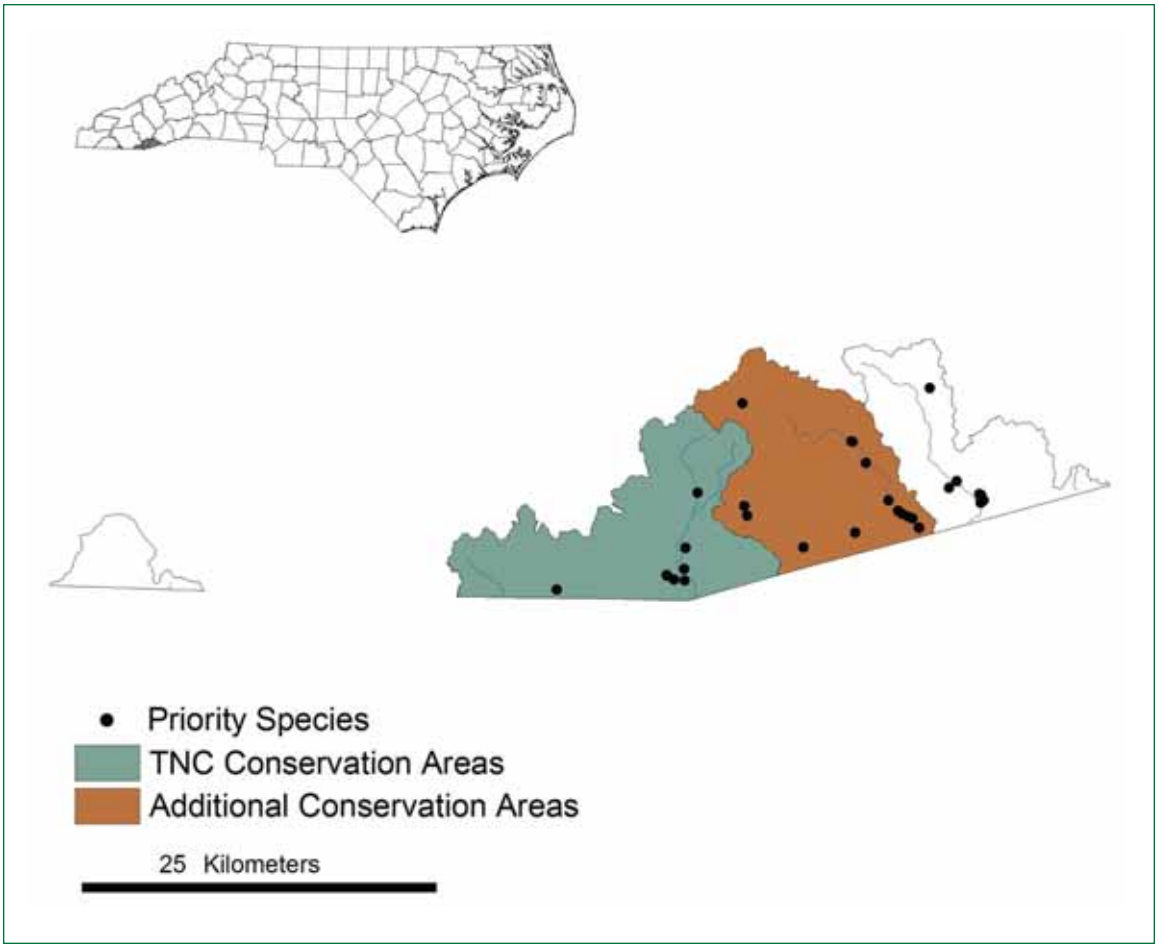
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

N.C. Division of Water Quality (NCDWQ). 2002. Savannah River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.6b. Savannah River basin, priority species occurrences and priority areas for freshwater conservation.

7. Broad River Basin

Priority aquatic species in the Broad River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Ameiurus brunneus*	Snail Bullhead	
	Carpiodes cyprinus	Quillback	
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
Mussels	*Elliptio icterina*	Variable Spike	
	Strophitus undulatus	Creeper (Squawfoot)	T
Crayfish	*Cambarus lenati*	Broad River Stream Crayfish	SR
	Cambarus spicatus	Broad River Spiny Crayfish	SC

A. Location and condition of basin (see Maps 5B.7a, 5B.7b):

Headwaters of the Broad River basin begin along the eastern slopes of the Blue Ridge Mountains (Blue Ridge Physiographic province) and flow southeast through foothills and piedmont (Inner Piedmont physiographic province) before crossing into South Carolina. The Broad River drains to the Atlantic Ocean via the Congaree and Santee Rivers in South Carolina. The basin area in North Carolina is 1,513 sq. miles, with 1,495 stream miles, and 1,954 reservoir acres. The basin primarily drains Polk, Rutherford, and Cleveland counties, with small portions of Henderson, Buncombe, and McDowell counties in the headwaters, and Lincoln and Gaston counties in the lower basin.

Land use in the basin is 74% forested, 22% pastureland, 2% urban (NCDWQ 2003). Land ownership in the Broad river basin is primarily private. Publicly owned lands include South Mountains Game Land (17,000 acres), Green River Game Land (11,000 acres), and a small portion of Crowders Mountain State Park.

The upper Broad River and major tributaries (Green River, Mountain Creek, Whiteoak Creek, and North Pacolet River) begin in the Blue Ridge physiographic province and flow through the foothills. The Second Broad River, First Broad River, Buffalo Creek and the lower Broad River drain the foothills and Inner Piedmont. Overall stream gradient decreases as the topography changes from the mountains of the Blue Ridge to the hills and rolling landscape of the Inner Piedmont. Soils in the piedmont generally contain greater proportions of sand and clay and higher erosion potential than those in the upper portion of the basin. Stream habitats in the lower basin are generally dominated by runs and pools with high proportions of sandy and silty substrates.

Major reservoirs (by tributary) include:

- Green River – Lake Summit and Lake Adger (Northbrook Carolina Hydro)
- Broad River – Lake Lure (Carolina Mountain Power, Town of Lake Lure) and Gaston Shoals (Duke Power)
- First Broad River – Stice Shoals (Northbrook Carolina Hydro)
- Second Broad River – Cliffside (Duke Power), Henrietta, and Caroleen
- Buffalo Creek – Kings Mountain Reservoir
- Britten Creek – Pavillon

Water quality ratings in the basin include 56.5% fully supporting, 0.3% impaired, 1.1% not rated, 42.1% no data (NCDWQ 2003). Overall, water quality is generally good where NC Division of Water Quality data are available; however, there are problems in parts of the basin and the lack of data for nearly half the basin leaves an unclear assessment of overall water quality.

B. *Problems affecting species and habitats:*

Habitat degradation primarily resulting from sedimentation is the main water quality issue in the basin. Stream sedimentation is severe and widespread in the Piedmont portion of the basin. The major causes of sedimentation are land clearing activities (construction, row crop agriculture, timber harvest, and mining), stream bank erosion, and runoff from unpaved rural roads and eroding road grades (NCDWQ 2003). Poorly managed pasture lands contribute substantially to overall soil and stream bank erosion. Often, riparian vegetation is minimal or non-existent and cattle have unlimited direct access to streams. Overall lack of riparian vegetation is a widespread problem throughout the basin.

Hydraulic and hydrologic alterations to streams, through accelerated stream bank erosion and channel instability, also contribute both directly and indirectly to habitat degradation. Streams have been channelized in both rural and developed areas in the basin. Development and urbanization also increase impervious surfaces and often produce drainage patterns and structures that speed the runoff of rainwater and alter hydrograph curves. This hydrologic alteration (flashiness) further accelerates stream bank erosion and channel degradation.

Water quality problems are attributable to both point and non-point sources. Point sources are primarily waste water treatment plants and industrial dischargers. Both municipal waste water treatment plants and industrial sources discharge colored effluents to streams in the basin, especially in the Second Broad River watershed. The impacts of these effluents at permitted levels are generally regarded as minimal, but effects on native aquatic communities from other solutes in these and other discharges are unclear. Problems with meeting permitted discharge limits have occurred at several waste water treatment plants in the basin (NCDWQ 2003). There may also be problems related to unpermitted waste water discharges. Additionally, there are 11 golf courses in the basin that add additional non-point inputs and contribute to overall water quality problems.

There are significant impacts to native aquatic communities in the Broad River basin from impoundments; however, they are not as widespread as in some of the other Western basins (e.g., Hiwassee, Little Tennessee, and Catawba). Lake Lure, Kings Mountain, and Lake Adger impoundments appear to have the greatest impact on aquatic resources. Impacts include thermal and hydrologic alteration to tailwaters, water quality issues due to nonexistent or inadequate minimum flow requirements, direct effects of impoundment, and fragmentation of upstream populations.

Several existing impoundments are used for water supply and new impoundments are being proposed within the basin for the same reason. As human population increases, water supply is an increasing burden on surface waters. Water withdrawals, impoundments, and interbasin water transfers can significantly alter habitats for native aquatic species. This is an emerging problem that will likely increase in importance in the near future.

Non-native species known from the Broad River basin include the Asian clam, common carp, smallmouth bass, muskellunge, and rainbow and brown trout. Some stream fishes found in the headwaters may also be introduced (e.g., warpaint shiner). Landlocked blueback herring and alewife are also present in some reservoirs. Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation and affect aquatic habitats (e.g., hemlock wooly adelgid). Presently, specific impacts from non-native species in the Broad River basin are unclear.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include the NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Elliptio* and *Strophitus* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with the NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin (cooperate with the NC Museum of Natural Sciences).

. **Research to facilitate appropriate conservation actions** – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Research must also be conducted to determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).
- Support research to improve habitat conditions in regulated rivers.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include the: NC Division of Water Quality, NC Department of Transportation, Duke Power, US Fish & Wildlife Service, and the NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
  - Performance of species restoration projects.
- Assess non-native species impacts and monitor populations of potentially injurious non-native species and their impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – (Potential partners in the Broad River Basin include: Upper Broad River Watershed Protection Program, Carolina Mountain Land Conservancy, Foothills Conservancy, Catheys Creek Watershed Technical Advisory Committee, Natural Resources Conservation Service, Ecosystem Enhancement Program, NC Natural Heritage Program, US Forest Service, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the Broad River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.7b):
    - Green River
    - Upper First Broad River
    - Kings Creek (mostly in South Carolina, headwaters in North Carolina)
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions
  - Specific to the Broad River basin: incorporate management goals for aquatic community conservation and enhancement into management plan for Green River Game Lands.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.). Specific basin priorities include updating crayfish and mussel atlases with presently known species occurrence and distributions in the Broad basin.
- Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include the: NC Division of Water Quality, NC Division of Land Quality, US Army Corps of Engineers, Federal Energy Regulatory Commission [FERC], US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the FERC relicensing process and other opportunities to mitigate negative impacts from hydropower development. Support practicable mitigation and restoration for hydropower impacts throughout the Broad River basin.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

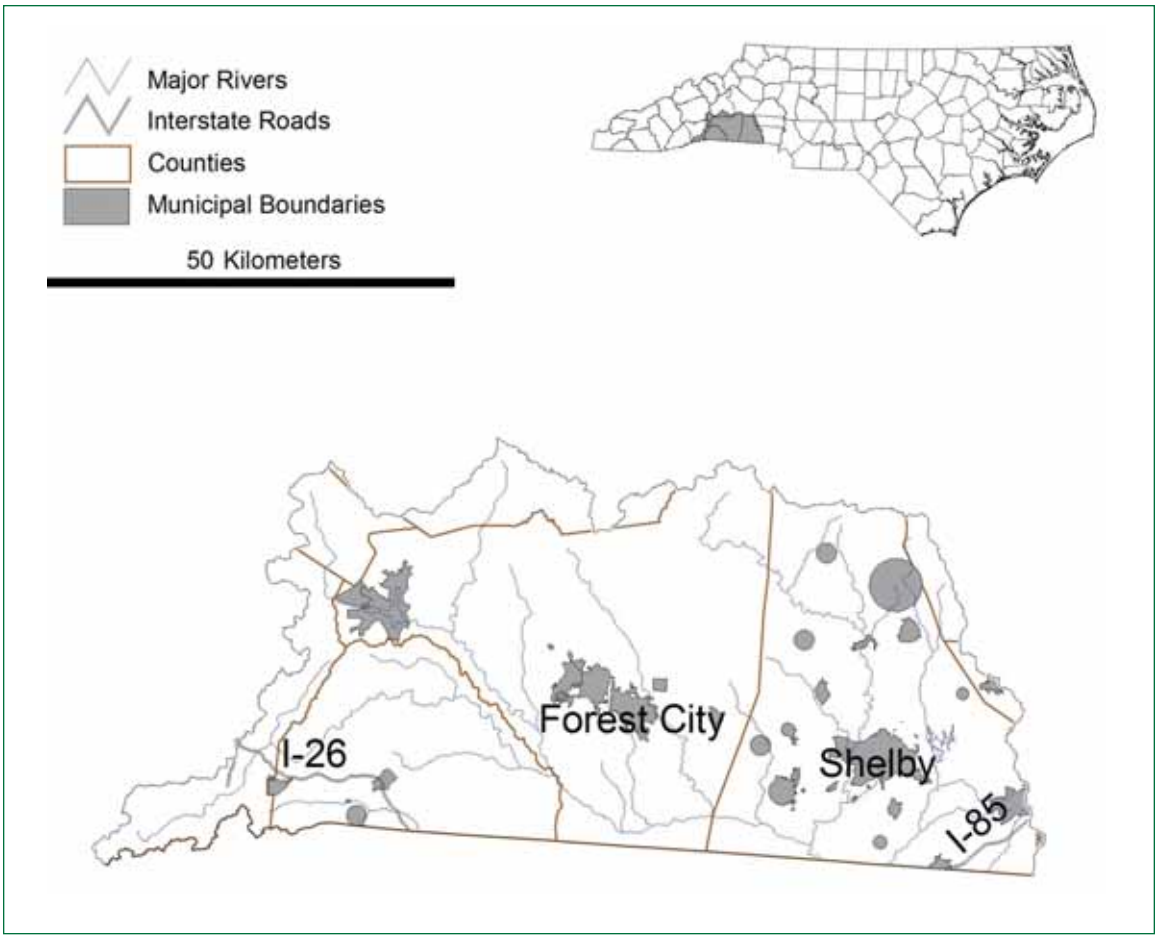
- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

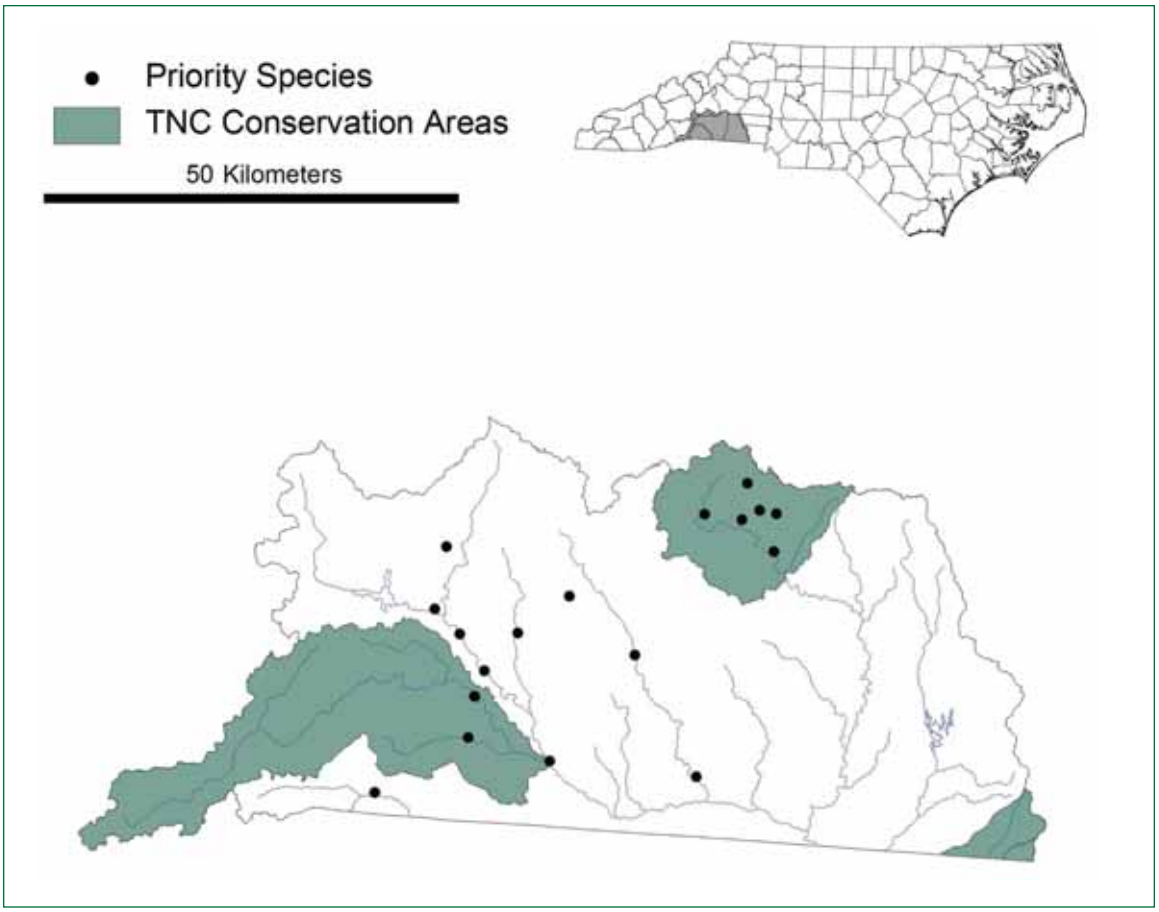
N.C. Division of Water Quality (NCDWQ). 2003. Broad River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.7a. Broad River basin, political information.



Map 5B.7b. Broad River basin, priority species occurrences and priority areas for freshwater conservation.

8. Catawba River Basin

Priority aquatic species in the Catawba River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish[1]	*Ameiurus brunneus*	Snail bullhead	
	Carpiodes cyprinus	Quillback	
	Carpiodes velifer	Highfin Carpsucker	SC
	Etheostoma collis	Carolina Darter	SC
	Lepomis marginatus	Dollar Sunfish	
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
Mussels	*Alasmidonta robusta*	Carolina Elktoe[2]	SR
	Alasmidonta varicosa	Brook Floater	E
	Elliptio cistellaeformis	Box Spike	
	Elliptio icterina	Variable Spike	
	Lasmigona decorata	Carolina Heelsplitter	E (E)
	Villosa constricta	Notched Rainbow	SC
	Villosa delumbis	Eastern Creekshell	SR
	Villosa vaughaniana	Carolina Creekshell	E

A. Location and condition of basin (see Maps 5B.8a, 5B.8b):

The Catawba River basin begins on the eastern slopes of the Blue Ridge (Blue Ridge Physiographic Province) and flows southeast through the Inner Piedmont to the South Carolina border near Charlotte. This system, along with the Broad system, forms the headwaters of the Santee-Cooper River system which flows through South Carolina to the Atlantic Ocean. The basin drains 3,285 sq. miles in primarily Avery, Burke, Caldwell, McDowell, Mecklenburg, Catawba, Caldwell, Alexander, Iredell, Lincoln, and Gaston counties. There are 3,005 stream miles in the North Carolina portion of the basin. There are three major river drainages in the basin:

- **Upper Catawba** – tributaries include Catawba River headwaters, Linville River, North Muddy Creek, Warrior Fork, Johns River, Silver Creek, Lower Creek, Little River, Gunpowder Creek, Muddy Fork, Dutchmans Creek, and Crowders Creek.
- **Lower Catawba** – tributaries include Twelve Mile Creek, Six Mile Creek, Waxhaw Branch, Irwin Creek, McAlpine Creek, and Sugar Creek.
- **South Fork Catawba** – tributaries include Henry Fork, Jacob Fork, Clark Creek, and Long Creek.

The upper Catawba River watershed begins along the eastern slopes of the Blue Ridge and descends into the foothills and Inner Piedmont physiographic province. Overall stream gradient decreases as the topography changes from the mountains of the Blue Ridge to the hills and rolling landscape of the Inner Piedmont. Soils in the Piedmont generally contain greater proportions of sand and clay and higher erosion potential than those in the upper portion of the basin. Stream habitats in the lower basin are generally dominated by runs and pools with high proportions of sandy and silty substrates.

[1] Smallmouth buffalo (Ictiobus bubalus) is a native priority fish species in the French Broad basin, but is a non-native in other basins (Catawba, Yadkin PeeDee, and Neuse). In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion should be initiated.

[2] Taxonomic status is unclear in the basin.

Land use in the basin is 67% forested, 24% pasture/managed herbaceous/cultivated, and 6% urban (NCDWQ 1999). Publicly owned lands in the basin include Pisgah National Forest, four state parks (parks total 17,700 acres), and South Mountains Game Land (20,697 acres). All other lands are privately owned. Land cover shifts from forested areas to agricultural and urban uses as the basin enters the Piedmont from the mountains. The lower Catawba region is highly developed and growing (Charlotte, major metropolitan area). This urban growth has greatly affected the water quality in the basin, along with nutrient enrichment and sedimentation from agricultural operations. Water quality ratings in the basin include 6% impaired, 79% fully supporting, and 15% not rated (NCDWQ 1999).

There are numerous hydropower facilities that impound over 60,000 reservoir acres within the Catawba basin. They include (by stream):

- Catawba River: James, Rhodhiss, Hickory, Lookout Shoals, Norman, Mountain Island, Wylie
- Lower Little River: Brushy Mountain
- South Fork Catawba River: McAdenville, Spencer Mountain, Hardins, High Shoals, and Long Shoals
- Henry Fork: Henry River

There are numerous small, non-hydropower producing dams scattered throughout the basin. Some of the larger of these dams include (by stream):

- Buck Creek: Lake Tahoma
- Linville River: Loch Dornie and Land Harbor
- Laurel Branch: Blue Ridge Country Club irrigation intake
- Killian Creek: Duke Power combustion turbine station
- Long Creek: Bessemer City intake

B. *Problems affecting species and habitats:*

Impoundment is a major factor in the loss and degradation of habitat for priority aquatic species in the Catawba basin. All but the upper headwater reaches of the Catawba River (upstream from Lake James) are either impounded or regulated by hydropower projects (Duke Energy). Cold water releases degrade the Lake James tailwater for many native species and it is presently managed as a stocked trout fishery. Migration of anadromous and potadramous fishes are severely limited, if not altogether prevented by dams. The few remaining free-flowing, cool-warm water high quality habitats in larger tributary streams are isolated and fragmented by the impoundment effects on the mainstem Catawba River. The impacts of this habitat fragmentation on priority species populations in not entirely clear; however, some impacts are evident. Habitats may be recovering in some streams where species were extirpated by past habitat loss. Potential recolonization of these recovering habitats may be impossible due to barriers created by dams, impoundments, and/or intervening habitat made unsuitable by other factors.

With the exception of streams located on public lands, streams within the basin are degraded or threatened by a number of factors, including sedimentation, loss of riparian woody vegetation, water withdrawls, channelization and/or relocation, point source pollution, and nutrient loading. Ground disturbance from development activities and agriculture are the primary sources of erosion, sedimentation, and nutrient enrichment. Point sources of pollution include waste water treatment plants and permitted industrial dischargers (much of the basin flows through highly urbanized areas). Alterations to stream channels, increased impervious surfaces (resulting in increased flashiness), and loss of riparian vegetation contribute to stream channel and bank erosion, which in turn contribute to sedimentation and other physical habitat degradation.

Several existing impoundments are used for water supply and new impoundments are being proposed within the basin for the same reason. As human population increases, water supply is an increasing burden on surface waters. Water withdrawals, impoundments, and interbasin water transfers can significantly alter habitats for native aquatic species. This is an emerging problem that will likely increase in importance in the near future.

Non-native species known from the basin include Asian clams, grass carp, blue, channel, and flathead catfishes, smallmouth bass, muskellunge, white bass, yellow bass, and rainbow and brown trout. Land-locked blueback herring, alewife, and white perch are known from several impoundments (in fact, over 33 exotic fish species have been identified in the basin, Bryn Tracy, pers. comm.). Non-native vegetation can also negatively impact native aquatic animal communities. This includes both aquatic and riparian plant species and non-native plant pathogens that can alter riparian vegetation (e.g., hemlock wooly adelgid). Non-native aquatic plants are also present in the Catawba basin and are a known nuisance, especially in reservoirs. Specific impacts in the Catawba basin from these and other introduced species are unclear.

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for aquatic snails, crayfish, mussels, and fish (in order of general need). (Cooperators in North Carolina include the NC Division of Water Quality, NC Department of Transportation, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Snails – inventory primary distribution; determine potential habitats and distribution surveys for hydrobiids.
- Crayfish – complete primary inventories and determine status of endemic species.
- Determine distribution of non-native species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Mussels in the genera *Alasmidonta*, *Elliptio* and *Strophitus* – support resolution of taxonomic problems and species descriptions (if required) (cooperate with the NC Museum of Natural Sciences, NC State University).
- Crayfish – support description and species diagnosis of all crayfish species in the basin – (cooperate with the NC Museum of Natural Sciences).

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, population genetics, feeding, competition, predation. Determine vulnerability of priority species to specific threats, particularly as related to our permit review and conditions responsibilities. Studies should provide recommendations for mitigation and restoration.

- Review available information and support life history investigations where lacking.
- Support investigations into impacts from habitat fragmentation in the basin (due to impoundments or other factors).
- Support investigations of population response to stream restoration projects (especially in priority areas).
- Support research to improve habitat conditions in regulated rivers.
- Support investigations into specific water and habitat quality impacts that limit populations of priority species throughout the basin.

- Investigate habitat requirements of mussel species and assess potential for reintroduction in recovering habitats (e.g., Jacobs Fork, Henry Fork, Catawba River-Lake James tailwater).
- Support life history research aimed at development of propagation techniques for priority mussel species (cooperate with NC State University).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible. (Cooperators in North Carolina include the: NC Division of Water Quality, NC Department of Transportation, South Mountains State Park, US Forest Service, US Fish & Wildlife Service, NC Museum of Natural Sciences; an interstate, intrabasin cooperator is the South Carolina Department of Natural Resources).

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring.
  - Basin specific priorities include the Carolina heelsplitter, brook floater, Carolina creekshell, notched rainbow.
- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
  - Performance of species restoration projects.
- Assess non-native species impacts. Monitor populations of potentially injurious non-native species and impacts on priority species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat conservation and restoration efforts by external entities. (Potential partners in the Catawba River Basin include: Natural Resources Conservation Service, Ecosystem Enhancement Program, NC Natural Heritage Program, US Forest Service, Duke Power, Crescent Lands, Carolina Mountain Land Conservancy, Foothills Conservancy, Bi-state Catawba River Task Force, South Mountains State Park, Lake James State Park, county-based soil and erosion control efforts, and private landowners).

- Identify priority areas for habitat conservation and restoration. Criteria include areas with high species diversity, rare species, and endemic species; specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites); and areas recognized by previous national and/or regional prioritization efforts.
  - Priority watersheds for freshwater conservation in the Broad River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.7b):
    - Johns River
    - Warrior Fork
    - Linville River
    - Waxhaw Creek
    - South Fork Catawba River headwaters
      - Jacob Fork
      - Henry Fork
    - Long Creek
    - Sixmile Creek
- Support conservation and restoration of streams and riparian zones in priority areas (acquisition, easements, and buffers). Support stream conservation and restoration by working collaboratively with other organizations.

- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions
  - Support efforts to acquire Game Lands in Johns River watershed.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.
- Investigate potential and seek opportunities for reintroduction of common mussel species to portions of Jacobs and Henry Forks.
- Support development of propagation techniques and production capacity for augmentation and reintroduction of priority mollusk species.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources. Improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.). Specific basin priorities include updating crayfish and mussel atlases with presently known species occurrence and distributions in the Broad basin.
  - Update crayfish and mussel atlases with presently known species occurrence and distributions in the Catawba basin.
  - Compile and post species accounts to fish atlas for state listed fishes from the Catawba basin.
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and the US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, and the US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.
  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
- Work through the Federal Energy Regulatory Commission (FERC) relicensing process and other opportunities to mitigate negative impacts from hydropower development. Specific basin priorities include:
  - Cooperate with Duke Energy, FERC, and resource agency cooperators during current hydropower relicensing process.
    - o Support habitat improvements for native species in the Lake James tailwaters.
    - o Support assessment of potential impacts to priority species from habitat fragmentation.
    - o Support practicable mitigation and restoration for hydropower impacts throughout the Catawba basin.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
  - Cooperate with US Fish & Wildlife Service to evaluate status of brook floater.
  - Assess other species in the Catawba basin for recommendation for state listing.
- Improve coordination with the US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery. Activities that are applicable to goals and objectives of recovery plans should be tracked and recovery plans should be updated and revised as necessary.
- Coordinate with US Fish & Wildlife Service to plan and align activities for federal Candidate species and Species of Concern with specific information or management needs.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

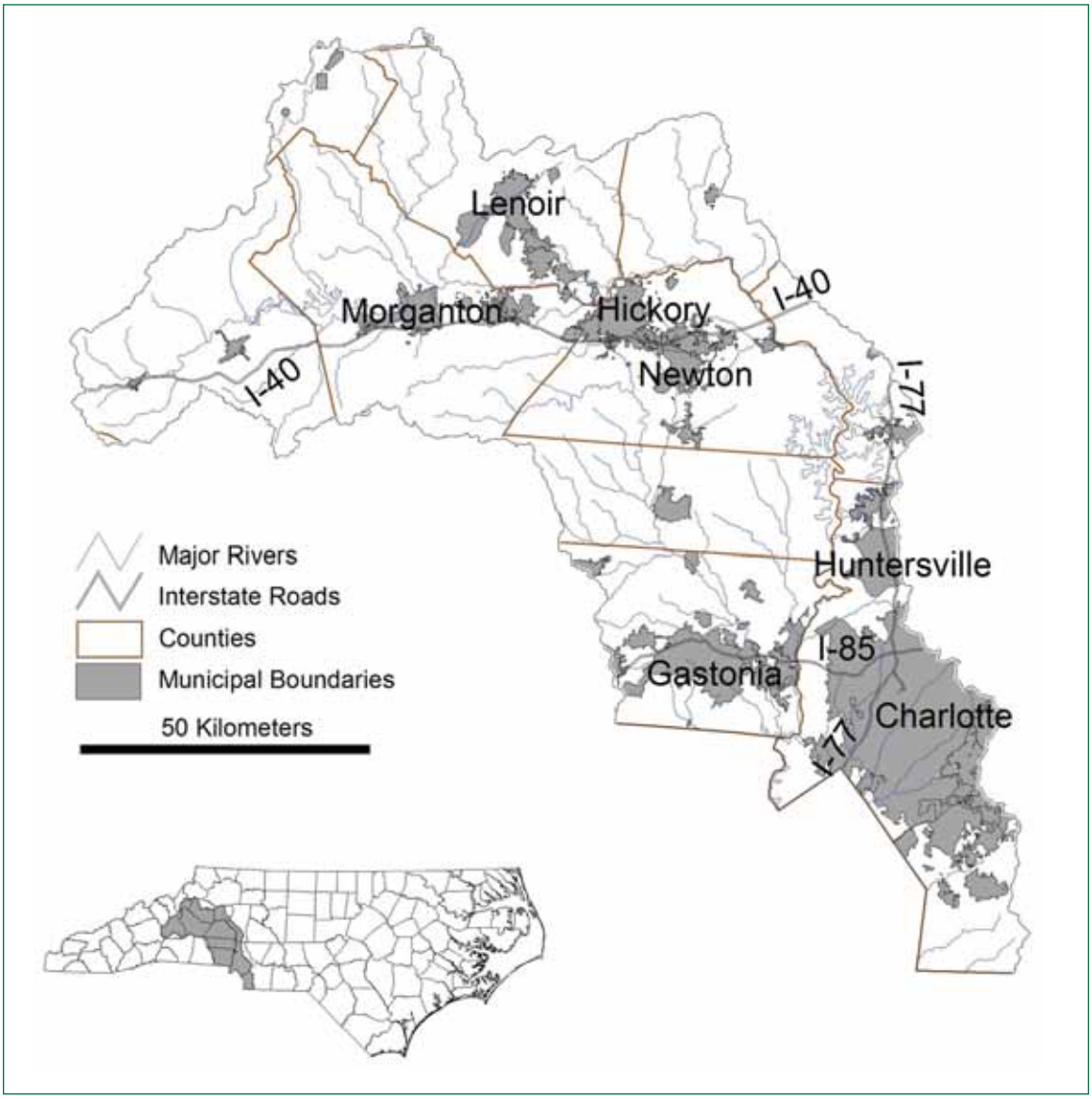
Supporting References

Besler, D.A., L.G. Dorsey, K.B. Hodges, K.J. Hining, W.E. Taylor, R.J. Brown, M.G. Martin. 2003. Fisheries and wildlife management plan for the Catawba River Basin. N.C. Wildlife Resources Commission, Raleigh, NC.

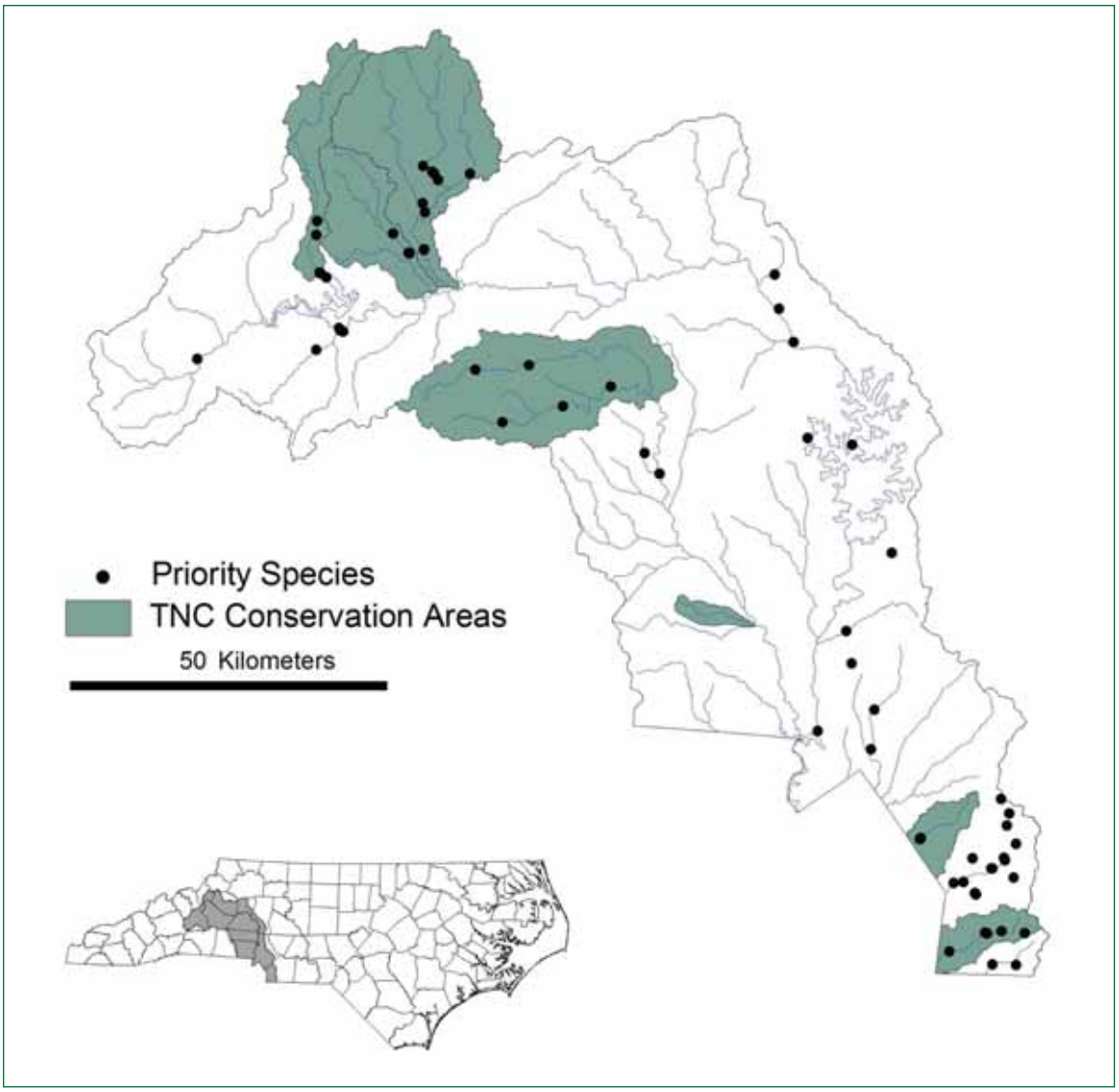
N.C. Division of Water Quality (NCDWQ). 1999. Catawba River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.



Map 5B.8a. Catawba River basin, political information.



Map 5B.8b. Catawba River basin, priority species occurrences and priority areas for freshwater conservation.

9. Yadkin-Pee Dee River Basin

Priority aquatic species in the Yadkin-Pee Dee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser brevirostrum*	Shortnose Sturgeon	E (E)
	Ameiurus brunneus	Snail Bullhead	
	Carpiodes cyprinus[1]	Quillback	
	Carpiodes velifer[1]	Highfin Carpsucker	SC
	Cyprinella sp. (cf. zanema)	Thinlip Chub	
	Etheostoma collis	Carolina Darter	SC
	Fundulus lineolatus	Lined Topminnow	
	Lepomis marginatus	Dollar Sunfish	
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Moxostoma robustum	Robust Redhorse	SR
	Moxostoma sp 2	Carolina Redhorse	SR
	Notropis maculatus	Taillight Shiner	
	Semotilus lumbee	Sandhills Chub	SC
Mussels	*Alasmidonta robusta*[2]	Carolina Elktoe	SR
	Alasmidonta undulata	Triangle Floater	T
	Alasmidonta varicosa	Brook Floater	E
	Anodonta implicata	Alewife Floater	T
	Elliptio cistellaeformis	Box Spike	
	Elliptio congaraea	Carolina Slabshell	
	Elliptio folliculata	Pod Lance	SC
	Elliptio icterina	Variable Spike	
	Elliptio roanokensis	Roanoke Slabshell	T
	Fusconaia masoni	Atlantic Pigtoe	E
	Lampsilis radiata conspicua	Carolina Fatmucket	T
	Lampsilis radiata radiata	Eastern Lampmussel	T
	Lasmigona decorata	Carolina Heelsplitter	E (E)
	Ligumia nasuta	Eastern Pondmussel	T
	Strophitus undulatus	Creeper	T
	Toxolasma pullus	Savannah Lilliput	E
	Villosa constricta	Notched Rainbow	SC
	Villosa delumbis	Eastern Creekshell	SR
	Villosa vaughaniana	Carolina Creekshell	E
Crayfish	*Cambarus catagius*	Greensboro Burrowing Crayfish	SC

[1] Smallmouth buffalo (*Ictiobus bubalus*) is a native priority fish species in the French Broad basin, but is a non-native in the Catawba, Yadkin-Pee Dee, and Neuse basins. Brook silverside (*Labidesthes sicculus*) is a native priority fish species in the Little Tennessee basin, but is a non-native in the Yadkin-Pee Dee and Lumber basins. Comely shiner (Notropis amoenus) is a native priority fish species in the Roanoke, Cape Fear, Neuse, Tar-Pamlico, and Chowan basins, but is a non-native in the Yadkin-PeeDee basin. In non-native basins, these species are not a priority for conservation. Rather, monitoring and possible control of range expansion of the species should be initiated. It is unclear whether the Quillback (*Carpiodes cyprinus*) and highfin carpsucker (*Carpiodes velifer*) are native or introduced.

[2] Status in basin unknown; possibly extirpated.

A. *Location and condition of basin (see Maps 5B.9a, 5B.9b):*

In North Carolina, the majority of the Yadkin-Pee Dee River basin is located within the Piedmont physiographic province. The headwaters, which are partially in the Blue Ridge physiographic region, are located in northwestern North Carolina and extreme southern Virginia. Water flows southeast across the Piedmont and through North Carolina's densely populated midsection, then moves through a portion of the Coastal plain before entering South Carolina and ultimately entering the Atlantic Ocean at Winyah Bay, South Carolina. The North Carolina portion of the Yadkin-Pee Dee River drains an area of about 7,221 sq. miles, with 5,862 stream miles and 22,988 lake acres (NCDWQ 2003).

There are eight impoundments on the main stem of the Yadkin River (W. Kerr Scott Reservoir, Idols Dam, High Rock Lake, Tuckertown Reservoir, Badin Lake, Falls Reservoir, Lake Tillery, and Blewett Falls Lake), plus many smaller reservoirs on tributaries. At the confluence with the Uwharrie River the Yadkin River is then called the Pee Dee River. Major tributaries in the Yadkin-Pee Dee basin are South Yadkin, Uwharrie River, and Rocky River. Land use in the basin is 50% forested, 30% agricultural, and about 13% developed. There has been a significant increase in the amount of urban/built-up area in recent years. National Resources Inventory data indicate that from 1982–1997 the urban/built-up land use category increased 226,500 acres (NRCS 2001). Ninety-three municipalities are completely or partially located within the Yadkin-Pee Dee River basin. The estimated 2000 population was 1,463,535 (163 persons per sq. mile); the basin population is projected to increase 36 % to about 2 million people by 2020 (NCDWQ 2003). The largest population increases are projected for Union, Mecklenburg, Cabarrus, and Iredell Counties.

Public lands make up less than 5% of the Yadkin-Pee Dee basin. Impaired (303 d list) streams in this drainage total 490.7 miles (NCDWQ 2003). There are 57 stream reaches that have a NC Division of Water Quality Outstanding Resource Waters (ORW) classification and 111 stream reaches that have High Quality Waters (HQW) classification (NCDWQ 2003).

B. *Problems affecting species and habitats:*

Our knowledge of aquatic species distribution is inadequate and general surveys are needed in most of the Yadkin-Pee Dee River basin (especially the upper half). We have a poor understanding of life history and habitat use for many species which is critical for managing these populations. It is difficult to monitor known populations of rare species at regular intervals which is needed to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species have become established in the Yadkin-Pee Dee River basin, with potential to negatively impact native species populations (Fuller et al. 1999).

The Yadkin-Pee Dee River basin has numerous problems affecting both species and their habitats. There is a significant loss of riverine habitat in this basin due to eight mainstem dams and the numerous impoundments on tributaries (hydroelectric plants, water supply lakes, and mill dams). Additional consequences of these impoundments include: an unnatural flow regime in riverine sections, migration routes are blocked for diadromous species as well as resident species, and recolonization and/or dispersal potential is significantly reduced. Streams are being impacted by excessive sedimentation and changes in hydrology and geomorphology (all due to urban development, agriculture, and instream mining; Williams et al. 1993, Etnier 1997, Neves et al. 1997, Warren et al. 2000). Water quality is also degraded by excessive nutrient input and other chemicals (waste water treatment plants, industry, agriculture, and hog/chicken farms; NCDWQ 2003). In the Yadkin-Pee Dee River basin there are 240 permitted discharges (36 of which are major discharges with ≥ 1 million gallons per day; NCDWQ 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for fish, mussels, crayfish, and aquatic snails. Areas where distributional surveys should be focused can be identified using the Commission aquatic nongame database and NC Natural Heritage Program data. For example, there are very few survey records in the upper half of the Yadkin-Pee Dee River basin (Yadkin, Wilkes, Surry, Caldwell, and Forsyth counties).

- Support work to confirm the distribution of the Carolina elktoe in the basin.
- Survey for other high priority mussel species in the Yadkin-PeeDee basin.

. **Taxonomic resolution: support species descriptions and diagnoses** – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio* and the Carolina elktoe (cooperate with NC Museum of Natural Sciences, NC State University).
- Support completion of species descriptions for undescribed taxa (e.g., Carolina redhorse and thinlip chub).

. **Research to facilitate appropriate conservation actions** – Research should focus on the life history studies of priority species. Specific questions to be addressed include: habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation.

- Determine vulnerability of priority species to guide permit regulations (moratoria).
- Determine how priority species are impacted by mainstem and tributary dams (habitat fragmentation). Studies should provide recommendations for mitigation and restoration.
- Study the potential effects of non-native species on native species

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol and schedule for long-term monitoring of priority species (collaborate with the NC Division of Water Quality, NC Museum of Natural Science, and US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of hydropower remediation.
  - Performance of species restoration projects.
- Assess non-native species impacts:
  - Determine the distribution of exotics (red shiner, flathead catfish, and others) in the Yadkin-Pee Dee basin and how are they effecting native species.

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection and stream restoration (acquisition, easements, and buffers)

- Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, Natural Resources Conservation Service, The Nature Conservancy, other non governmental organizations, and the US Forest Service (Uwharrie National Forest).
- Support dam removal (work with US Fish & Wildlife Service and other interested non governmental organizations).
- Negotiate a more natural flow regime in the main stem during the Federal Energy Regulatory Commission (FERC) relicensing process and support mitigation and restoration for hydropower impacts.
- Identify priority areas for habitat protection by locating areas with high species diversity, rare species, and endemic species. Identify specific areas that are critical to the survival of priority species (e.g., particular streams or spawning sites), including the robust redhorse, Carolina redhorse, brook floater, Carolina creekshell.
  - Priority watersheds for freshwater conservation in the Yadkin-Pee Dee basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.9b):
    - Roaring River
    - Mitchell River
    - The upper Yadkin (east of Elkin downstream to Winston-Salem)
    - Uwharrie River
    - Dutch Buffalo Creek
    - Goose Creek
    - Crooked Creek
    - Coddle Creek
    - Clarke Creek
    - Back/Reedy Creeks
    - Big Bear Creek
    - Island Creek
    - Long Creek
    - Richardson Creek
    - Lower Rocky River
    - Brown Creek
    - Little River
    - Mountain Creek
    - Lanes Creek
    - Lower Pee Dee River (riverine section below Tillery Dam, and downstream of Blewett Falls Dam)
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them (e.g., brook floater).
- Continue mussel relocation project (restore common species to recovering habitats in the Piedmont).

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Coordinate sampling with other resource groups.
- Continue work with the Robust Redhorse Conservation Committee.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, FERC, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, FERC, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Promote programs that help farmers reduce sedimentation and erosion (install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
  - Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
  - Protect existing good water and habitat quality throughout the basin (ORW and HQW streams).
  - Promote programs to upgrade hog and chicken farms waste treatment.
  - Work through the Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (partners include NC Division of Water Quality, NC Natural Heritage Program, and US Fish & Wildlife Service).

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Work with county and city officials and developers to incorporate buffers along streams, to implement low impact development, and to develop better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Work with hydropower producers to develop programs to minimize their impacts.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Support listing process and update recovery plans for listed species (e.g., Carolina heelsplitter).
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Etnier, D. A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pages 87-104 in G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special publication 1, Southeast Aquatic Research Institute, Decatur, GA.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Natural Resources Conservation Service (NRCS). 2001. 1997 National Resources Inventory, updated June 2001. U.S. Department of Agriculture, North Carolina State Office, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2003. Yadkin-PeeDee River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2004. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

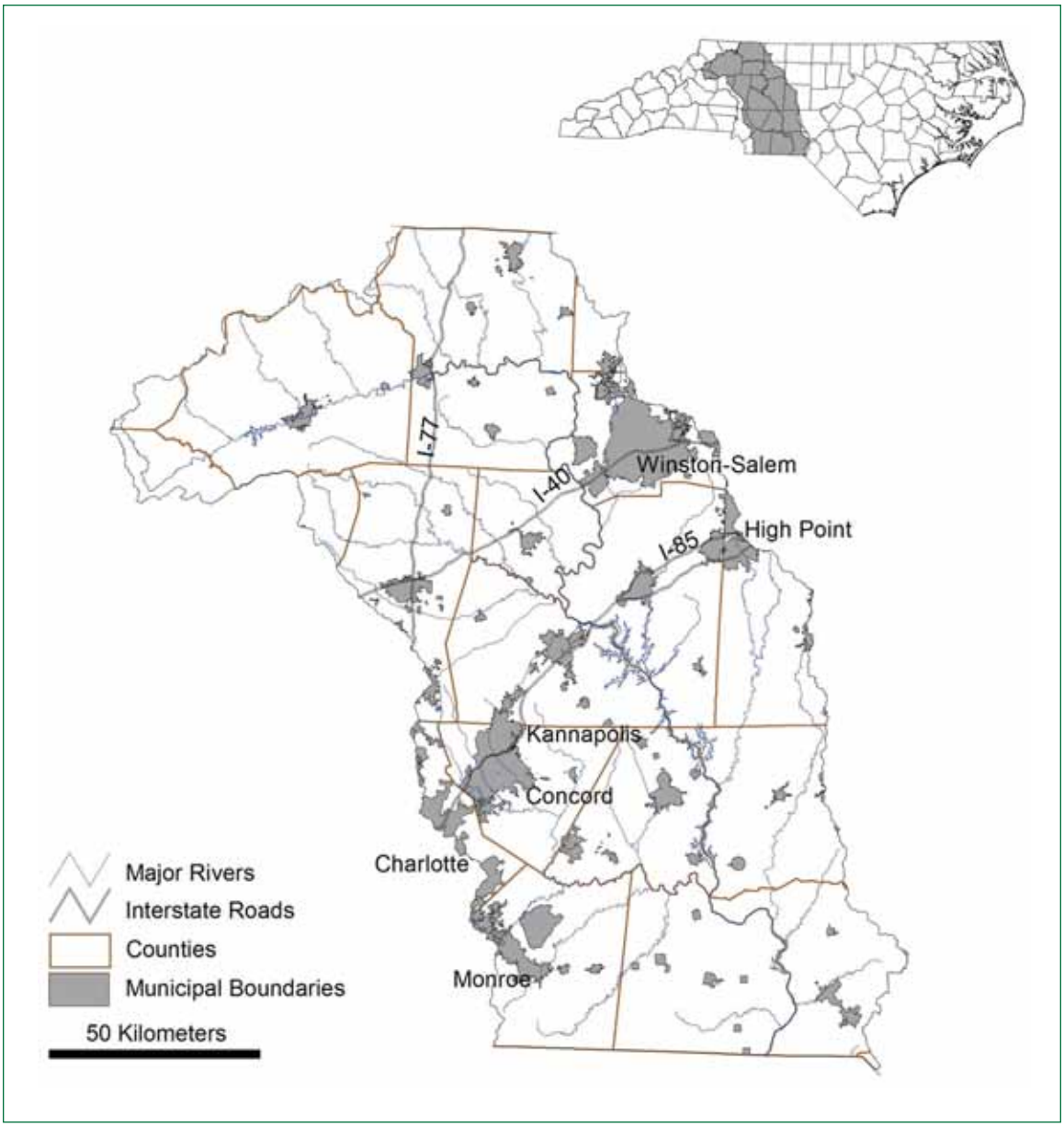
N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Neves R. J., A. E. Bogan, J. D. Williams, S. A. Ahlstedt, and P. W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pages 43–86 in G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special publication 1, Southeast Aquatic Research Institute, Decatur, GA.

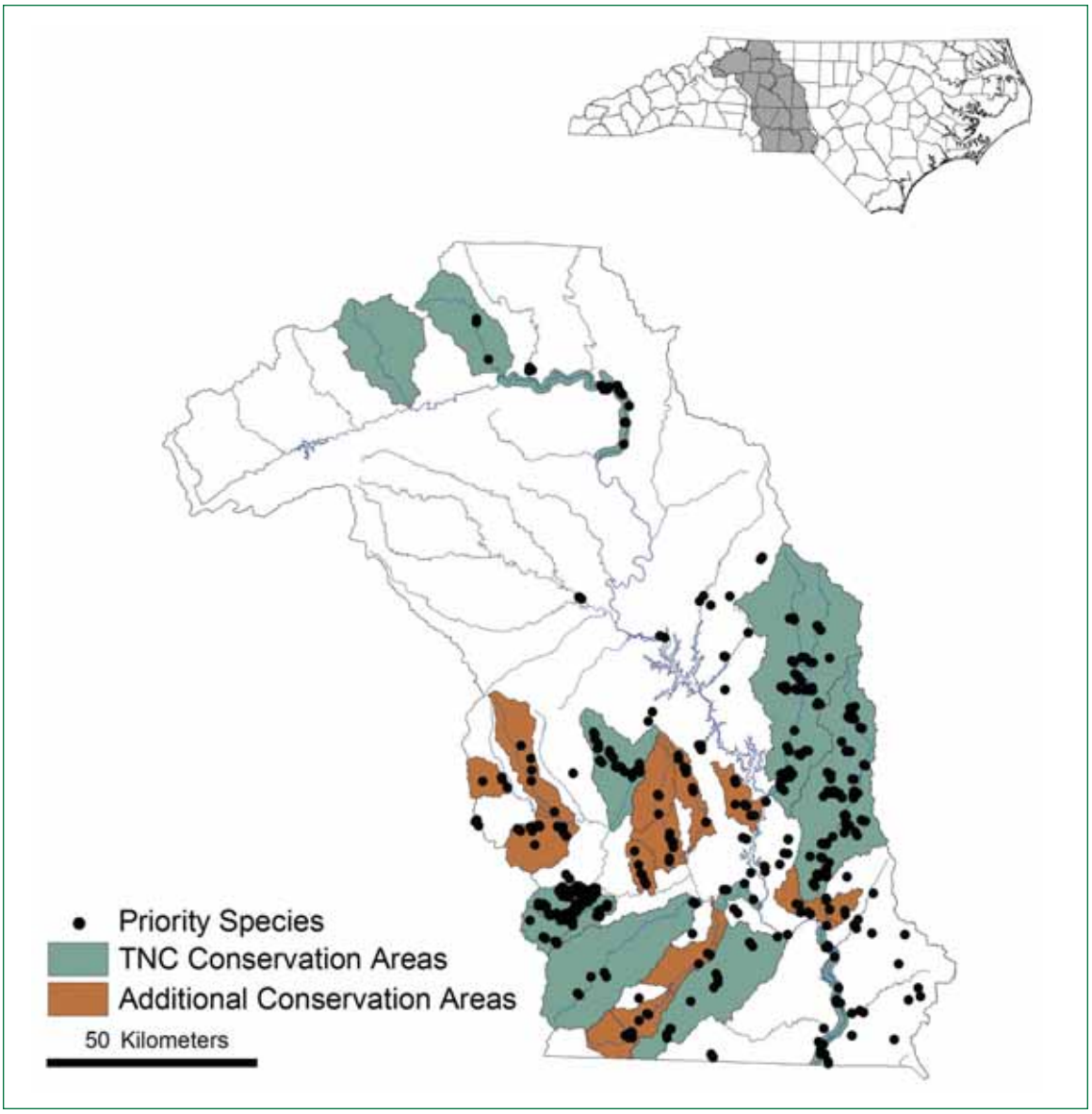
Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25:7–31.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18:6–22.



Map 5B.9a. Yadkin-PeeDee River basin, political information.



Map 5B.9b. Yadkin-PeeDee River basin, priority species occurrences and priority areas for freshwater conservation.

10. Roanoke River Basin

Priority aquatic species in the Roanoke River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser oxyrhynchus*	Atlantic Sturgeon	SC
	Ameiurus brunneus	Snail Bullhead	
	Carpiodes cyprinus	Quillback	
	Cottus caeruleomentum	Blue Ridge Sculpin	SR
	Elassoma zonatum	Banded Pygmy Sunfish	
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Etheostoma collis	Carolina Darter	SC
	Etheostoma nigrum	Johnny Darter	
	Etheostoma podostemone	Riverweed Darter	SC
	Etheostoma vitreum	Glassy Darter	
	Exoglossum maxillangua	Cutlip Minnow	E
	Fundulus diaphanus	Banded Killifish	
	Fundulus lineolatus	Lined Topminnow	
	Hypentelium roanokense	Roanoke Hog Sucker	SR
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Notropis amoenus	Comely Shiner	
	Notropis chalybaeus	Ironcolor Shiner	
	Noturus gilberti	Orangefin Madtom	E
	Scartomyzon ariommus	Bigeye Jumprock	T
	Thoburnia hamiltoni	Rustyside Sucker	E
Mussels	*Alasmidonta undulata*	Triangle Floater	T
	Alasmidonta varicosa	Brook Floater	E
	Anodonta implicata	Alewife Floater	T
	Elliptio icterina	Variable Spike	
	Elliptio roanokensis	Roanoke Slabshell	T
	Fusconaia masoni	Atlantic Pigtoe	E
	Lasmigona subviridis	Green Floater	E
	Leptodea ochracea	Tidewater Mucket	T
	Ligumia nasuta	Eastern Pondmussel	T
	Pleurobema collina	James Spinymussel	E (E)
	Strophitus undulatus	Creeper (Squawfoot)	T
	Villosa constricta	Notched Rainbow	SC
Crayfish	*Orconectes virginiensis*	Chowanoke Crayfish	SC

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.10a, 5B.10b):

The Roanoke River basin is an Atlantic Slope basin with its headwaters located in the Blue Ridge Mountains of Virginia. Approximately 64% of the basin is in Virginia. The basin is the sixth largest in North Carolina and has an area of 3,503 sq. miles within the state (the entire basin is approximately 9,766 sq. miles), draining 2,213 miles of North Carolina streams. The Roanoke River carries more water and has the widest floodplain (up to 5 miles wide in parts) of any North Carolina river. There are 10 subbasins in the Roanoke River basin. Major tributaries to the Roanoke River include the Dan River, Mayo River, Smith River, Country Line Creek, Hyco Creek/River, Cashie River, and Conoho Creek (NCDWQ 2001).

The North Carolina portion has two distinct parts: the western section in the Piedmont physiographic region (87% of the North Carolina basin, above Roanoke Rapids Dam), and the eastern section in the Coastal Plain physiographic region (13% of basin, below Roanoke Rapids Dam), which is heavily used by anadromous fishes. The upper Dan River area in western North Carolina shows characteristics of both the Southern Blue Ridge and Piedmont physiographic regions. The fairly steep topography of headwater areas of most tributaries has allowed them to remain forested whereas many downstream sections are farmed (NCDWQ 2001). The Piedmont physiographic region features rolling hills and is underlain with crystalline or sedimentary rocks. Many tributary streams in the Piedmont have large sediment bedloads. The transition zone between the Piedmont and Coastal Plain occurs below Roanoke Rapids Lake with the lower 60 miles of river part of the Coastal Plain. The river terminates at Albemarle Sound, which is the second largest estuary system (Albemarle-Pamlico) in the United States (NCDWQ 2001). The Coastal Plain portion features a flat topography and is underlain by sand, silt, clay, and limestone. Tobacco, peanuts, cotton and soybeans are among the most common crops grown in the basin (NCDENR 2003).

The Coastal Plain is divided into two geographic regions by the Suffolk Scarp, which is a fossil barrier island sand ridge formed as an ocean shoreline during the previous interglacial period when sea level was higher than present. Areas west of the Suffolk Scarp feature higher elevations, slightly rolling topography, and moderately well-drained soils with sandy texture. East of the Suffolk Scarp, elevations range from 15-20 feet above sea level with gently sloping land surface. Swamps in this area have poorly drained soils organic peat, whereas non-swamp areas have fine-grained sandy soils with high organic and clay content (Rulifson and Manooch 1993).

There are 41 municipalities within the basin. The most populated areas are located northeast of the Greensboro/Winston-Salem/High Point area and around the larger municipalities in the basin such as Roanoke Rapids, Eden, Williamston and Plymouth. According to 2000 census data, the population within the basin is 335,194. Land use in the basin is 17.0% cultivated cropland, 2.1% uncultivated cropland, 3.9% pasture, 61.5% forested, 6.1% urban, 0.9% Federal, and 8.5% other (rural transportation, small water areas, census water, minor land; NCDWQ 2001).

Several tributaries within the basin have been identified as High Quality Waters by the NC Division of Water Quality. Portions of Cascade and Indian Creeks (Hanging Rock State Park) are designated as Outstanding Resource Waters due to excellent water quality and rare aquatic species. Areas within the basin identified by the NC Natural Heritage Program with significant biological diversity include the following: Hanging Rock State Park, Dan River aquatic habitat, Mayo River aquatic habitat, Caswell Game Lands, Country Line Creek aquatic habitat, Aaron's Creek aquatic habitat, Occoneechee Neck Floodplain Forest, Buzzard Point/Ventosa Plantation, Broadneck Swamp, Conoho Neck Swamp, Devil's Gut, Broad Neck Creek, Roanoke River delta islands, and Roquist Pocosin (NCDWQ 2001). The Roanoke River in the Coastal Plain is bordered by extensive floodplain forests. The Nature Conservancy has identified these high quality alluvial bottomland hardwood forests as the largest intact and least disturbed ecosystem of this type in the mid-Atlantic region. Federal and State lands within the basin include the 51,321 acre Roanoke River National Wildlife Refuge located near Albemarle Sound, Hanging Rock State Park, Kerr Lake State Recreation Area, and Morningstar Wildlife Refuge (NCDENR 2003).

There are 11 major reservoirs along the North Carolina portion of the Roanoke River; most are in the upper basin on tributaries of the Dan and Roanoke Rivers. There are three major reservoirs which regulate flow on the Roanoke River main channel: Kerr, Gaston, and Roanoke Rapids. These three reservoirs impound 82 miles of Roanoke River between South Boston, Virginia and Roanoke Rapids, North Carolina. Other reservoirs in the basin include Hanging Rock Lake, Kernersville Reservoir, Belews Lake, Farmer Lake, Hyco Lake, Lake Roxboro, Roxboro City Lake (Water Works Lake), and Mayo Reservoir (NCDWQ 2001).

There are 263.2 miles of impaired streams in the Roanoke River basin from the following locations: Cashie River (54.6), Welch Creek (13.3), Roanoke River (138.7), Quankey Creek (3.4), Smith Creek (10.4), Nutbush Creek (4.6), Marlowe Creek (10.9), Smith River (5.1), Dan River (14.2), Town Fork Creek (8.0) (NCDWQ 2004).

B. *Problems affecting species and habitats:*

Destruction of aquatic habitat appears to be the largest water quality issue in the basin (NCDENR 2003). Sedimentation caused by agriculture, forestry, and construction has degraded water and habitat quality. Dioxin, selenium (from historic discharge from ash pond basins), and mercury levels have resulted in fish consumption advisories. According to 1998 USDA data, the Roanoke basin is responsible for 2% of the swine, 3% of the dairy, and 2% of the poultry in North Carolina (NCDWQ 2001).

Demand for water is becoming a contentious issue in the Roanoke basin. In 1997, 43 public water systems served 114,000 consumers in the basin. Demand for water is expected to increase as much as 55% by 2020. As of 2000, there were 26 registered water withdrawals allowed in the basin (NCDWQ 2001). The Roanoke basin is viewed as a potential source of water by those living outside the basin. For example, the city of Virginia Beach withdraws up to 60 million gallons/day from Lake Gaston (NCDENR 2003). Current and future water withdrawals have the potential to reduce flows to the lower Roanoke River and, hence, increase downstream salinity levels. Although there are no current certified interbasin transfers in the Roanoke River basin, future transfers from Roanoke to Tar-Pamlico are expected to occur (NCDWQ 2001).

Several development-related issues affect the Roanoke River basin. In addition to nonpoint source pollution, point source pollution (municipal waste water treatment plants, selenium ash pond discharge, industrial facilities, small package treatment plants, urban and industrial storm-water systems) can degrade aquatic habitats. Waste water treatment plants can cause elevated nitrogen, phosphorus, copper, and fecal coliform levels. Waste water discharges have led to elevated ammonia nitrogen (NH3) concentrations at San Souci. Stokes and Granville counties are the fastest growing counties in the basin and are expected to grow 20–30% by 2018 (NCDWQ 2001). Growth in these areas will affect land use, cover, and water quality.

Amount and timing of water releases from dams, particularly along the Roanoke River, can alter downstream aquatic and riparian flora and fauna. Many species in these areas have adapted to seasonal flooding, which has changed over time. There will be a continuing need to balance water releases to meet human and aquatic ecosystem needs (NCDENR 2003). For example, striped bass, hickory shad, American shad, and sturgeon have declined from these downstream areas compared to historic levels. Low dissolved oxygen concentrations also present a problem for the lower mainstem Roanoke River. The frequency of low dissolved oxygen events increases with distance from the Roanoke Rapids dam and usually occurs in late spring, summer, and early fall (Mulligan 1991). Over a three-year monitoring period, the month during which daily mean dissolved oxygen was most likely to be less than the standard of 5 mg/l was June, and this is typically the month when higher spawning-enhancement flows are stepped down to lower, summer load-following flows (Bales and Walters 2003). It is likely that this change in flow regime and the associated draining of the backswamps is at least partially responsible for the increased frequency of low dissolved oxygen in June (Bales and Walters 2003).

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for fish, mussels, and crayfish priority species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the Roanoke River.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Cutlip minnow – North Carolina population known from only a few streams in the upper Dan drainage; should survey for additional populations in upper Dan; focus on habitat protection due to the species' intolerance of siltation.
- Rustyside sucker – known only from one site on Little Dan River in 1986; need further status surveys and if still present, should consider the possibility of reintroductions into high quality waters.
- Orangefin madtom – restricted to upper Dan River drainage; populations could be declining due to cold water release from dams, causing disruption of reproductive cycle.
- Bigeye jumprock – known from larger, fast-flowing sections of the Dan and Mayo Rivers and associated tributaries; intolerant of sedimentation effects, therefore indicator of good water quality.
- Riverweed darter – restricted to Dan River headwaters; needs special protection because of intolerance to siltation of streams and because of restricted range.
- Chowanoke crayfish – found only in lower Roanoke basin and Chowan basin in North Carolina; need further information about life history and distribution; considered by Smith et al. (2002) as a South Atlantic Aquatic Region data gap in species knowledge.
- Survey for high priority mussel species (e.g., Atlantic pigtoe) in the Roanoke basin.

. **Taxonomic resolution: support species descriptions and diagnoses** – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support taxonomic research for other species as needed.

. **Research to facilitate appropriate conservation actions** – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).

- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of restoration projects (e.g., Piedmont mussel relocation sites).
  - Performance of hydropower remediation (e.g., Roanoke Rapids bypass monitoring).
  - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
  - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
  - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat protection efforts of external entities

- Provide support for land protection (property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, US Army Corps of Engineers).
- Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
  - Priority areas for freshwater conservation in the Roanoke River basin include (based on Smith et al. 2002, NC Natural Heritage Program and Commission data) (see Map 5B.10b):
    - Upper Dan/Mayo Rivers
    - Country Line Creek and tributaries
    - Aarons Creek, Grassy Creek, Gill Creek and tributaries
    - Lower Roanoke River
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.
  - Coordinate sampling with other resource groups.
  - Hydropower issues: work with Cooperative Management Teams concerning Roanoke Rapids bypass relicensing.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Strengthen water quality rules/issues:
  - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include the NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
  - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (cooperators include the NC Division of Water Quality, NC Natural Heritage Program, US Fish & Wildlife Service).
  - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
  - Support stormwater management and wastewater treatment plant improvements and upgrades.
  - Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Bales, J.D. and D.A. Walters. 2003. Relations among floodplain water levels, instream dissolved-oxygen conditions, and streamflow in the lower Roanoke River, North Carolina, 1997–2001. WRIR 03-4295, U.S. Geological Survey, Raleigh, NC.

Bass, G. November 1999. Roanoke's dazzling diversity. Pgs. 50–59, Wildlife in North Carolina. N.C. Wildlife Resources Commission, Raleigh, NC.

Bogan, A.E. 2002. Workbook and key to the freshwater bivalves of North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000. Nonindigenous crayfishes threaten North American freshwater biodiversity: lessons from Europe. Fisheries 25(8):7–20.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

Moyle, P.B., and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127–169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York, NY.

Mulligan, J. 1991. Ambient monitoring. Pages 42–47 in R.A. Rulifson and C.S. Manooch, III (eds.). Roanoke River Water Flow Committee Report for 1990. NOAA Tech. Mem. NMFS-SEFC-291. National Marine Fisheries Service, Beaufort, NC.

N.C. Department of Environment and Natural Resources (NCDENR). 2003. Discover North Carolina's River Basins – Roanoke River Basin. Office of Environmental Education, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2000. Basinwide assessment report for the Roanoke River basin. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2001. Roanoke River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2004. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

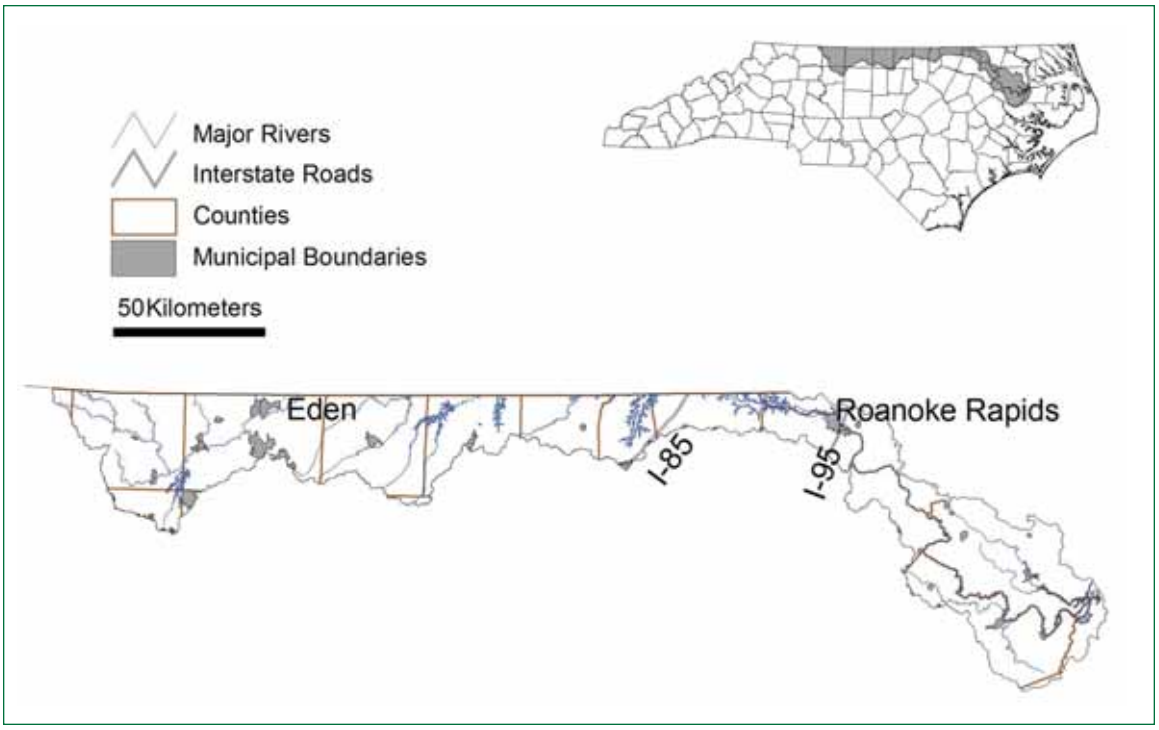
N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Rulifson, R. A. and C. S. Manooch, III (eds.). 1993. Roanoke River Water Flow Committee Report for 1991–1993. Published by the Albemarle-Pamlico Estuarine Study, Raleigh, NC. Project No. APES 93-18.

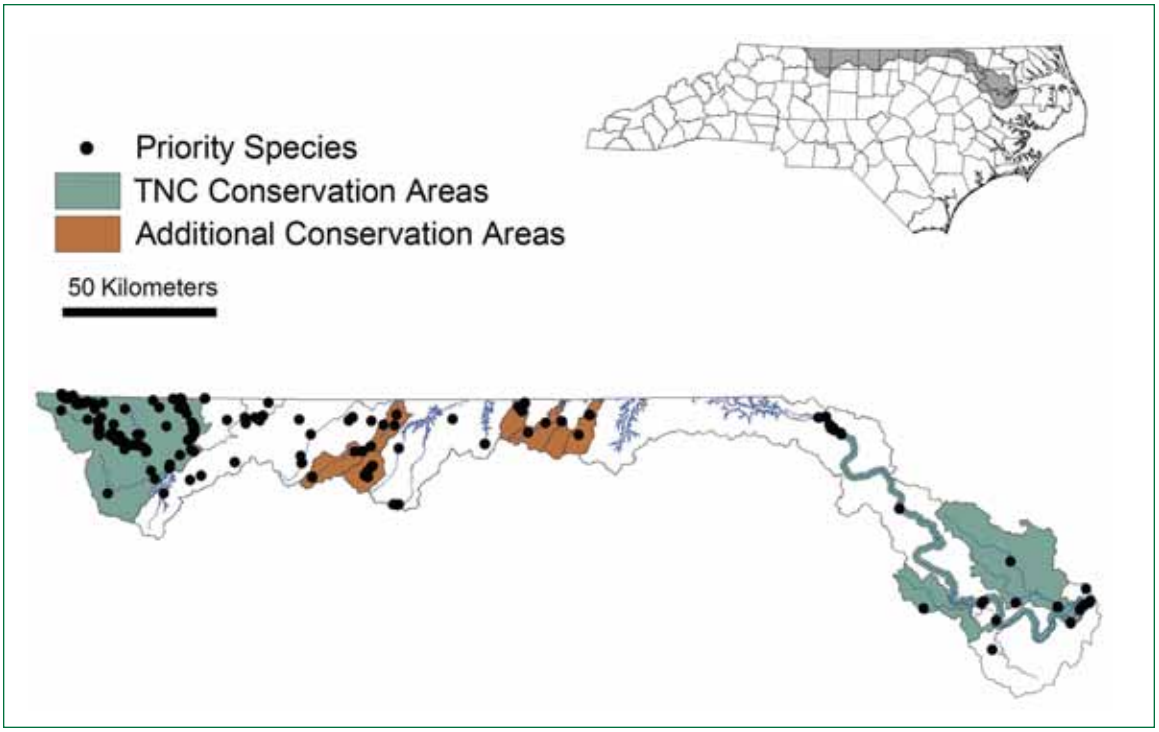
Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Warren, M.L., Jr., and B.M. Burr. 1994. Status of freshwater fishes of the United States: overview of an imperiled fauna. Fisheries 19(1):6–18.



Map 5B.10a. Roanoke River basin, political information.



Map 5B.10b. Roanoke River basin, priority species occurrences and priority areas for freshwater conservation.

11. Cape Fear River Basin

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser brevirostrum*	Shortnose Sturgeon	E (E)
	Acipenser oxyrhynchus	Atlantic Sturgeon	SC
	Ambloplites cavifrons	Roanoke Bass	SR
	Ameiurus brunneus	Snail Bullhead	
	Carpiodes velifer	Highfin Carpsucker	SC
	Cyprinella sp. (cf. zanema)	Thinlip Chub	SC
	Elassoma evergladei	Everglades Pygmy Sunfish	
	Elassoma zonatum	Banded Pygmy Sunfish	
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Etheostoma collis	Carolina Darter	SC
	Fundulus diaphanus	Banded Killifish	
	Fundulus lineolatus	Lined Topminnow	
	Heterandria formosa	Least Killifish	SC
	Lepomis marginatus	Dollar Sunfish	
	Lepomis punctatus	Spotted Sunfish	
	Lucania goodei	Bluefin Killifish	SC
	Lythrurus matutinus	Pinewoods Shiner	SR
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Moxostoma sp 2	Carolina Redhorse	SR
	Notropis amoenus	Comely Shiner	
	Notropis chalybaeus	Ironcolor Shiner	
	Notropis maculatus	Taillight Shiner	
	Notropis mekistocholas	Cape Fear Shiner	E (E)
	Noturus n. sp.	Broadtail Madtom	SC
	Petromyzon marinus	Sea Lamprey	
	Poecilia latipinna	Sailfin Molly	
	Semotilus lumbee	Sandhills Chub	SC
Mussels	*Alasmidonta undulata*	Triangle Floater	T
	Alasmidonta varicosa	Brook Floater	E
	Anodonta couperiana	Barrel Floater[1]	E
	Elliptio cistellaeformis	Box Spike	
	Elliptio congaraea	Carolina Slabshell	
	Elliptio folliculata	Pod Lance	SC
	Elliptio icterina	Variable Spike	

[1] Possibly extirpated.

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mussels, cont.	*Elliptio marsupiobesa*	Cape Fear Spike	SC
	Elliptio roanokensis	Roanoke Slabshell	T
	Fuscionaia masoni	Atlantic Pigtoe	E
	Lampsilis cariosa	Yellow Lampmussel	E
	Lampsilis radiata radiata	Eastern Lampmussel	T
	Ligumia nasuta	Eastern Pondmussel	T
	Strophitus undulatus	Creeper (Squawfoot)	T
	Toxolasma pullus	Savannah Lilliput	E
	Villosa constricta	Notched Rainbow	SC
	Villosa delumbris	Eastern Creekshell	SR
	Villosa vaughaniana	Carolina Creekshell	E
Crayfish	*Cambarus catagius*	Greensboro Burrowing Crayfish	SC
	Cambarus davidi	Carolina Ladle Crayfish	SR
	Cambarus hystricosus	Sandhills Spiny Crayfish	SR
	Procambarus ancylus	Edisto Crayfish	
	Procambarus plumimanus	Croatan Crayfish	SR
Snails	*Helisoma eucosmium*	Greenfield Rams-horn	E
	Planorbella magnifica	Magnificent Rams-horn	E
	Viviparus intertextus	Rotund Mysterysnail	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.11a, 5B.11b):

The Cape Fear River basin is the largest river basin in North Carolina and is located entirely within the state. The Cape Fear River basin can be characterized by three distinct regions: the upper Cape Fear including the headwaters in the Piedmont, the middle Cape Fear including the fall line and the sandhills regions, and the lower Cape Fear which includes the coastal region with blackwater streams, peatlands, and swamps. The headwaters include the Deep River, originating near High Point, and the Haw River, originating north of Greensboro, which join to form the Cape Fear River just downstream of the B. Everett Jordan Reservoir dam. Much of the headwaters are located in and flow through highly urbanized areas which significantly impacts water quality in the basin. The Cape Fear River flows southeast across the Piedmont, through Fayetteville, and through the Sandhills and Coastal Plain regions before reaching Wilmington and entering the ocean. Blackwater streams and rivers in the lower Cape Fear include the South River, Black River, and the Northeast Cape Fear River. The Sandhills and Coastal Plain regions have a high rate of endemism due to their unique habitats. Cape Fear River basin also includes estuarine areas along the coast that serve as fish nurseries.

The total area of the Cape Fear River basin is 9,322 sq. miles, with 6,049 total stream miles (NCDWQ 2000a). There are 26 counties and 116 municipalities in the basin. The population density is 160 people/sq. mile with the most populated areas in the Greensboro, Burlington, and High Point areas. Other large urban areas in the basin include Durham, Chapel Hill and

Fayetteville. There was a 43% increase in developed land in the basin between 1982–1992 (NCDWQ 2000b). Land cover in the basin includes 56% forest land, 24% agricultural lands, 9% urban areas, and 11% other (rural transport, small water areas, lakes and estuaries; NCDWQ 2000b).

B. Problems affecting species and habitats:

Water quality problems occur throughout the basin; there are about 730 miles of impaired waters (NCDWQ 2000b). Causes of impairment include sediment, fecal coliform, ammonia, chlorides, low dissolved oxygen, turbidity, nutrients, mercury, and other point- and non-point pollutants. Sedimentation is a major issue in the basin; sources include agriculture, forestry, construction, and stormwater discharge in urbanized areas. The Cape Fear is interrupted by three lock and dams in the middle and lower portions of the river. There are also many smaller dams on the tributaries to the Cape Fear (e.g., Rocky River, Deep, Haw, Stony Creek, Reedy Fork). The consequences of these impoundments include blocked migration routes for diadromous and resident species, reduced recolonization and dispersal potential, and unnatural flow regimes (Williams et al. 1993, Etnier 1997, Neves et al. 1997, Warren et al. 2000).

Our knowledge of aquatic species distributions in the basin is inadequate; general surveys are needed throughout much of the Cape Fear River basin. We have a poor understanding of life history and habitat use for many species, knowledge that is critical for managing these populations. We have difficulty monitoring known populations of rare species at regular intervals in order to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species (e.g., flathead catfish, red swamp crayfish) have become established in the Cape Fear River basin and continue to negatively impact native species populations (Fuller et al. 1999, Cooper 2005).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status of fish, mussels, crayfish, and snails (in order of need).

- Fish – basin priorities include surveys for Cape Fear shiner and Carolina redhorse.
- Mussels – basin priorities include surveys for rare or listed species.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic studies to improve understanding of the freshwater mussel genus *Elliptio*.
- Support species descriptions for undescribed taxa (e.g., Carolina redhorse).

Research to facilitate appropriate conservation actions – Research should focus on life history studies of priority species and for taxa which little information is known.

- Determine vulnerability of species across all taxa groups to threats such as dams, pollutants (animal wastes, toxic releases, and nutrient loading), and sedimentation.
- Study the potential effects of non-native species on native species.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. New monitoring plans must be developed in coordination with existing monitoring efforts in order to meet shared goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends of priority species. Establish protocol, schedule, and sites for long-term population monitoring (collaborate with the NC Division of Water Quality, NC Museum of Natural Sciences, and the US Fish and Wildlife Service).

- Conduct special purpose monitoring to assess performance of specific conservation actions:
  - Performance of stream restoration projects.
  - Impacts of dam removal projects.
- Determine distribution of non-native species (e.g., flathead catfish and introduced crayfish).

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (acquisition, easements, buffers):
  - Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, Natural Resources Conservation Service, The Nature Conservancy, other non governmental organizations, and the US Forest Service (Uwharrie National Forest).
  - Support dam removal (work with US Fish & Wildlife Service and other interested non governmental organizations).
- Identify priority areas for habitat protection (areas with high species diversity, rare species, and endemic species). Identify specific areas that are critical to the survival of species (e.g., spawning areas) and/or diverse communities.:
  - Priority watersheds for conservation in the Cape Fear River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.11b):
    - Upper Haw River
    - Middle Haw River tributaries
    - Deep/Rocky/Haw/Cape Fear Rivers
    - New Hope Watershed above B. Everett Jordan Reservoir
    - Cape Fear sandhills tributaries
    - Lower Cape Fear/Black/South Rivers
    - Northeast Cape Fear River
    - Town Creek
    - Merrick's Creek/Holly Shelter Game Lands
    - Orton Pond/Military Ocean Terminal Sunny Point
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.

- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitat.

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection

- Address secondary and cumulative impacts upon water quality (e.g., buffer ordinances, water supply watershed protection, protect headwaters) (NCDWQ 2000a, NCWRC 2002).
- Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
- Work with and promote existing programs that help farmers reduce sedimentation/erosion (e.g., install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
- Protect existing good water and habitat quality throughout the basin (Outstanding Resource Water and High Quality Water streams).
- Promote programs to upgrade wastewater treatment at hog and chicken farms.
- Work through Site-Specific Management Plan process to improve water quality protection for waters containing federally listed species (potential partners include the NC Division of Water Quality, the NC Natural Heritage Program, and the US Fish & Wildlife Service).

Land-use planning

- Work with county and city officials and developers to incorporate buffers along streams, implement low impact development, and better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Support sustainable land use planning that considers long-term effects of development.
- Support dam and lock removal where feasible (work with US Fish & Wildlife Service, the US Army Corps of Engineers, and private dam owners).

Species protection

- Work with the US Fish & Wildlife Service on listed species recovery plans.
- Make recommendations, as appropriate, to the Commission's Nongame Wildlife Advisory Committee for state listed species status changes.
- Ensure that collection permits for impact assessments are issued to qualified applicants.

Supporting References

Adams, W. F. (Chairman), Alderman, J.M., Biggins, R. G., Gerberich, A.G., Keferl, E. P., Porter, H.J., Van Devender, A.S. 1990. A report on the conservation status of North Carolina's freshwater and terrestrial molluscan fauna. Prepared by: The Scientific Council on Freshwater and Terrestrial Mollusks in accordance with Article 25 of Chapter 113 of the General Statutes of North Carolina.

Cooper, J.E. 2004. Guide to crayfishes of the Cape Fear and Northeast Cape Fear River drainages. N.C. Museum of Natural Sciences, Raleigh, NC.

Cooper, J.E. 2005. A report on adventive crayfishes in North Carolina. Unpublished report, N.C. Museum of Natural Sciences, Raleigh, NC.

Etnier, D. A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pages 87–104 in G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special publication 1, Southeast Aquatic Research Institute, Decatur, GA.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2000a. North Carolina's 2000 303(d) List. N.C. Department of Environment and Natural Resources, Division of Water Quality – Planning Branch. Raleigh, North Carolina

N.C. Division of Water Quality (NCDWQ). 2000b. Cape Fear River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2004. Basinwide Information Management System (BIMS). N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC. http://h2o.enr.state.nc.us/bims/: accessed August 9, 2004.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

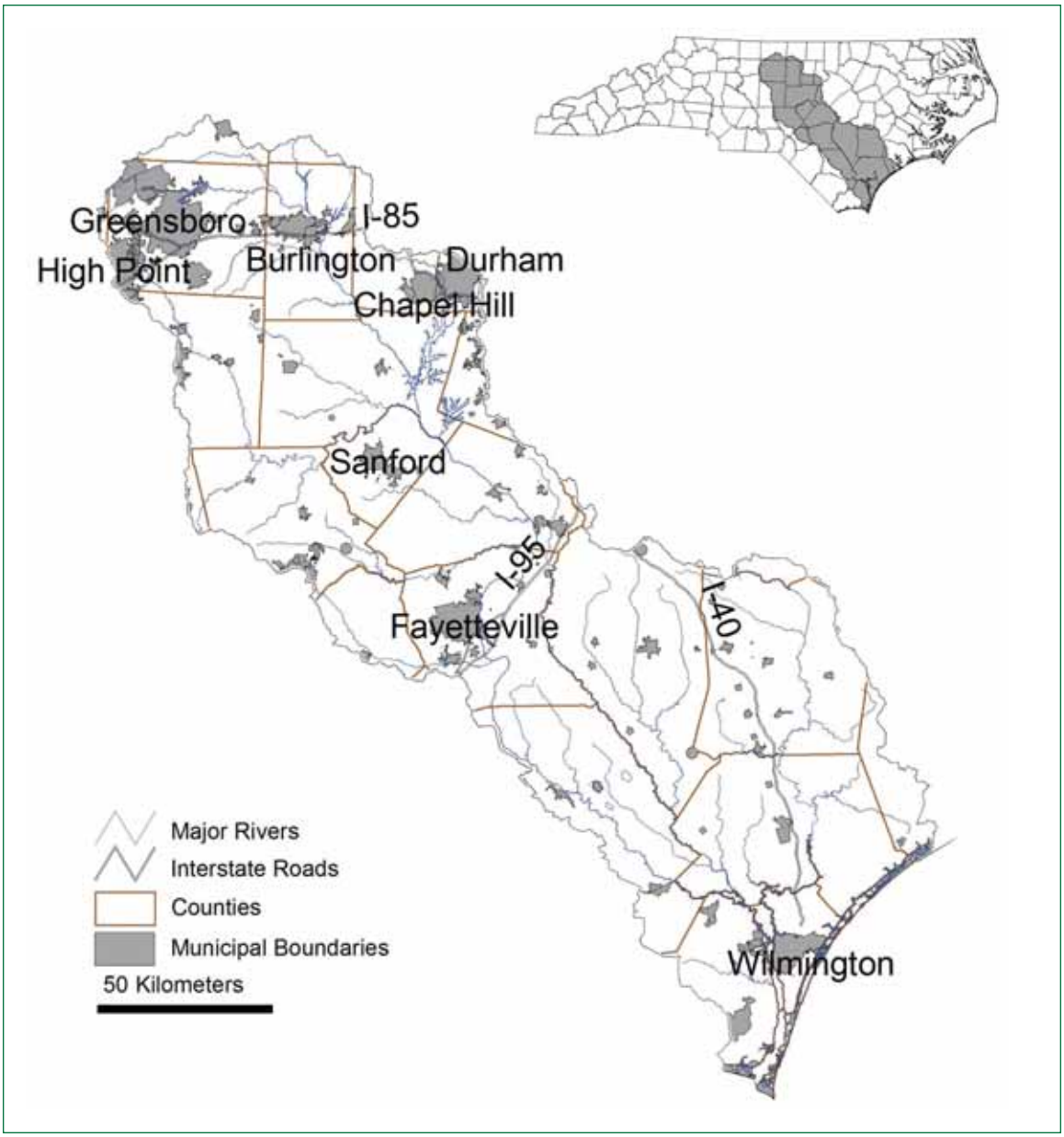
Neves R. J., A. E. Bogan, J. D. Williams, S. A. Ahlstedt, and P. W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pages 43–86 in G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special publication 1, Southeast Aquatic Research Institute, Decatur, GA.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

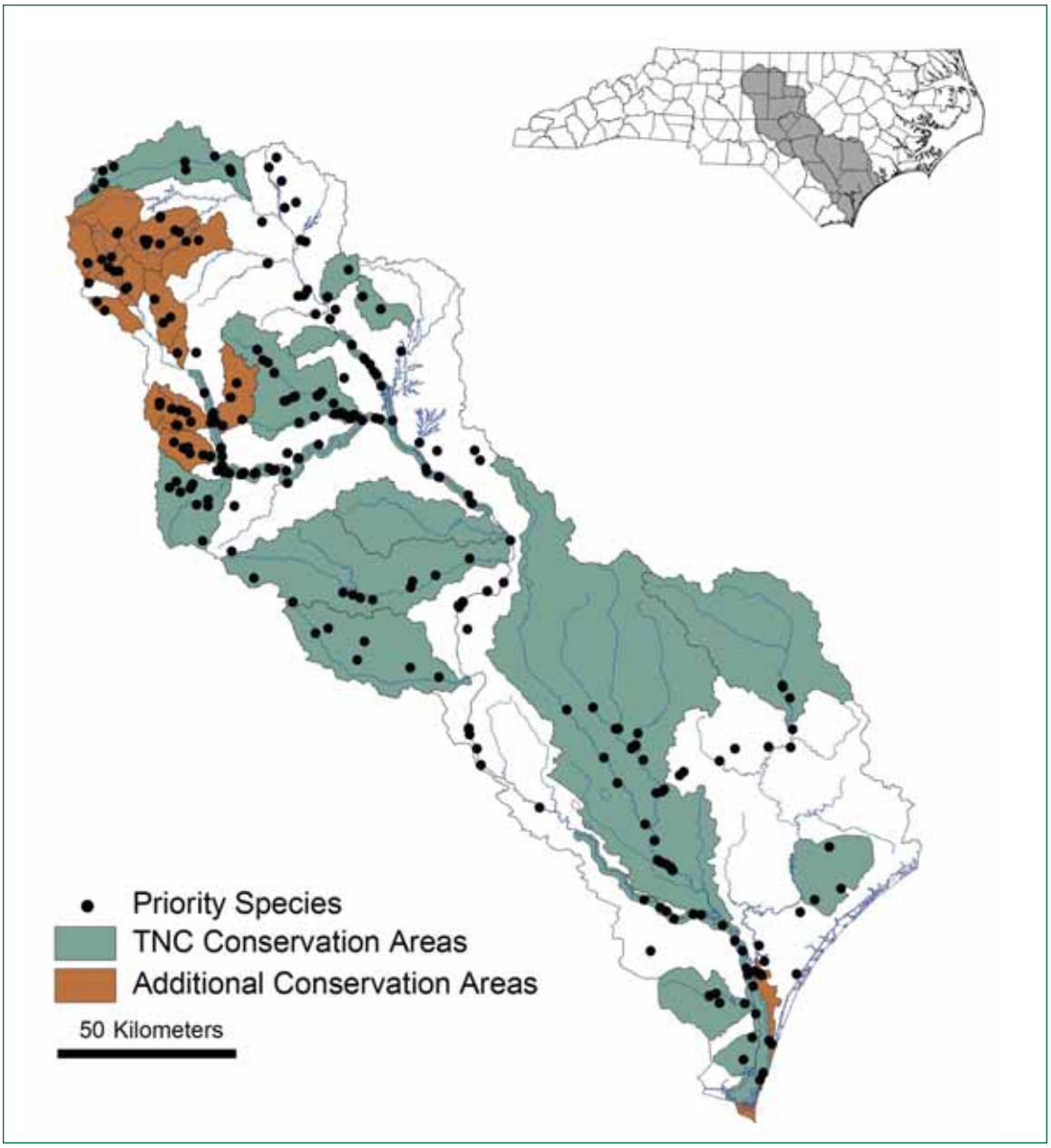
Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25:7–31.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18:6–22.



Map 5B.11a. Cape Fear River basin, political information.



Map 5B.11b. Cape Fear River basin, priority species occurrences and priority areas for freshwater conservation.

12. Neuse River Basin

Priority aquatic species in the Neuse River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish[1]	*Acipenser oxyrhynchus*	Atlantic Sturgeon	SC
	Ambloplites cavifrons	Roanoke Bass	SR
	Ameiurus brunneus	Snail Bullhead	
	Carpiodes cyprinus	Quillback	
	Elassoma zonatum	Banded Pygmy Sunfish	
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Etheostoma collis	Carolina Darter	SC
	Etheostoma nigrum	Johnny Darter	
	Etheostoma vitreum	Glassy Darter	
	Fundulus diaphanus	Banded Killifish	
	Fundulus lineolatus	Lined Topminnow	
	Lampetra aepyptera	Least Brook Lamprey	T
	Lepomis marginatus	Dollar Sunfish	
	Lythrurus matutinus	Pinewoods Shiner	SR
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Notropis amoenus	Comely Shiner	
	Notropis bifrenatus	Bridle Shiner	SC
	Notropis chalybaeus	Ironcolor Shiner	
	Notropis volucellus	Mimic Shiner	
	Noturus furiosus	Carolina Madtom	SC
	Petromyzon marinus	Sea Lamprey	
Mussels[2]	*Alasmidonta heterodon*	Dwarf Wedgemussel	E (E)
	Alasmidonta undulata	Triangle Floater	T
	Alasmidonta varicosa	Brook Floater	E
	Elliptio cistellaeformis	Box Spike	
	Elliptio congaraea	Carolina Slabshell	
	Elliptio icterina	Variable Spike	
	Elliptio lanceolata	Yellow Lance	E
	Elliptio marsupiobesa	Cape Fear Spike	SC
	Elliptio roanokensis	Roanoke Slabshell	T
	Elliptio steinstansana	Tar River Spinymussel	E (E)
	Fusconaia masoni	Atlantic Pigtoe	E
	Lampsilis cariosa	Yellow Lampmussel	E

[1]Smallmouth buffalo (*Ictiobus bubalus*) is a native priority fish species in the French Broad basin, but is a non-native in the Catawba, Yadkin-PeeDee, and Neuse basins. In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion should be initiated.

[2]An undescribed *Lampsilis* species exists in this basin.

Priority aquatic species in the Cape Fear River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Mussels, cont.	*Lampsilis radiata conspicua*	Carolina Fatmucket	T
	Lampsilis radiata radiata	Eastern Lampmussel	T
	Lasmigona subviridis	Green Floater	E
	Strophitus undulatus	Creeper (Squawfoot)	T
	Villosa constricta	Notched Rainbow	SC
Crayfish	*Cambarus davidi*	Carolina ladle crayfish	SR
	Orconectes carolinensis	North Carolina spiny crayfish	SC
	Procambarus medialis	Tar River crayfish	
	Procambarus plumimanus	Croatan crayfish	SR
Snails	*Somatogyrus virginicus*	Panhandle pebblesnail	SR
	Viviparus intertextus	Rotund Mysterysnail	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps R12a, R12b):

The Neuse River basin is an Atlantic Slope drainage originating in Person and Orange Counties in the Piedmont region of North Carolina and flowing through the Coastal Plain to Pamlico Sound. The Neuse is the third largest basin in North Carolina and has an area of 6,235 sq. miles, draining 3,497 miles of streams. There are 16,414 freshwater lake acres, 369,977 estuarine acres, and 21 miles of coastline in the basin. The Neuse River flows as freshwater until reaching New Bern, where it turns into a 40 mile long brackish tidal estuary to the mouth of the Pamlico Sound. Major tributaries to the Neuse River include the Eno River, Flat River, Little River, Trent River, Crabtree Creek, Swift Creek, and Contentnea Creek (NCDWQ 2001).

There are two distinct portions of the Neuse River basin: the upper one-third in the Piedmont physiographic region and the lower two-thirds in the Coastal Plain physiographic region. The upper Neuse River basin, including the Flat, Eno, and Little Rivers, lies within the Slate Belt Ecoregion. The Piedmont portion typically features a low gradient with sluggish pools separated by riffles and occasional small rapids. Soils are highly erodible and are underlain by fractured rock formations that have limited water storage capacity. This portion tends to have low summer flows and limited ability to assimilate oxygen-consuming wastes. The Coastal Plain portion features slow-moving blackwater streams, low-lying swamps and productive estuarine waters. The larger waterbodies are meandering, often lined with swamps and bottomland hardwoods, and often have naturally low dissolved oxygen and pH. Soils are deep sands that have a high groundwater storage capacity. Natural lakes include the remnants of bay lakes in the lower Coastal Plain (NCDWQ 2001).

The Neuse river basin has 74 municipalities within 18 basin counties. The most urbanized section of the river basin is from Falls of the Neuse Reservoir to southern Johnston county, including Swift and Crabtree Creeks (NCDWQ 2002). Major cities include Raleigh, Durham, and Cary in the upper basin and Goldsboro, Kinston, and New Bern in the lower basin. The basin has a population of 1,320,379 (2000 census data), containing approximately one-sixth of North Carolina's total population. Population density is 211 people/sq. mile. Approximately 13% of the basin is considered urban, 45% forested, and 29% crop and pasture land (NCDWQ 2001).

The upper 22 miles of the Neuse River proper are impounded by Falls of the Neuse Dam. The river flows for approximately 185 miles below the dam until it terminates at Pamlico Sound. The Neuse River is 6 miles wide at its mouth, the widest river in America (NCDENR 2003), and the longest river within North Carolina's borders. Other major reservoirs in the Neuse River Basin include Milburnie Dam, Little River Reservoir, Lake Michie, Lake Orange, Corporation Lake, Lake Ben Johnson (run-of-the-river dam), Lake Butner, Lake Rogers, Lake Wheeler, Lake Benson, and Buckhorn Reservoir. Removal of Quaker Neck Dam (near Goldsboro) in 1997 opened up 1,000 miles of river to migratory fishes (75 miles of Neuse River, 925 miles of tributaries; NCDWQ 2001).

The West Bay subbasin (Pamlico Sound, upper Core Sound, West Bay and their embayments and tributaries) contains 63,513 acres of Outstanding Resource Waters (ORW) because of their high fisheries value. There are 582 acres of High Quality Waters (HQW), mostly associated with Greens Creek and Smith Creek in the lower Neuse River basin. (NCDWQ 2002). The basin contains 555 miles of impaired streams and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDWQ 2004).

B. Problems affecting species and habitats:

Non-point source pollution from agriculture and forestry has degraded aquatic habitats within the basin. For example, animal waste byproducts cause increased levels of nitrates and phosphates, which can lead to: 1) excess growth of aquatic plants, such as algae, and 2) decreased dissolved oxygen levels (especially during summer months), resulting in fish kills. Bank erosion can result from channelization of streams for agriculture. Fertilizers and livestock contribute 60 percent of nitrates and phosphates in the basin and forestry contributes 13 and 6 percent of nitrogen and phosphorus, respectively (NCDENR 2003).

Hydrology within the basin has been altered by dam construction and water withdrawals. Impoundments in the basin have affected aquatic species by physically altering habitat, reducing flows and dissolved oxygen, and causing erosion. Modification of flow regimes by upstream impoundments affects various life history characteristics of downstream migratory fishes and other aquatic fauna, such as limiting dispersal and recolonization. Additionally, water withdrawals for irrigation reduce the quantity of available habitat for aquatic species (NCDWQ 2002).

Several development-related threat sources are negatively impacting aquatic habitats in the Neuse River basin. Increasing population leads to increased water demands and wastewater discharges. The human population within the basin is expected to grow by more than 867,000 by 2020 to almost 3 million people. Losses of natural areas and increases in impervious surfaces, as a result of rapid population growth, result in high sediment runoff from construction. More homes contribute to an increase in lawn fertilizer runoff. Heavy metal runoff contributes to elevated mercury levels in fish tissue. These point and nonpoint runoff sources accumulate in the Pamlico Sound, where researchers at the University of North Carolina at Wilmington found one-third of the sediments contaminated with chemicals and toxic metals (Powell 1999). Additionally, atmospheric deposition of nitrogen from cars and factories can lead to decreased water quality. Large quantities of nutrients, especially nitrogen, from nonpoint sources are considered the greatest threat to water quality of the Neuse River estuary. There are over 400 point source waste discharge permits for the basin from municipal wastewater treatment plants, industrial facilities, small package treatment plants, and large urban and industrial stormwater. Municipal point source waste pollution contributes 13 and 23 percent of nitrogen and phosphorus, respectively (Powell 1999).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Least brook lamprey – status survey is needed by electroshocking; species in danger of extirpation due to its intolerance of turbidity and its historical records being close to the Raleigh area where sedimentation effects are present due to urbanization.
- Carolina madtom – endemic to North Carolina; previous records show distribution in Neuse and Tar-Pamlico River basins, but need current data on distribution in Neuse basin; could possibly be extirpated from the Neuse; water quality degradation probably cause of decline in population.
- Roanoke bass – native of the basin and populations should be monitored; populations in VA have declined due to habitat alterations and also due to the introduction of rock bass; have hybridized and displaced VA Roanoke bass.
- Bridle shiner – known from one site, Tucker Creek, in lower Neuse basin; need to resurvey Tucker Creek and other streams with similar habitat to determine if species still occurs in Neuse basin.
- Tar spinymussel – determine if the species remains in Neuse basin and if so, determine its distribution.
- Other mussel survey priorities in the basin include the Atlantic pigtoe and yellow lance.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support completion of species description for undescribed taxa (mussel, *Lampsilis* sp.; possible undescribed crayfish species in *Cambarus acuminatus* complex).
- Support genetics work on Roanoke and rock bass to determine hybridization effects.
- Support work to resolve taxonomic disputes surrounding least brook lamprey.
- Determine if bridle shiner populations are native or introduced.
- Data gap exists for Carolina fatmucket for entire South Atlantic Aquatic Region (Smith et al. 2002).
- Support taxonomic research for other species as needed.

. **Research to facilitate appropriate conservation actions** – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends. Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of restoration projects.
  - Performance of dam removal projects; many are being removed for mitigation credits – what are the short and long-term effects on species and habitat?
- Assess non-native species impacts:
  - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
  - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Promote and support habitat protection efforts of external entities.

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, The Nature Conservancy, US Army Corps of Engineers).
  - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
  - Priority areas for freshwater conservation in the Neuse basin include (based on Smith et al., 2002, NC Natural Heritage Program, and Commission data) (see Map R12a):
    - Neuse River headwaters
    - Crabtree Creek
    - Middle Neuse River and tributaries
    - Blue Pond
    - Mill Creek
    - Trent River
    - Moccasin/Turkey Creeks
    - Knapp of Reeds Creek
    - Middle Creek
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, into Game Lands management, and into Game Lands acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential cooperators include the NC Division of Water Quality, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
  - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (potential cooperators include the NC Division of Water Quality, the NC Natural Heritage Program, and the US Fish & Wildlife Service).
  - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
  - Support stormwater management and wastewater treatment plant improvements and upgrades.
  - Promote protection of areas with good water quality through HQW/ORW designations.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Work with the US Fish & Wildlife Service on listed species recovery plans – Dwarf wedgemussel and Tar spinymussel.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Abell, R. A., D. M. Olsen, E. Dinerstein, P. T. Hurley, J. T. Diggs, W. Erichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America. A conservation assessment. Island Press, Washington, DC.

Bogan, A.E. 2000. Introduction to the Freshwater Gastropods. N.C. Museum of Natural Sciences, Raleigh, NC.

Bogan, A.E. 2002. Workbook and key to the freshwater bivalves of North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Cooper, J. E. 2004. Guide to crayfishes of the Neuse and Tar-Pamlico River drainages. N.C. Museum of Natural Sciences, Raleigh, NC.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

Moyle, P.B., and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127-169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York, NY.

N.C. Department of Environment and Natural Resources (NCDENR). 2003. Discover North Carolina's River Basins – Neuse River Basin. Office of Environmental Education, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2001. Basinwide assessment report for the Neuse river basin. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2002. Neuse River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

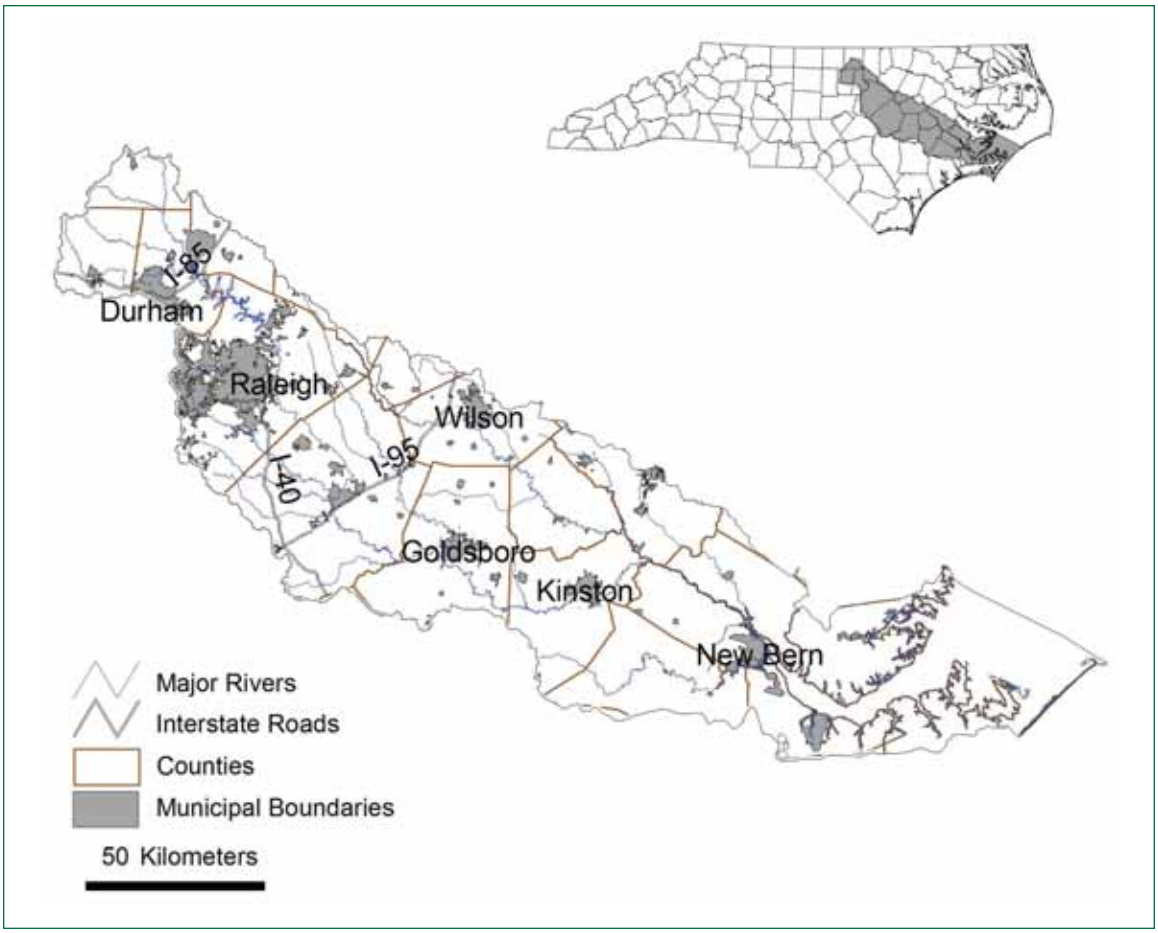
N.C. Division of Water Quality (NCDWQ). 2004. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

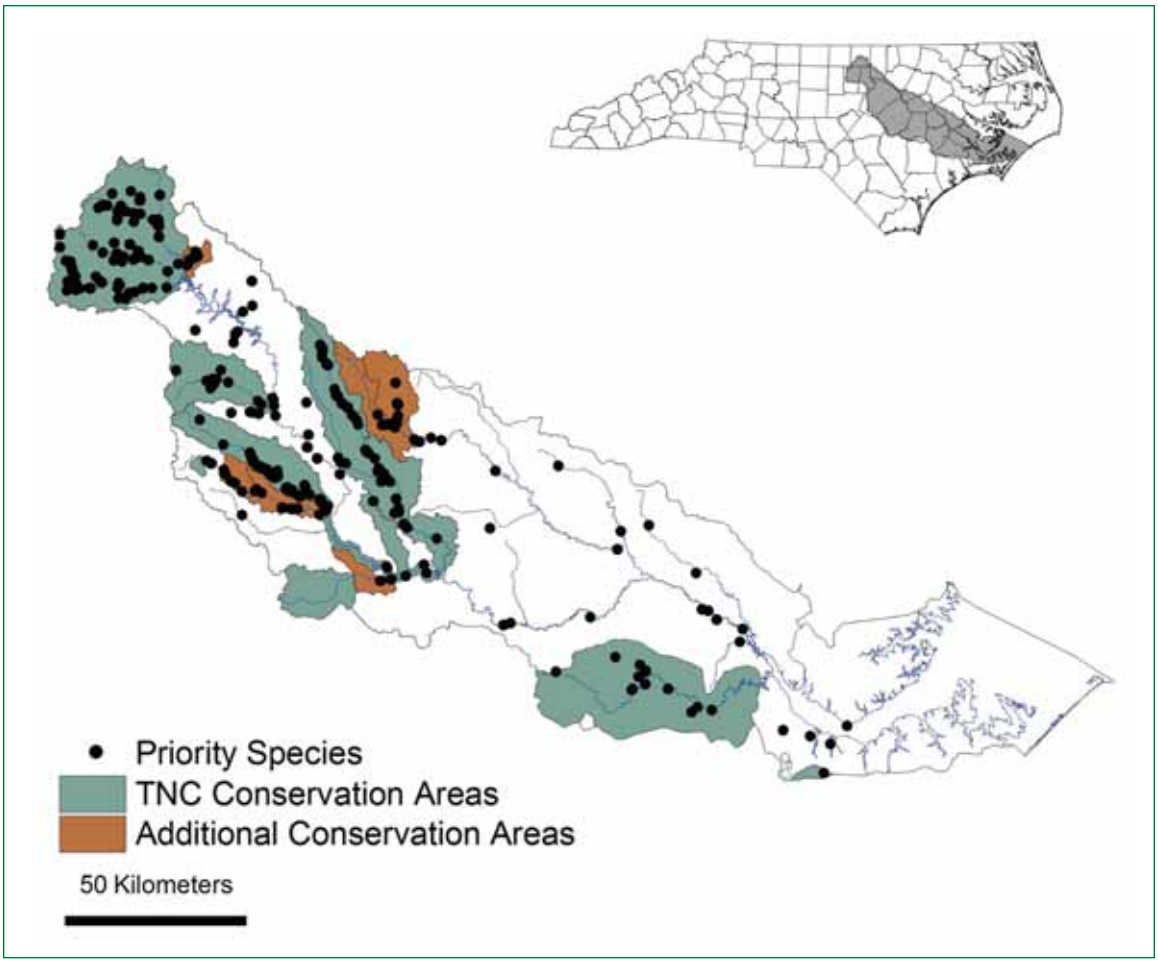
Powell, C. November 1999. The fight for the River of Peace. Pages 72–81 in Wildlife in North Carolina. N.C. Wildlife Resources Commission, Raleigh, NC.

Smith, R.K., P.L. Freeman, J.V. Higgins, K.S. Wheaton, T.W. FitzHugh, K.J. Ernstrom, A.A. Das. 2002. Priority Areas for Freshwater Conservation Action: A Biodiversity Assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.



Map 5B.12a. Neuse River basin, political information.



Map 5B.12b. Neuse River basin, priority species occurrences and priority areas for freshwater conservation.

13. Tar-Pamlico River Basin

Priority aquatic species in the Tar-Pamlico River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser oxyrhynchus*	Atlantic Sturgeon	SC
	Ambloplites cavifrons	Roanoke Bass	SR
	Elassoma zonatum	Banded Pygmy Sunfish	
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Etheostoma collis	Carolina Darter	SC
	Etheostoma nigrum	Johnny Darter	
	Etheostoma vitreum	Glassy Darter	
	Fundulus diaphanus	Banded Killifish	
	Fundulus lineolatus	Lined Topminnow	
	Lampetra aepyptera	Least Brook Lamprey	T
	Lepomis marginatus	Dollar Sunfish	
	Lythrurus matutinus	Pinewoods Shiner	SR
	Moxostoma collapsum	Notchlip Redhorse	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Notropis amoenus	Comely Shiner	
	Notropis chalybaeus	Ironcolor Shiner	
	Notropis volucellus	Mimic Shiner	
	Noturus furiosus	Carolina Madtom	SC
Mussels[1]	*Alasmidonta heterodon*	Dwarf Wedgemussel	E (E)
	Alasmidonta undulata	Triangle Floater	T
	Elliptio cistellaeformis	Box Spike	
	Elliptio congaraea	Carolina Slabshell	
	Elliptio icterina	Variable Spike	
	Elliptio lanceolata	Yellow Lance	E
	Elliptio roanokensis	Roanoke Slabshell	T
	Elliptio steinstansana	Tar River Spinymussel	E (E)
	Fusconaia masoni	Atlantic Pigtoe	E
	Lampsilis cariosa	Yellow Lampmussel	E
	Lampsilis radiata radiata	Eastern Lampmussel	T
	Lasmigona subviridis	Green Floater	E
	Leptodea ochracea	Tidewater Mucket	T
	Ligumia nasuta	Eastern Pondmussel	T
	Strophitus undulatus	Creeper (Squawfoot)	T
	Villosa constricta	Notched Rainbow	SC
Crayfish	*Orconectes carolinensis*	North Carolina Spiny Crayfish	SC
	Procambarus medialis	Tar River Crayfish	

[1]An undescribed Lampsilis species exists in the basin.

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.13a, 13b):

The Tar-Pamlico River basin is an Atlantic Slope basin originating in Person County, in North Carolina's Piedmont region. The Tar-Pamlico is the fourth largest basin in the state, encompassing 5,440 sq. miles and draining 2,355 miles of streams. There are 3,977 lake acres, 663,593 estuary acres, and 17 coastline miles within the basin. With a length of approximately 180 miles, the Tar River becomes the Pamlico River (lowermost 40 miles) at U.S. 17 in Washington. The Tar-Pamlico River terminates at Pamlico Sound. Major tributaries include Fishing Creek, Swift Creek, Cokey Swamp, Tranters Creek and the Pungo River (NCDWQ 2004a).

There are two distinct portions of the Tar-Pamlico River basin: the upper one-fifth in the Piedmont physiographic region and the lower four-fifths in the Coastal Plain physiographic region. The Piedmont portion, running from the river headwaters to the fall line, lies on the Carolina Slate Belt and Triassic Basins ecoregion. This portion features low gradients with sluggish pools separated by riffles and occasional small rapids. Soils are highly erodible and are underlain by fractured rock formations that have limited water storage capacity. Streams and rivers in the Piedmont portion tend to have low summer flows and limited ability to assimilate oxygen-consuming wastes (NCDWQ 2003). The Coastal Plain portion features slow-moving blackwater streams, low-lying swamps and productive estuarine waters. The larger waterbodies are meandering, often lined with swamps and bottomland hardwoods, and often have naturally low dissolved oxygen and pH. Soils are deep sands that have a high groundwater storage capacity. Natural lakes include the remnants of bay lakes in the lower Coastal Plain (NCDWQ 2004a).

There are 50 municipalities within 16 counties in the Tar-Pamlico River basin. Rocky Mount, Greenville, Henderson, Oxford, Tarboro, and Washington are the largest municipalities in the basin. Population within the basin is 414,929 (2000 census, NCDWQ 2004a). At a population density of 75 people/sq. mile, compared to statewide density of 152 people/sq. mile, the basin is relatively rural (NCDWQ 2004a). Land use in the basin is approximately 38% forest and wetland, 23% crop and pasture land, and 5% urban (NCDWQ 2004a). Publicly owned lands include three National Wildlife Refuges (Lake Mattamuskeet, Pocosin Lakes, Swanquarter) and two State Parks (Goose Creek and Medoc Mountain). North Carolina's largest lake, Lake Mattamuskeet, also is located in this basin (NCDENR 2003).

Major reservoirs in the Tar-Pamlico River basin include Lake Devin (a water supply reservoir for Oxford), Lake Royale, and Tar River Reservoir in Rocky Mount. Several old millponds and beaver impoundments are found throughout the Tar-Pamlico River basin (NCDWQ 2003).

There are 24,178 total acres of Outstanding Resource Waters (ORW) in the basin. The ORWs are primarily composed of Swanquarter Bay Refuge, Juniper Bay (and many of their tributaries), and parts of Pamlico Sound. There are 80 miles of impaired stream in the Tar-Pamlico River basin and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDWQ 2004b).

B. Problems affecting species and habitats:

The basin has a high rate of erosion and sedimentation as compared to other North Carolina river basins (Alderman 1999). Sedimentation can result from land clearing activities, streambank erosion, and channelization associated with construction and agriculture. Historic stream channelization for crop irrigation and drainage continues to this day in Conetoe Creek watershed (NCDWQ 2004a). According to 1998 USDA data, the Tar-Pamlico basin is responsible for 5% of the swine, 4% of the dairy, and 7% of the poultry in North Carolina (NCDWQ 2004a).

Abandoned swine lagoons in the basin are susceptible to flooding. In particular, the lower portion of Tar-Pamlico basin (below Tarboro) is heavily affected by agriculture. These agricultural activities contribute to nutrient inputs, erosion, and sedimentation. Influxes of sediment reduce the quality and quantity of necessary habitat for aquatic organisms (NCDWQ 2003).

Water supply withdrawals and interbasin transfers can be expected to increase with development pressures, which will require management measures to avoid negative impacts to aquatic habitats (NCDWQ 2004a). Currently, there are 60 (77 million gallons/day total) registered water withdrawals in the basin (NCDWQ 2004a). Water withdrawals for irrigation purposes continue to reduce the quantity of available habitat for aquatic species.

Several development-related threat sources are negatively impacting aquatic habitats in the Tar-Pamlico River basin. Population growth creates a need for increased drinking water and wastewater discharges. Franklin, Granville, and Nash counties are the fastest growing counties in the upper part of the basin; the basin population is expected to grow by more than 170,000 by 2020, to almost one million people (NCDWQ 2004a). Cumulative and secondary impacts due to urban expansion (e.g., greater Raleigh and Rocky Mount) will cause increased impervious surfaces, which in turn may lead to increased stream sedimentation. Population growth within the basin will also lead to increased demands for drinking water, wastewater discharge, and stormwater control.

Point source discharges (municipal wastewater treatment plants, industrial facilities, small package treatment plants, large urban and industrial stormwater systems) all degrade water quality in the basin. Wastewater treatment plant effluent increases conductivity, elevates nitrogen levels, and lowers dissolved oxygen (NCDWQ 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered.
- Carolina darter – recognized as a data gap for entire South Atlantic Aquatic Region (Smith et al. 2002) and recognized as in need of a status survey due to increased developmental pressures on North Carolina aquatic systems (Menhinick and Braswell 1997).
- Least brook lamprey – status survey is needed by electroshocking; species in danger of extirpation due to its intolerance of turbidity and its historical records being close to the Raleigh area where sedimentation effects are present due to urbanization.
- Carolina madtom – distributional information needed; good populations in Tar-Pamlico basin; this information can be used to help locate populations within Neuse basin.
- Roanoke bass – native of the basin and populations should be monitored; populations in VA have declined due to habitat alterations and also due to the introduction of rock bass; have hybridized and displaced VA Roanoke bass.
- North Carolina spiny crayfish and Tar River crayfish – both are endemic to North Carolina.
- Mussel survey priorities in the basin include the Atlantic pigtoe and yellow lance.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support completion of species description for undescribed taxa (mussel, *Lampsilis* sp.).
- Support genetics work on Roanoke and rock bass to determine hybridization effects.

- Support work to resolve taxonomic disputes surrounding least brook lamprey.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of restoration projects.
  - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
  - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
  - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, Tar River Land Conservancy, US Army Corps of Engineers).
  - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
  - Priority areas for freshwater conservation in the Tar-Pamlico basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.13b):
    - Upper Tar (designated as one of three key centers of endemism in Southern Atlantic Aquatic Region, Smith et al. 2002) - The upper Tar fits into a priority area for ecosystem management due to presence of endemics, large faunal diversity, high likelihood of restoration/conservation, etc. (Shute et al. 1997).
    - Fishing Creek Watershed (Fishing Creek, Little Fishing creek, Shocco Creek, Little Shocco Creek, Maple Branch, Red Bud Creek, Rocky Swamp)
    - Swift Creek Watershed
    - Middle Tar
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.
  - Explore possibilities for Shocco Game Land expansion.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Develop Habitat Conservation Plan for upper Tar (potential cooperators include US Fish and Wildlife Service, NC Department of Transportation, Tar River Land Conservancy, Clean Water Management Trust Fund, The Nature Conservancy, NC Department of Environment and Natural Resources, NC Natural Heritage Program, Natural Resources Conservation Service, Pamlico-Tar Foundation, Medoc Mountain State Park, US Army Corps of Engineers, International Paper, county governments, private landowners, NC Homebuilders Association).
- Work with Tar River Land Conservancy to support conservation priorities.
- Support other cooperative efforts as opportunities arise.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
  - Promote Outstanding Resource Water designation for lower Swift Creek in Nash and Edgecombe Counties; protect other areas of good water quality through Outstanding Resource Water and High Quality Water designations.
  - Work through Site-Specific Management Plan process to obtain stricter regulations for waters containing federally listed species (cooperators include NC Division of Water Quality, NC Natural Heritage Program, US Fish & Wildlife Service).
  - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of stream, etc.) and reduce nutrient inputs (pesticide/herbicide use).
  - Support stormwater management and wastewater treatment plant improvements and upgrades.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Work with the US Fish & Wildlife Service on listed species recovery plans – Dwarf wedgemussel and Tar spinymussel.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Abell, R. A., D. M. Olsen, E. Dinerstein, P. T. Hurley, J. T. Diggs, W. Erichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America. A conservation assessment. Island Press, Washington, DC.

Alderman, J.M. November 1999. Treasures of the Upper Tar. Pgs. 66–67, Wildlife in North Carolina. N.C. Wildlife Resources Commission, Raleigh, NC.

Alderman, J.M., A.L. Braswell, S.P. Hall, A.W. Kelly, and C. McGrath. 1993. Biological inventory: Swift Creek subbasin. N.C. Wildlife Resources Commission, Raleigh, NC.

Bogan, A.E. 2000. Introduction to the freshwater gastropods. N.C. Museum of Natural Sciences, Raleigh, NC.

Bogan, A.E. 2002. Workbook and key to the freshwater bivalves of North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Cooper, J. E. 2004. Guide to crayfishes of the Neuse and Tar-Pamlico River drainages. N.C. Museum of Natural Sciences, Raleigh, NC.

Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000. Nonindigenous crayfishes threaten North American freshwater biodiversity: lessons from Europe. Fisheries 25(8):7–20.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

Moyle, P.B., and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127–169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York, NY.

N.C. Department of Environment and Natural Resources (NCDENR). 2003. Discover North Carolina's River Basins – Tar-Pamlico River Basin. Office of Environmental Education, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2003. Basinwide assessment report for the Tar-Pamlico River basin. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2004a. Tar-Pamlico River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

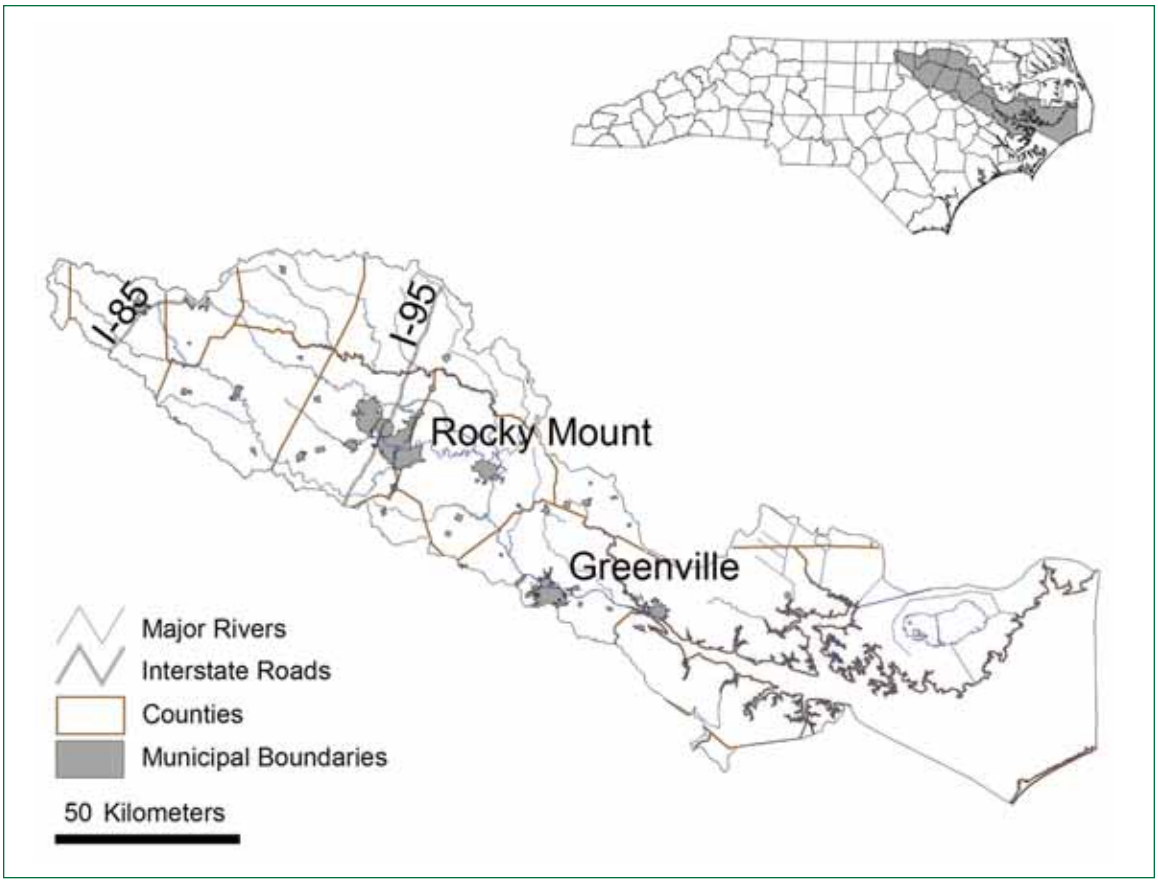
N.C. Division of Water Quality (NCDWQ). 2004b. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

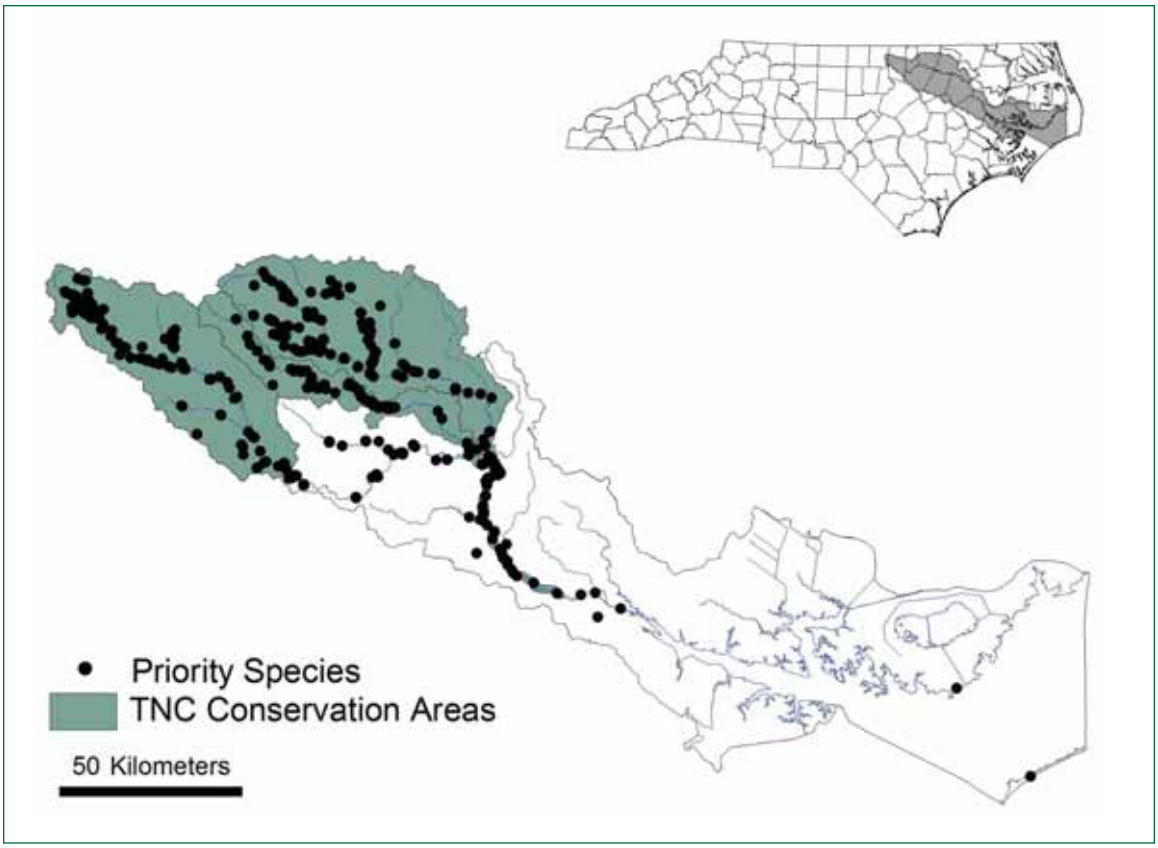
Shute, P.W., R.G. Biggins, and R. S. Butler. 1997. Management and conservation of rare aquatic resources: a historical perspective and recommendations for incorporating ecosystem management. Pages 445–468 *in* G.W. Benz and D.E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special Publication 1, Southeast Aquatic Research Institute, Decatur, GA.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.



Map 5B.13a. Tar-Pamlico River basin, political information.



Map 5B.13b. Tar-Pamlico River basin, priority species occurrences and priority areas for freshwater conservation.

14. Chowan River Basin

Priority aquatic species in the Chowan River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser brevirostrum*	Shortnose Sturgeon	E (E)
	Acipenser oxyrhynchus	Atlantic Sturgeon	SC
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Etheostoma vitreum	Glassy Darter	
	Fundulus diaphanus	Banded Killifish	
	Fundulus lineolatus	Lined Topminnow	
	Moxostoma macrolepidotum	Shorthead Redhorse	
	Moxostoma pappillosum	V-lip Redhorse	
	Notropis amoenus	Comely Shiner	
	Notropis chalybaeus	Ironcolor Shiner	
	Petromyzon marinus	Sea Lamprey	
Mussels	*Alasmidonta undulata*	Triangle Floater	T
	Anodonta implicata	Alewife Floater	T
	Lampsilis radiata radiata	Eastern Lampmussel	T
	Leptodea ochracea	Tidewater Mucket	T
	Ligumia nasuta	Eastern Pondmussel	T
	Villosa constricta	Notched Rainbow	SC
Crayfish	*Orconectes virginiensis*	Chowanoke Crayfish	SC

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.14a, 5B.14b):

The Chowan River basin is an Atlantic Slope drainage. Headwaters of the Chowan River begin in Virginia's Coastal Plain (75% of the basin is found in Virginia) in the Coastal Plain region. The Chowan is the twelfth largest river basin in North Carolina, with a watershed of 1,378 sq. miles, draining 803 miles of streams. The basin enters North Carolina in the northeastern portion of the state and empties into Albemarle Sound. The sound is part of the 2nd largest estuary system in the United States (Albemarle-Pamlico estuary), including 16,971 estuary acres. Movement of fishes between the Chowan, Roanoke and Pasquotank River basins freely occurs as a result of the common connection with Albemarle Sound. The Chowan River proper (50 miles long) forms at the North Carolina/Virginia line where the Blackwater and Nottoway Rivers meet. Major tributaries of the basin include the Meherrin River, Wiccacon River, Potecasi Creek, Ahoskie Creek, Bennetts Creek, Indian Creek, and Rockyhock Creek (NCDWQ 2002).

The Chowan River basin in North Carolina lies in the Coastal Plain Physiographic Region. Geology of this area consists of alternating layers of sand, silt, clay and limestone. Land in this area is very flat. Low flow over the warmest months of the year limits streams' ability to maintain high dissolved oxygen levels (NCDWQ 2002).

There are 19 municipalities within five basin counties. Edenton, Ahoskie, and Murfreesboro are the largest municipalities. Human population size in the basin is 61,034, which is <1% of North Carolina population (NCDENR 2003). Population density is 48 persons/sq. mile. Land use in the basin is approximately 55% forest, 34% crop and pasture land, and 3% urban (NCDWQ 2002).

Many streams in the Chowan basin have been classified as High Quality Waters (HQW). The basin contains 136 miles of impaired streams and all waters in the basin have a supplemental classification of Nutrient Sensitive Waters (NCDENR 2003).

No major reservoirs exist in the North Carolina portion of the basin. However, several small millponds exist, including 760 acre Merchant's Millpond and Bennett's Millpond, which impounds upper Rockyhock Creek near Edenton.

B. Problems affecting species and habitats:

Water quality appears to be the greatest problem within the Chowan River basin. The Chowan River was the site of North Carolina's first known large-scale coastal algae bloom in 1972 (NCDENR 2003), which resulted from excessive levels of nitrogen and phosphorus in wastewater and runoff. Lowered dissolved oxygen levels from excessive nutrient inputs killed fish and led to fish diseases. As a result, the Chowan River was the first basin in North Carolina to receive "nutrient sensitive waters" classification in 1979 by the NC Division of Water Quality (NCDWQ 2002). Chronic episodes of hypoxia exist in the Chowan River and its tributaries from late June through September during most years. Dissolved oxygen levels frequently fall below 3.0 mg/l, which negatively affects aquatic biota. Cyclonic events and their accompanying rainfall, storm surge, inundation and flushing of bottomland swamp habitats have occurred repeatedly within the basin since 1995. These tropical events exacerbate an already fragile summer ecosystem by lowering dissolved oxygen levels, which has produced major fish kills within the basin (NCDWQ 2002).

There are no interbasin transfers between the Chowan and other river basins. Water withdrawals, however, do occur, primarily for agricultural purposes (NCDWQ 2002).

Non-point pollution sources that degrade water quality include agriculture, animal operations, urban development, forestry, stormwater discharge, rural residential development, hydrologic modifications, and septic systems. Point-source pollution sources in the basin may include municipality waste water treatment plants, industrial facilities, and urban and industrial stormwater systems. As of 2001, there were 11 permitted wastewater discharges and 34 registered animal operations in the basin (NCDWQ 2002). Soil erosion and runoff of fertilizer and animal waste caused by farming has been a concern within the basin. However, farmers have taken positive steps to reduce runoff effects which have resulted in 123,244 fewer tons of eroding soils each year (NCDENR 2003).

Historically, dioxin, a by-product of paper mill bleaching practices, degraded water quality and negatively affected aquatic biota. However, new bleaching technologies have reduced contaminates from paper plant wastewater that enter the basin (NCDENR 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for priority fish, mussels, crayfish, and snail species. Basin specific priorities include:

- Atlantic sturgeon – initiate surveys for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the Chowan River.
- Chowanoke crayfish – found only in lower Roanoke basin and Chowan basin in North Carolina; collect further information about life history and distribution; considered by Smith et al. (2002) as a South Atlantic Aquatic Region data gap in species knowledge.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed.

- Support genetic work to gain better understanding of mussel genus *Elliptio*.
- Support genetic work on banded killifish to determine genetic relationship to the Lake Phelps killifish in the Pasquotank basin.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions

- Life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of restoration projects (potential renovation of Dillard's Millpond).
  - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
  - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
  - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration

- Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with the Ecosystem Enhancement Program, NC Natural Heritage Program, the US Fish & Wildlife Service, the US Forest Service, the Natural Resources Conservation Service, The Nature Conservancy, and the US Army Corps of Engineers).
  - Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
  - Priority areas for freshwater conservation in the Chowan River basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.14b):
    - Lower Meherrin River/Chowan River
- Gain better understanding of land ownership in basin and begin prioritization of other important aquatic habitats (i.e., shoreline habitats, submerged aquatic vegetation [SAV] beds in sound).
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration – Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

- Investigate potential for reintroduction of extirpated mollusk and fish species to the basin in restored or improved habitats as opportunities become available.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Protect SAV in coastal areas (collaborate with Coastal NC SAV Coalition).
- Coordinate sampling efforts with other resource groups.
- Support cooperative efforts as opportunities arise (potential collaborators include the Division of Parks and Recreation at Merchant's Millpond and Albemarle Learning Center at Bennett's Millpond).

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats.

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., NC Division of Water Quality, US Fish & Wildlife Service, etc.) to minimize negative impacts on species and habitats.

- Support strengthening of water quality protection.
  - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (potential partners include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
  - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of streams, etc.) and reduce nutrient inputs (pesticide/herbicide use).
  - Support stormwater management and wastewater treatment plant improvements and upgrades.
  - Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations.
- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts; NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Land-use planning

- Work with county and city officials and developers to incorporate buffers along streams, implement low impact development, and better stormwater regulations (e.g., secondary and cumulative impacts; NCWRC 2002).
- Promote sustainable land use planning that considers long-term effects of development.
- Support dam and lock removal (work with US Fish & Wildlife Service, US Army Corps of Engineers, and private dam owners).

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.
  - Work with US Fish & Wildlife Service on listed species recovery plans, e.g., shortnose sturgeon.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Bogan, A.E. 2002. Workbook and key to the freshwater bivalves of North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000. Nonindigenous crayfishes threaten North American freshwater biodiversity: lessons from Europe. Fisheries 25(8):7–20.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

Moyle, P.B., and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127-169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York, NY.

N.C. Department of Environment and Natural Resources (NCDENR). 2003. Discover North Carolina's River Basins – Chowan River Basin. Office of Environmental Education, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2001. Basinwide assessment report for the Chowan and Pasquotank River basins. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

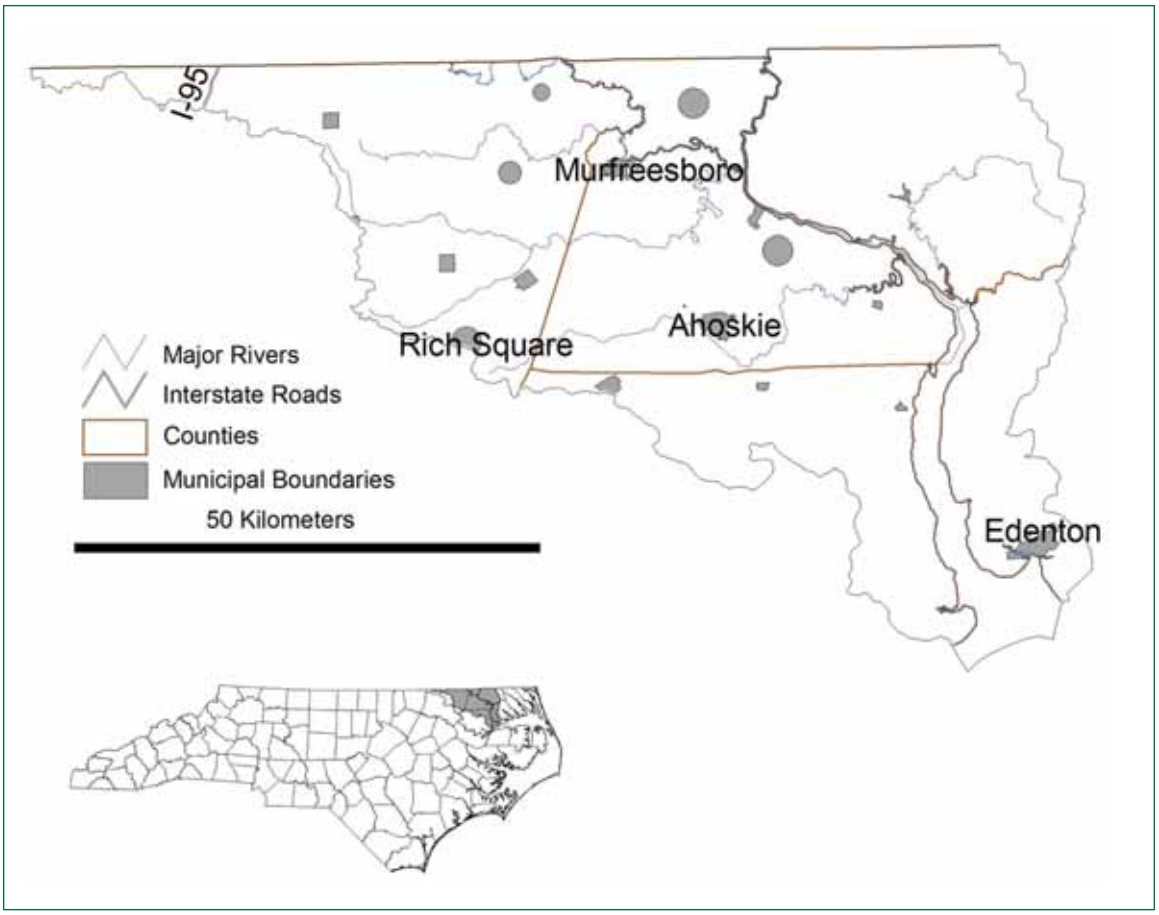
N.C. Division of Water Quality (NCDWQ). 2002. Chowan River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

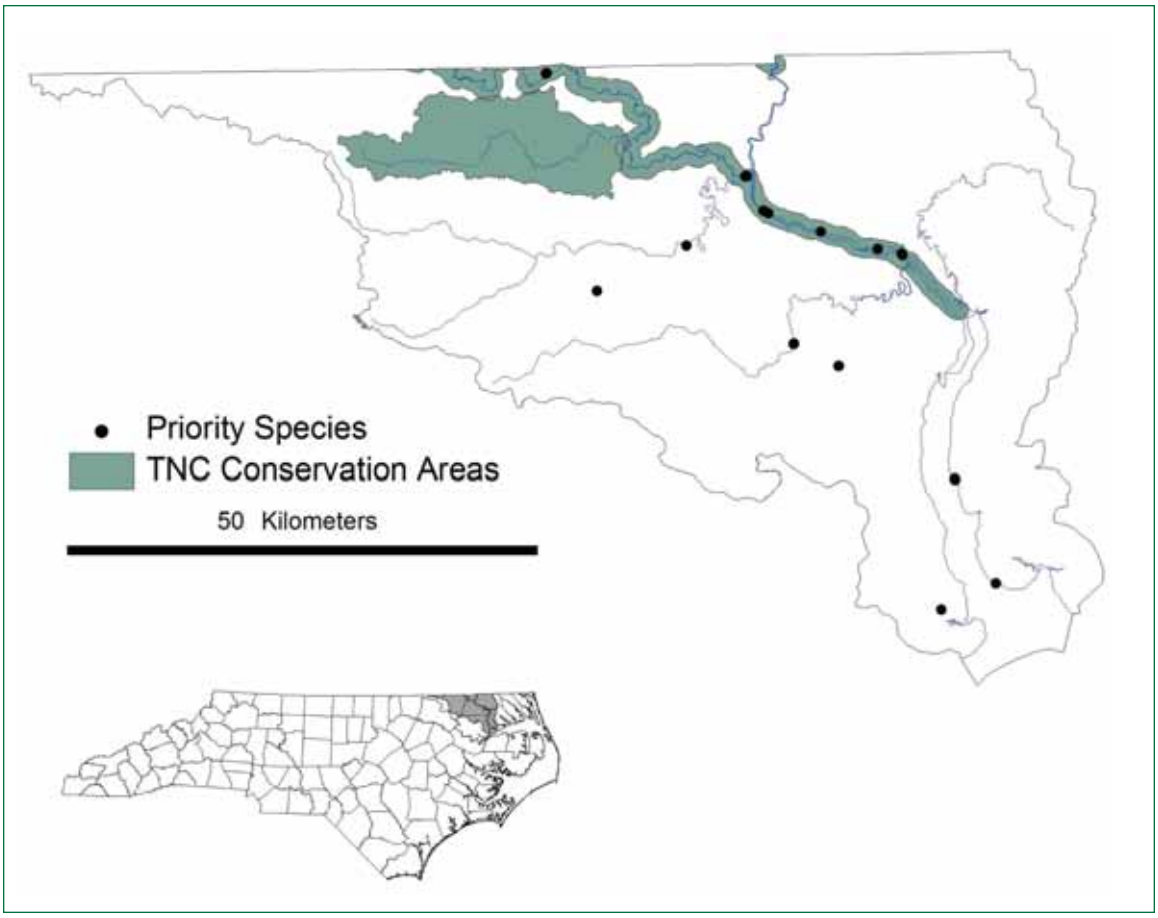
Shannon, R. W. and B. A. Doll. November 1999. Patience pays off. Pages 60–61 *in* Wildlife in North Carolina. N.C. Wildlife Resources Commission, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.



Map 5B.14a. Chowan River basin, political information.



Map 5B.14b. Chowan River basin, priority species occurrences and priority areas for freshwater conservation.

15. Pasquotank River Basin

Priority aquatic species in the Pasquotank River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser oxyrhynchus*	Atlantic Sturgeon	SC
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Fundulus cf. diaphanus	Lake Phelps Killifish	SR
	Notropis chalybaeus	Ironcolor Shiner	
	Petromyzon marinus	Sea Lamprey	

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.15a, 5B.15b):

The Pasquotank River basin is an Atlantic Slope drainage with a small portion of its headwaters in Virginia. The remainder of the basin lies in North Carolina's Coastal Plain and drains into Albemarle Sound. The Pasquotank is the fifth largest river basin in the state, encompassing 3,635 sq. miles, draining 474 miles of streams. The entire basin is 41% water, including 22,770 freshwater acres, 918,224 estuarine acres, and 111 miles of coast. The river flows as freshwater until tidal influence begins downstream of Elizabeth City. Major tributaries within the river basin include Alligator River, Perquimans River, Little River, Yeopim River, Scuppernong River, and North River (NCDWQ 2002).

The basin lies entirely in the Coastal Plain Physiographic region. The geology of this area consists of alternating layers of sand, silt, clay and limestone. Land in the basin is very flat. Low flows over the warmest months of the year limits streams' ability to maintain high dissolved oxygen levels (NCDWQ 2002).

There are 11 municipalities within the 10 counties in the basin. The largest municipalities are Elizabeth City, Hertford, Columbia, Manteo, and the Outer Banks north of Manteo. Basin population size (based on 2000 census) is 118,912 (NCDWQ 2002). Population density is 46 persons/sq. mi (2000 census; NCDWQ 2002). Land use in the basin is approximately 24% forest land, 22% crop and pasture land, and 3% urban (NCDWQ 2002). No major reservoirs exist in the basin.

The basin (which contains approximately 13% federal lands) contains more National Wildlife Refuges than any other basin in North Carolina (Pea Island National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, Currituck National Wildlife Refuge, Alligator River National Wildlife Refuge, Pocosin Lakes National Wildlife Refuge, and Mackay Island National Wildlife Refuge). Lake Phelps, located in Pettigrew State Park, is the state's second largest natural lake at 16,000 acres. Additionally, the basin contains the 70-mile long Cape Hatteras National Seashore (NCDENR 2003).

Lake Phelps, Alligator River and many of its tributaries, Swan Creek Lake, Stumpy Creek, The Frying Pan, Coopers Creek, and Sandy Ridge Gut have been designated as Outstanding Resource Waters (NCDWQ 2002). There are 150 miles of impaired streams in the basin (NCDWQ 2004).

B. Problems affecting species and habitats:

Physical habitat destruction is the primary threat to aquatic fauna within the Pasquotank River basin (NCDENR 2003). Basin waters have suffered from losses of riparian vegetation, straightening of streams, erosion of banks, and reductions of aquatic vegetation that serves as food and shelter for fish, birds, and other wildlife.

There are no interbasin transfers between the Pasquotank and other river basins. Water withdrawals, however, do occur, primarily for agricultural purposes (NCDWQ 2002).

Non-point pollution sources that degrade water quality include agriculture, animal operations, urban development, forestry, stormwater discharge, rural residential development, hydrologic modifications, and septic systems. Point-source pollution sources in the basin may include municipal waste water treatment plants, industrial facilities, reverse-osmosis water treatment facilities, and urban and industrial stormwater systems. As of 2001, there were 34 permitted wastewater discharges, 51 general stormwater permits, and 29 registered animal operations in the basin (NCDWQ 2002).

Human population is increasing throughout the basin, primarily in beach communities and particularly as a result of the formation of bedroom communities south of Chesapeake, Virginia. This type of growth will increase pressure and demand on wastewater treatment systems. High levels of fecal coliform stemming from human or animal wastes already have led to degradation of some shellfish beds (NCDENR 2003).

Historically, dioxin, a by-product of paper mill bleaching practices, degraded water quality and negatively affected aquatic biota. However, new bleaching technologies have reduced contaminates from paper plant wastewater that enter the basin (NCDENR 2003).

C. Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:

Inventory: distributional and status surveys – General surveys are needed to complete distributional status for fish priority species. Basin specific priorities include:

- Atlantic sturgeon – survey for abundance, population status, and migrations; effects of dams should be considered; should also conduct surveys for shortnose sturgeon because it could potentially use the rivers in this basin.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic work on banded killifish and Lake Phelps killifish; determine genetic relationship between the two.
- Support taxonomic research for other species as needed.

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies for priority species including habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation, migration patterns (where applicable).
- Determine vulnerability of priority species to specific threats; relate results to permit condition and review responsibilities.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
  - Performance of restoration projects.
  - Performance of dam removal projects to monitor short and long-term effects on species and habitats.
- Assess non-native species impacts:
  - Establish distribution and monitoring survey protocol for non-natives, possibly incorporating strategy into long-term monitoring for native species.
  - Determine effects of non-native species on natives

D. Conservation actions necessary to conserve the species and habitat and priorities for implementation:

Habitat conservation and restoration – Provide support for land protection (e.g., property purchase, land preservation agreements, buffers) and stream restoration (collaborate with Ecosystem Enhancement Program, NC Natural Heritage Program, US Fish & Wildlife Service, US Forest Service, Natural Resources Conservation Service, The Nature Conservancy, US Army Corps of Engineers).

- Support dam removal, as appropriate for stream restoration.
- Identify priority areas for habitat protection:
  - Priority areas for freshwater conservation in the Chowan River basin include (based on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.15b):
    - Lake Phelps
- Gain better understanding of land ownership in basin and begin prioritization of other important aquatic habitats (i.e. shoreline habitats, submerged aquatic vegetation beds in the sound).
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies to minimize negative impacts on species and habitats.

- Strengthen water quality rules/issues.
  - Support clean-up efforts and stricter enforcement of animal operations in addition to promoting animal waste treatment improvements and upgrades (cooperators include NC Division of Water Quality, Natural Resources Conservation Service, Albemarle Pamlico National Estuary Program, Ecosystem Enhancement Program, private corporations).
  - Promote programs to reduce working farm-related sedimentation/erosion (using best management practices, fencing livestock out of streams, etc.) and reduce nutrient inputs (pesticide/herbicide use).
  - Support stormwater management and wastewater treatment plant improvements and upgrades.
  - Promote protection of areas with good water quality through Outstanding Resource Water and High Quality Water designations.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Bogan, A.E. 2002. Workbook and key to the freshwater bivalves of North Carolina. N.C. Museum of Natural Sciences, Raleigh, NC.

Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000. Nonindigenous crayfishes threaten North American freshwater biodiversity: lessons from Europe. Fisheries 25(8):7–20.

Menhinick, E.F. and A.L. Braswell. 1997. Endangered, threatened, and rare fauna of North Carolina, Part IV. A reevaluation of the freshwater fishes. Occasional Papers of the N.C. Museum of Natural Sciences and the N.C. Biological Survey. Number 11.

Moyle, P.B., and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127-169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York, NY.

N.C. Department of Environment and Natural Resources (NCDENR). 2003. Discover North Carolina's River Basins – Pasquotank River Basin. Office of Environmental Education, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2002. Pasquotank River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

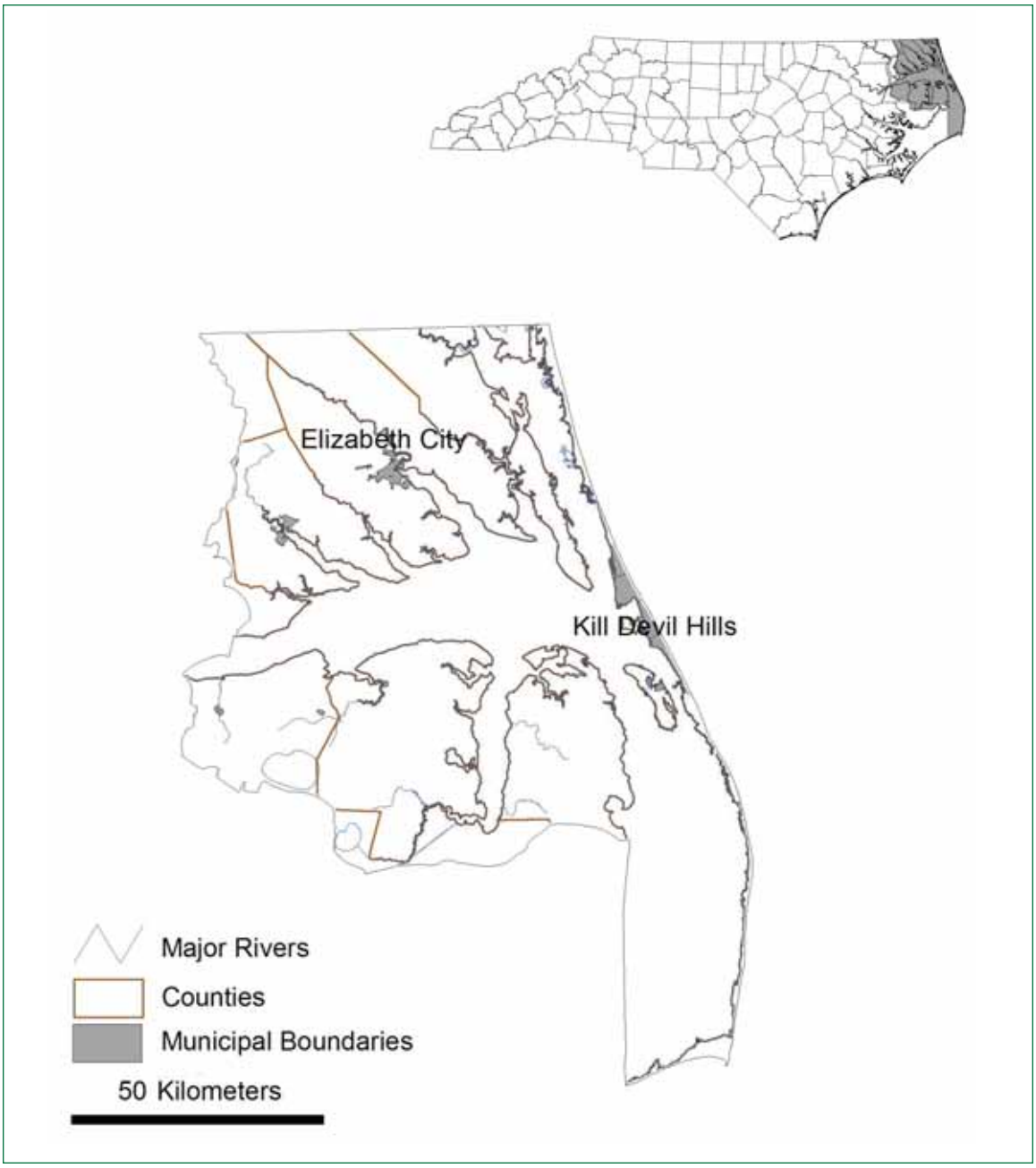
N.C. Division of Water Quality (NCDWQ). 2004. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

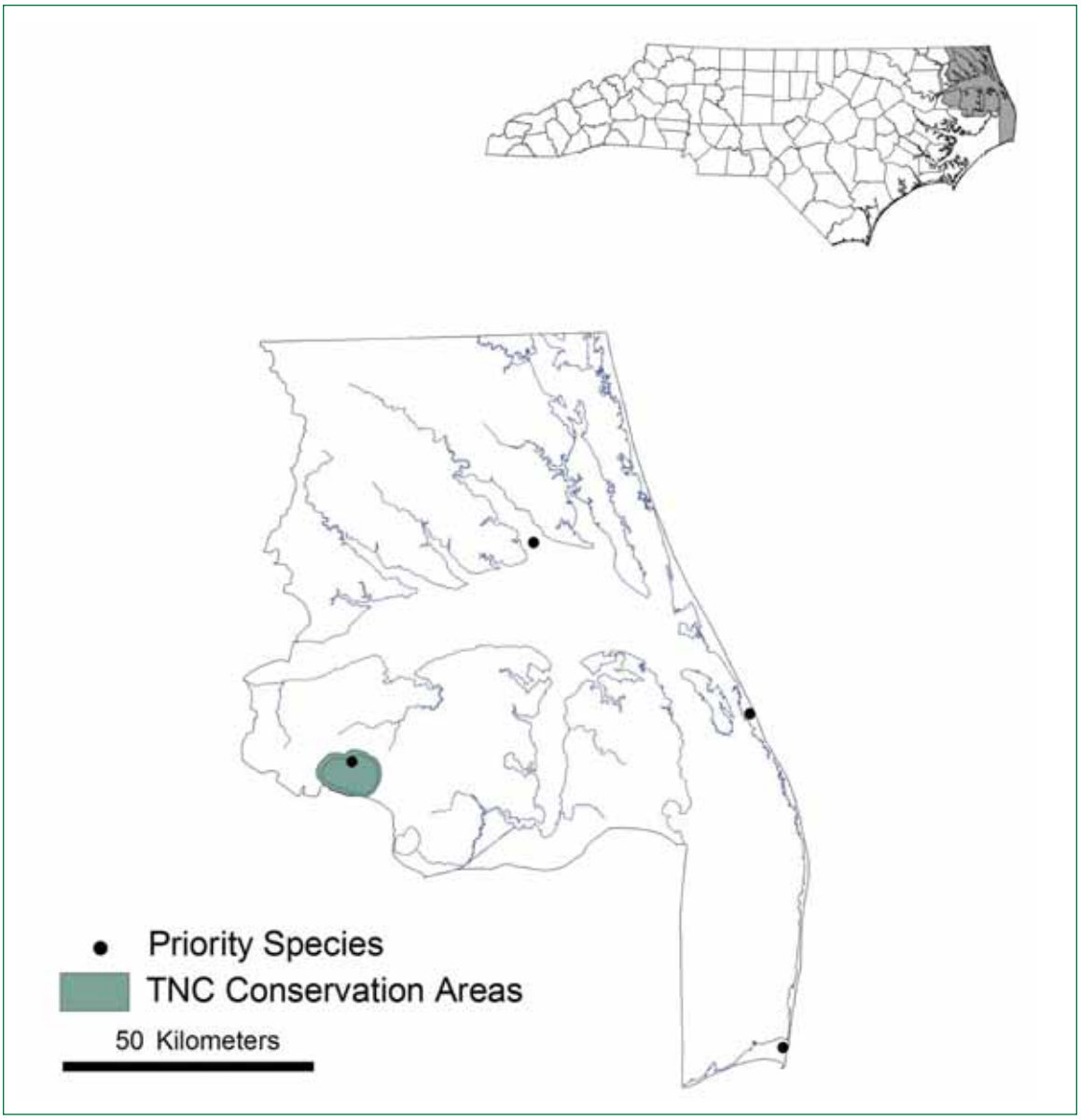
Shannon, R. W. and B. A. Doll. November 1999. Patience pays off. Pages 60–61 *in* Wildlife in North Carolina. N.C. Wildlife Resources Commission, Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.



Map 5B.15a. Pasquotank River basin, political information.



Map 5B.15b. Pasquotank River basin, priority species occurrences and priority areas for freshwater conservation.

16. Lumber River/Lower Pee Dee Basin

Priority aquatic species in the Lumber River/Lower Pee Dee River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish[1]	*Ameiurus brunneus*	Snail Bullhead	
	Cyprinella sp. (cf. zanema)	Thinlip Chub	
	Elassoma boehlkei	Carolina Pygmy Sunfish	T
	Elassoma evergladei	Everglades Pygmy Sunfish	
	Elassoma zonatum	Banded Pygmy Sunfish	
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Etheostoma mariae	Pinewoods Darter	SC
	Etheostoma perlongum	Waccamaw Darter	T
	Fundulus lineolatus	Lined Topminnow	
	Fundulus waccamensis	Waccamaw Killifish	SC
	Lepomis marginatus	Dollar Sunfish	
	Lepomis punctatus	Spotted Sunfish	
	Menidia extensa	Waccamaw Silverside	T (T)
	Notropis chalybaeus	Ironcolor Shiner	
	Notropis maculatus	Taillight Shiner	
	Noturus n. sp.	Broadtail Madtom	SC
	Poecilia latipinna	Sailfin Molly	
	Semotilus lumbee	Sandhills Chub	SC
Mussels	*Elliptio cistellaeformis*	Box Spike	
	Elliptio folliculata	Pod Lance	SC
	Elliptio icterina	Variable Spike	
	Elliptio marsupiobesa	Cape Fear Spike	SC
	Elliptio waccamawensis	Waccamaw Spike[2]	E
	Lampsilis cariosa	Yellow Lampmussel [2]	E
	Lampsilis fullerkati	Waccamaw Fatmucket[2]	T
	Lampsilis radiata radiata	Eastern Lampmussel[2]	T
	Leptodea ochracea	Tidewater Mucket[2]	T
	Villosa delumbris	Eastern Creekshell[2]	SR
Crayfish	*Procambarus ancylus*	Edisto Crayfish	
	Procambarus blandingii	Santee Crayfish	
	Procambarus braswelli	Waccamaw Crayfish	SC
Snails	*Amnicola sp.*	Waccamaw Snail	SC
	Cincinnatia sp.	Waccamaw Siltsnail	SC
	Viviparus intertextus	Rotund Mysterysnail[2]	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

[1] Brook silverside (*Labidesthes sicculus*) is a native priority fish species in the Little Tennessee basin, but is a non-native in the Yadkin-PeeDee and Lumber basins. In non-native basins, this species is not a priority for conservation. Rather, monitoring and possible control of range expansion of the species should be initiated.

[2] Species is only found in Lake Waccamaw, not in the Lumber River basin proper.

A. *Location and condition of basin (see Maps 5B.16a, 5B.16b):*

The Lumber basin is located in the southeastern corner of North Carolina and the northeast corner of South Carolina. The headwaters of the Lumber River originate in the Sandhills region (a notable center of endemism) in the northwest corner of the Lumber basin. The remaining portion of the basin occurs in the Coastal Plain region. The Lumber River, Little Pee Dee, Waccamaw and Carolina-Coastal constitute four major hydrological units within the basin. The basin can be divided into two types of waters based upon physiographic attributes (NCDWQ 2003):

1) Sandhills Region – waterbodies are typified by flowing sandy streams, supplied by groundwater and rainfall, and are primarily located in the northwestern portion of the basin (constituting one-third of the basin).

2) Coastal Plain – waterbodies are typically meandering and are associated with swamps, hardwood bottoms, wetland communities, peatlands (these waterbodies also have low assimilation, i.e., ability to handle any oxygen consuming wastes).

In the Lumber River basin, all but two rivers flow into the Pee Dee River in South Carolina. The Shallote and Lockwoods Folly Rivers drain directly to the Atlantic Ocean. The Lumber River mainstem is the only North Carolina blackwater river designated as a National Wild and Scenic River.

The total area of the basin is 3,336 sq. miles, with 2,232 freshwater stream miles and 8,965 freshwater lakes acres (NCDWQ 2003). There are 4,305 total estuarine acres and 25 coastline miles. The Lumber basin contains 51 municipalities, with the cities of Lumberton, Laurinburg, and Whiteville being the largest urban areas. Population size in 2000 was 304,579 corresponding to a density of 92 persons/sq. mile (NCDWQ 2003). The population is expected to increase by 45% before 2010 (NCDWQ 2003).

Land use in the basin is 60% forest land, 25% agricultural/cultivated cropland, 7.1% urban, and 8% other (rural transport., small water areas, lake, and estuaries; NCDWQ 2003). Two thirds of the forest land in the basin is held by non-industrial private landowners. The remaining third of the forest land is owned by the forest industry. Impaired streams in the Lumber basin total 252 miles (NCDWQ 2003). Causes of impairment include mercury and fecal coliform (NCDWQ 2003). Sources of pollutants contributing to impairment include industrial and municipal emissions, municipal wastewater outfalls, urban runoff/storm sewers, and discharges from animal farms. Despite the impairments in the basin, the Lumber River basin contains three Outstanding Resource Waters (NCDWQ 2004), including Naked Creek, Rocky Ford Branch, and Lake Waccamaw. Lake Waccamaw is a notable center of endemism in the southeast (Smith et al. 2002).

B. *Problems affecting species and habitats:*

Numerous problems affect species and their habitats within the Lumber River basin. Sources of non-point pollution in the basin include agriculture, forestry, construction, and stormwater discharges. The major pollutant in this group is sedimentation. Activities that contribute to stream habitat degradation in the basin include land-clearing (forestry, urban development), agriculture activities, and wetland fills. The Lumber basin has a high concentration of swine farms. Poor or improper management of animal discharges contributes to organic pollution in the basin and results in high concentrations of fecal coliform. Other point sources include industrial and municipal discharges that contribute toxic compounds and elements such as ammonia, chlorine, and mercury.

Our knowledge of aquatic species distributions in the basin is inadequate; general surveys are needed throughout much of the Lumber River basin. We also have a poor understanding of life history and habitat use for many species, knowledge that is critical for managing these populations. We have difficulty monitoring known populations of rare species at regular intervals, which is needed to track changes in abundance and habitat quality. In addition, there are few long-term data sets or monitoring sites. Distributional surveys of invasive species (e.g., flathead catfish, red swamp crayfish) are also needed.

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status of fish, mussels, crayfish, and snails (in order of need).

- Basin specific priorities include *Elassoma spp.* (pygmy sunfish species), the broadtail madtom, Sandhills chub.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions are needed for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms.

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio*.
- Support completion of species descriptions for undescribed taxa.

Research to facilitate appropriate conservation actions

- Research should focus on life history studies of priority species and for taxa which little information is known.

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol and schedule for long-term monitoring of priority species (collaborate with the NC Division of Water Quality, NC Museum of Natural Science, and the US Fish & Wildlife Service).
  - Monitor populations of fishes and mussels occurring in Lake Waccamaw (e.g., Waccamaw darter, Waccamaw killifish, Waccamaw silverside, Waccamaw spike, Waccamaw fatmucket) to assess the effect of land use changes and practices in the surrounding watershed.
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
- Assess non-native species impacts:
  - Determine distribution of non-native species in the Lumber River basin and their potential effects on native species

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Habitat conservation and restoration – Provide support for land protection (e.g., acquisition, easements, buffers).

- Work with local conservation and watershed groups to promote and protect the Lumber watershed (e.g., NC Natural Heritage Program, US Fish & Wildlife Service, Natural Resources Conservation Service, Ecosystem Enhancement Program, Lumber River Conservancy, Friends of Lake Waccamaw State Park, The Nature Conservancy, Winyah Rivers Foundation, Waccamaw Riverkeeper, Lumber River Consortium).
- Identify priority areas for habitat protection (areas with high species diversity, rare species, and endemic species). Identify specific areas that are critical to the survival of species (e.g., spawning areas) and/or diverse communities.
  - Priority areas for freshwater conservation in the Lumber River basin include (based in part on Smith et al. 2002, NC Natural Heritage Program, and Commission data) (see Map 5B.16b): :
    - Lumber River and sandhills tributaries
    - Ashpole Creek/Hog Swamp

  - o Little Pee Dee River sandhills tributaries
  - o Waccamaw Lake and River/Juniper Swamp
  - o Royal Oak Swamp

- Promote and support conservation and restoration efforts within the Commission.
  - – Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Population management and restoration

- Reintroduce or augment rare mollusk and fish species populations in areas where water quality and stream habitats have recovered sufficiently to support them.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - – Deliver oral presentations.
  - – Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (e.g., US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service, etc.) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - – Support water quality rules and watershed designations that conserve habitats for priority aquatic species. Outstanding Resource Water and High Quality Water designations should be supported wherever the criteria for designation are met, especially in watersheds that support priority species.

  - Support incentive and information programs that help reduce sedimentation/erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, modernize wastewater treatment facilities, etc.
  - Specific issues needing to be addressed in this basin include:
    - Secondary and cumulative impacts upon water quality
    - Buffer ordinances
    - Water supply watershed protection
    - Ordinances more stringent than state requirements
    - Protect headwaters

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishment of riparian buffers along streams, implementation of low impact development and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - Focus analysis and synthesis of inventory and monitoring data and reporting to inform decision making pertaining to initial species listing and status revision.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Adams, W. F. (Chairman), Alderman, J.M., Biggins, R. G., Gerberich, A.G., Keferl, E. P., Porter, H.J., Van Devender, A. S. 1990. A report on the conservation status of North Carolina's freshwater and terrestrial molluscan fauna. Prepared by: The Scientific Council on Freshwater and Terrestrial Mollusks in accordance with Article 25 of Chapter 113 of the General Statutes of North Carolina.

Fuller, P. L., L. G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Fullerton, A.H. and J.E. Cooper. 2002. Status inventory of uncommon crayfishes in North Carolina. Final Report 2001: Savannah, French Broad, and Lumber (Waccamaw) river basins. N.C. Wildlife Resources Commission, Raleigh, NC.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

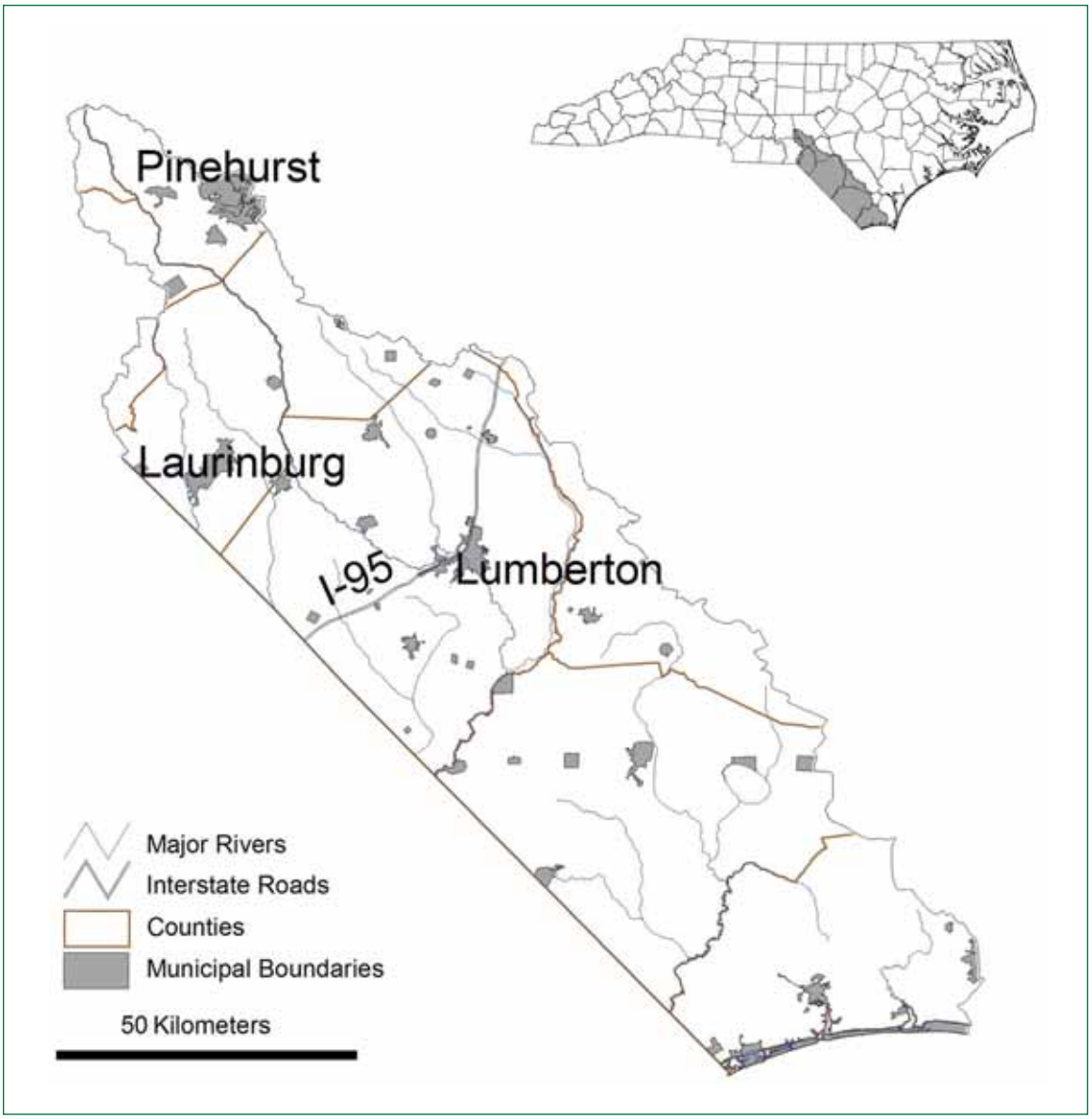
N.C. Division of Water Quality (NCDWQ). 2000. North Carolina's 2000 303(d) List. N.C. Department of Environment and Natural Resources, Division of Water Quality – Planning Branch. Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2003. Lumber River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

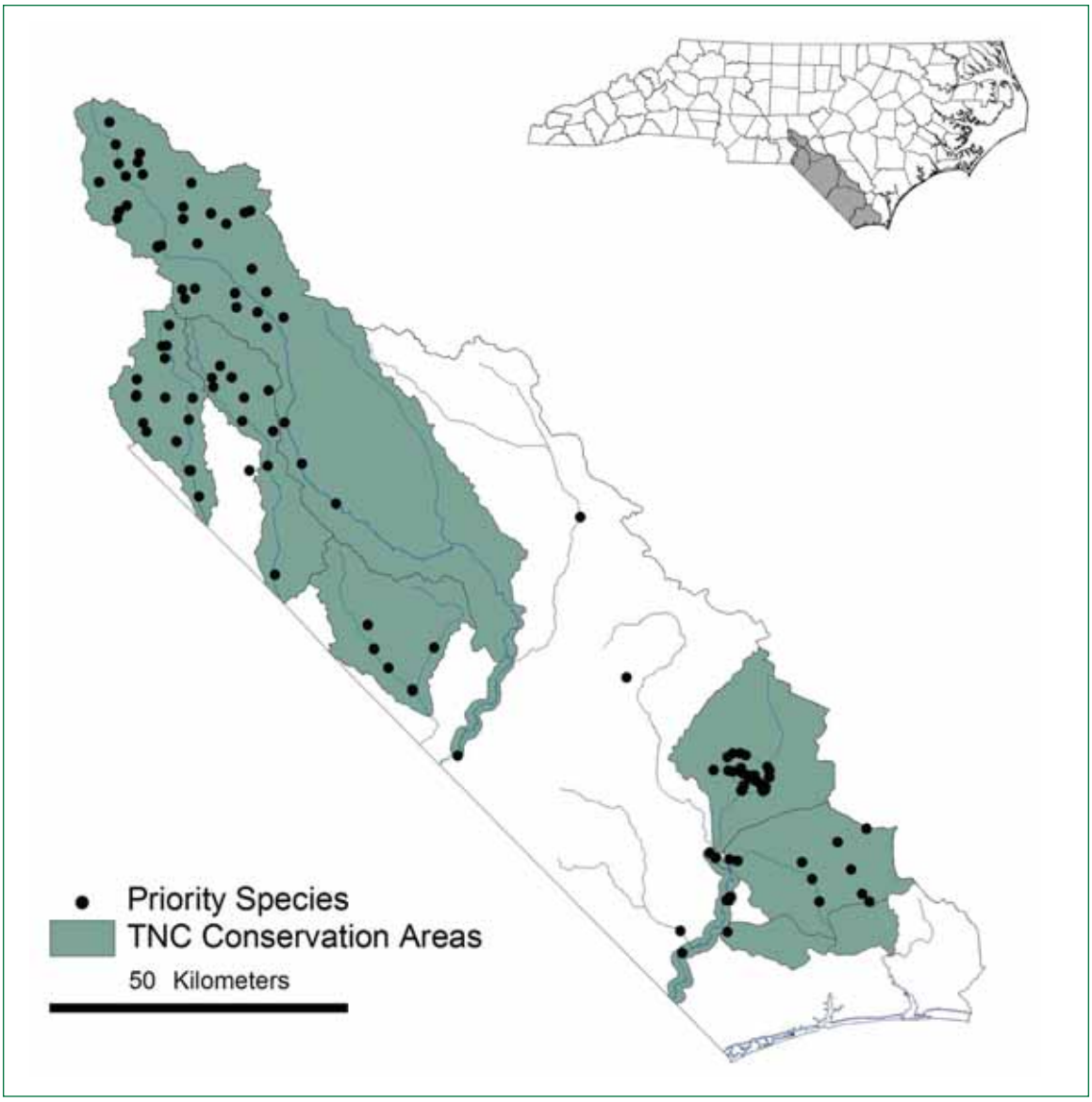
N.C. Division of Water Quality (NCDWQ). 2004. (BIMS) Basinwide Information Management System. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC. http://h2o.enr.state.nc.us/bims/: accessed August 9, 2004.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.



Map 5B.16a. Lumber River basin, political information.



Map 5B.16b. Lumber River basin, priority species occurrences and priority areas for freshwater conservation.

17. White Oak River Basin

Priority aquatic species in the White Oak River basin:

Group	Scientific Name	Common Name	State Status (Federal Status)
Fish	*Acipenser oxyrhynchus*	Atlantic Sturgeon	SC
	Enneacanthus chaetodon	Blackbanded Sunfish	
	Enneacanthus obesus	Banded Sunfish	
	Erimyzon sucetta	Lake Chubsucker	
	Fundulus lineolatus	Lined Topminnow	
	Notropis chalybaeus	Ironcolor Shiner	
Mussels	*Elliptio icterina*	Variable Spike	
Crayfish	*Procambarus plumimanus*	Croatan Crayfish	SR

Note: As a coastal basin, information contained in Chapter 5C (Marine Systems), especially related to the Coastal Habitat Protection Plan (Street et al. 2004), may also apply to this basin.

A. Location and condition of basin (see Maps 5B.17a, 5B.17b):

This basin lies entirely within the Coastal Plain, and includes four small separate river systems (New River, White Oak River, Newport River, and North River). The White Oak River basin encompasses 1,264 sq. miles, 446 stream miles, and 130,009 estuarine acres (NCDWQ 2001). Sixteen municipalities are located in whole or in part of the basin.

Land use in the basin is 49% forest and wetlands, 8% urban and built-up, and 6% agriculture. From 1982-1997 there was an 81.6% increase in the amount of developed land (NRCS 2001). Public lands make up a large portion of this basin and include: Croatan National Forest, Hoffman State Forest, and Camp Lejeune. The estimated 1990 human population was 149,032 and is predicted to increase to 188,403 by 2015 (NCDWQ 2001).

There are a number of impaired (303 d list) streams in this drainage, totaling 169.3 miles (NCDWQ 2001). There are 58 waterbodies (stream reaches, intercoastal waterways, bays) that have a NC Division of Water Quality Outstanding Resource Waters (ORW) classification and 174 waterbodies that have High Quality Waters (HQW) classification.

B. Problems affecting species and habitats:

Our knowledge of aquatic species distribution is inadequate within the White Oak River basin and general surveys are needed in most areas. We have a poor understanding of life history and habitat use for many species which is critical for managing these populations. It is difficult to monitor known populations of rare species at regular intervals which is needed to track changes in abundance and habitat quality. In addition, there are few long term data sets or monitoring sites. Invasive species have become established in the White Oak River basin, which may negatively impact native species populations (Fuller et al. 1999).

Water quality is degraded by excessive nutrient input (such as waste water treatment plants, industry, agriculture, and hog/chicken farms; NCDWQ 2001). In the White Oak River basin there are 50 permitted discharges (four of which are major discharges with ≥ 1 million gallons per day; NCDWQ 2001).

C. *Priority research, survey, and monitoring efforts needed to identify factors to assist in restoration/conservation of species:*

Inventory: distributional and status surveys – General surveys are needed to complete the distributional status for fish, mussels, crayfish, and aquatic snails. Areas where distributional surveys should be focused can be identified using the Commission's aquatic nongame database and NC Natural Heritage Program data.

Taxonomic resolution: support species descriptions and diagnoses – Formal descriptions for known or putative undescribed species, as well as investigations aimed at resolving taxonomic or evolutionary status of locally variable forms are needed

- Support genetic studies to help improve our understanding of the mussel genus *Elliptio.*

Research to facilitate appropriate conservation actions – Research should generally focus on life history of priority species.

- Conduct life history studies of priority species to address habitat use/preferences, spawning location and timing, fecundity, population dynamics, feeding, competition, predation.
- Determine vulnerability of priority species to guide permit regulations (moratoria).

Monitoring – Long-term monitoring must be improved across species groups, habitats, and management actions. We must develop monitoring plans that coordinate with existing monitoring programs and overall goals and objectives wherever possible.

- Conduct long-term monitoring to identify population trends:
  - Establish protocol, schedule, and locations for long-term monitoring of priority species (collaborate with NC Division of Water Quality, NC Museum of Natural Sciences, US Fish & Wildlife Service).
- Conduct special purpose monitoring:
  - Performance of stream restoration projects.
- Assess non-native species impacts:
  - Examine distribution of exotics in the White Oak River basin and their effects on native species.

D. *Conservation actions necessary to conserve the species and habitat and priorities for implementation:*

Habitat conservation and restoration – Provide support for land protection and stream restoration (acquisition, easements, and buffers).

- Support stream protection/restoration by working collaboratively with other organizations including: Ecosystem Enhancement Program, NC Natural Heritage Program, Natural Resource Conservation Service; The Nature Conservancy, other non-profits, and the US Forest Service (Croatan National Forest).
- Identify priority areas for habitat protection by locating areas with high species diversity, rare species, and endemic species. Identify specific areas that are critical to the survival of priority species(e.g., particular streams or spawning sites), such as ironcolor shiner, blackbanded and banded sunfish, Croatan crayfish):
  - Priority areas for freshwater conservation in the White Oak basin include (based in part on Smith et al. 2002) (see Map 5B.17b):
    - White Oak River
    - Newport River
- Promote and support conservation and restoration efforts within the Commission.
  - Incorporate aquatic priorities into the Watershed Enhancement Program prioritization process, and into Game Lands and acquisitions.

Data collection, management, and dissemination among agencies

- Improve the quality of data obtained from survey permit holders (this includes capturing data from standard scientific collection permit reports, as well as endangered species permits).
- Improve data exchange with NC Natural Heritage Program.

Partnerships – Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts.

- Coordinate sampling with other resource groups.
- Issue collection permits for research activities and educational purposes that help achieve specific conservation goals and objectives.
- Support the development and application of an aquatic nuisance species management plan with other agencies/groups.
- Participate in guidance of academic research projects to help achieve specific conservation goals and objectives.

Education/outreach

- Develop new web-based resources; improve and maintain existing web resources (mussel, crayfish, and fish atlases, etc.).
- Develop and disseminate print media, including stand alone documents, press releases, newspaper and magazine articles, and displays.
- Direct public involvement/outreach:
  - Deliver oral presentations.
  - Participate in educational activities.
- Seek opportunities for direct outreach throughout the basin.

Species and habitat protection efforts

Technical guidance and permit review – Minimize negative impacts on species and habitats (partners include: US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, Federal Energy Regulatory Commission, US Fish & Wildlife Service).

- Increase efficiency and effectiveness of the technical guidance and permit review process.
- Provide technical guidance to conserve habitats for priority species.

Water quality and habitat protection – Work with regulatory agencies (US Army Corps of Engineers, NC Division of Water Quality, NC Division of Land Quality, US Fish & Wildlife Service, etc.) to conserve and restore water and habitat quality.

- Support strengthening of water quality protection.
  - Promote programs that help farmers reduce sedimentation/erosion (install fences to keep live stock out of streams and improve tilling practices) as well as reduce pesticide and herbicide use.
  - Promote programs to help modernize wastewater treatment facilities and inform public about proper upkeep of septic systems.
  - Protect existing good water and habitat quality throughout the basin (ORW and HQW streams).
  - Promote programs to upgrade hog and chicken farms waste treatment.

Land-use planning – Improve coordination with local and regional land-use planning efforts to affect water quality and habitat conservation.

- Support establishing riparian buffers along streams, implement low impact development, and better stormwater management (e.g., secondary and cumulative impacts, NCWRC 2002) through program coordination, cooperative projects, and technical guidance.

Species protection – Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats.

- Support federal and state species listing processes.
  - When warranted, make recommendations for state listing to the Commission's Nongame Wildlife Advisory Committee.

Permitting – Help ensure that reliable information is provided for project impact assessments by issuing endangered species and scientific collection permits to qualified applicants.

- Improve processes for reviewing applications and tracking performance of permit holders.
- Support education opportunities for potential applicants.

Supporting References

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Natural Resources Conservation Service (NRCS). 2001. 1997 National Resources Inventory, updated June 2001. U.S. Department of Agriculture, North Carolina State Office, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2001. White Oak River basinwide water quality plan. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

N.C. Division of Water Quality (NCDWQ). 2004. North Carolina water quality assessment and impaired waters list [2004 integrated 305(b) and 303(d) report]. N.C. Department of Environment and Natural Resources, Division of Water Quality, Raleigh, NC.

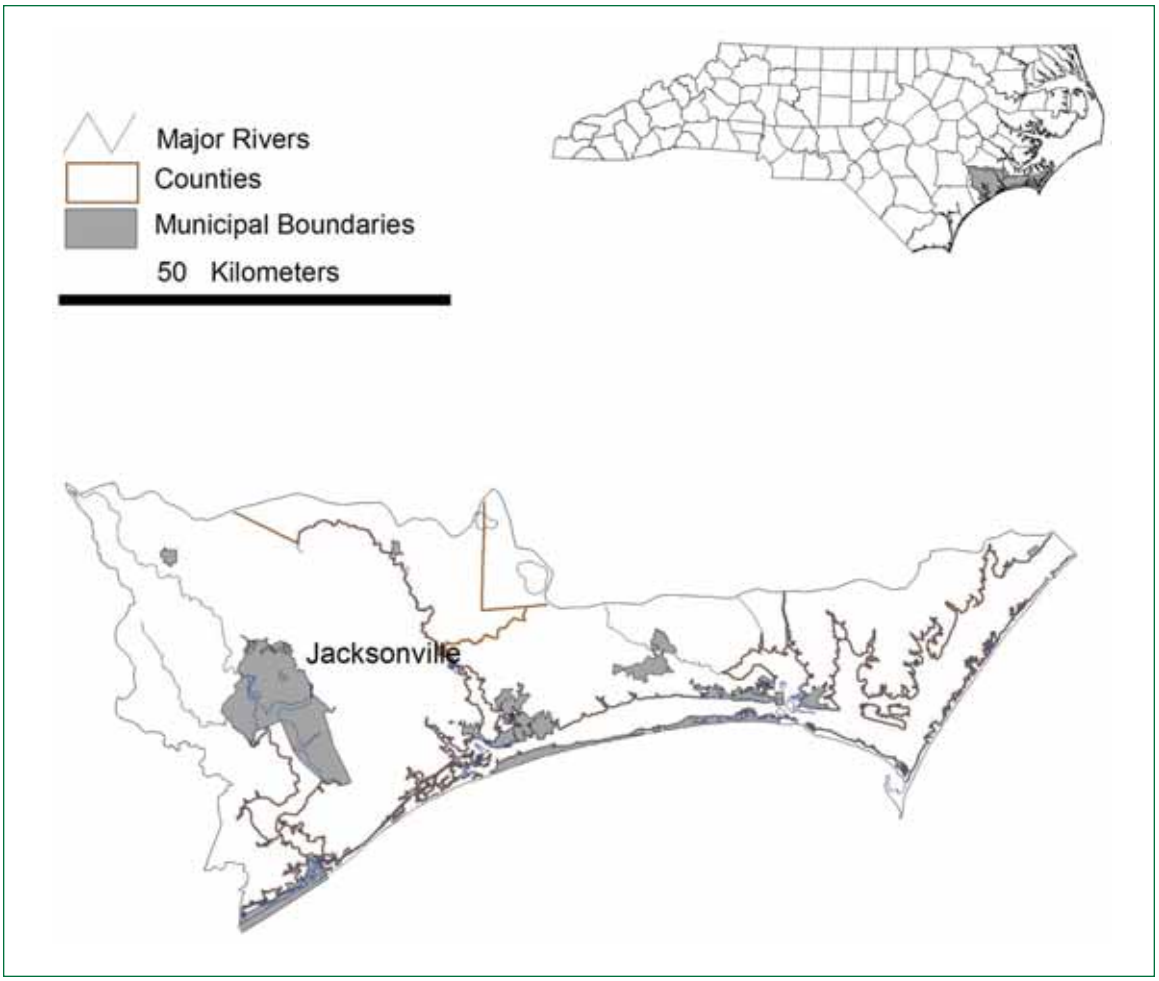
N.C. Wildlife Resources Commission (NCWRC). 2002. Guidance memorandum to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality. Raleigh, NC.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

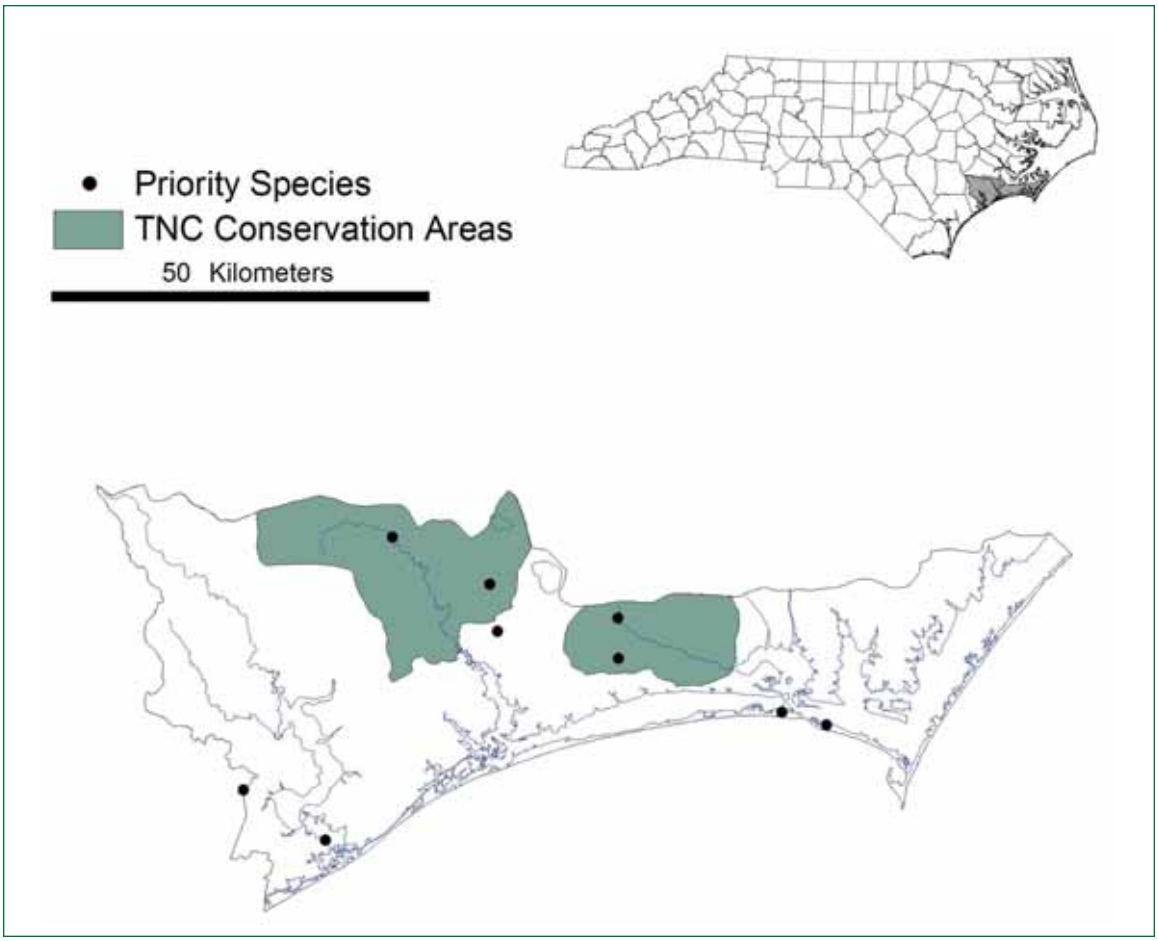
Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25:7–31.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18:6–22.



Map 5B.17a. White Oak River basin, political information.



Map 5B.17b. White Oak River basin, priority species occurrences and priority areas for freshwater conservation.

5C. Marine Systems

The management and protection of pelagic, migratory, or other marine species fall under a host of jurisdictions in North Carolina depending on the location of the species at a given point in time, as does the management of coastal, estuarine and marine habitats that are critical to marine species survival. This presents a constant challenge to resource managers in that coordinated efforts among multiple agencies are necessary to effectively manage the fish and wildlife resources of the state.

Pelagic and marine species were not directly prioritized in the process described in Chapter 2, for reasons of jurisdictional limitations, a lack of information, and/or practicality within the time-frame for completion of the first iteration of the Plan. However, we cannot ignore the marine habitats of North Carolina within the Plan. In this chapter, like those previous, we outline critical direction for the management and conservation of those resources. We have developed the chapter, and the priorities identified within, by reviewing existing information sources on marine and pelagic species and habitats.

Pelagic Birds

North Carolina plays a key role in the life cycle of many migratory shorebirds, thus conservation activities directed at shorebird stopover or breeding habitats (primarily beach, dune, estuarine, and coastal marsh habitats) can have a substantial impact on shorebird conservation. The impact that conservation efforts in North Carolina can have on pelagic birds (birds that spend most of their life feeding and living on the open ocean, coming to land only to breed) is less direct, especially since none of the pelagic bird species listed below breed in North Carolina (except the occasional sooty tern). Key breeding areas for these pelagic species include the Arctic region, the north Atlantic, the West Indies/Caribbean, and other portions of the south Atlantic. Still, all efforts to promote activities that aid in research, management, and conservation of pelagic bird species should be pursued whenever possible in North Carolina.

Priority Species

The following list (Table 5C.1) identifies pelagic bird species priorities in the Southeast, as indicated by various bird conservation efforts. (*Note:* Some species may be priorities in the region but are, in fact, extremely rare to North Carolina waters).

Key Pelagic Habitats

The Gulf Stream, a warm water current which runs roughly parallel to the North Carolina coast, is a critical region for pelagic birds in North Carolina between the months of May and October (especially that segment offshore from Oregon Inlet to south of Cape Hatteras) due to the interplay with the southbound Labrador current, which creates an up-welling of nutrient-rich waters. Key pelagic species with this region include the black-capped petrel and other tubenoses. Cold inshore waters are a critical zone during wintertime. Key pelagic species associated with this region include gannets, loons, and alcids.

Management

Management of pelagic birds in the United States falls under the jurisdiction of the US Fish & Wildlife Service. To address concerns about negative interactions with marine fisheries, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Unit (hereafter NOAA Fisheries) works with the US Fish & Wildlife Service, regional fisheries management councils and coastal states through the Interagency Seabird Working Group. As a part of this Working Group's effort, in 2001 NOAA Fisheries (then called the National Marine Fisheries Service, NMFS) began implementing the National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (NMFS 2001). In that same year it was established that, by Executive Order, every Federal agency whose actions are likely to negatively impact migratory bird populations must enter into a Memorandum of Understanding with the US Fish & Wildlife Service (Murphy 2004a).

Table 5C.1. Priority pelagic bird species in the southeastern United States.

Species	Priority Listing Source[1] and Associated Conservation Rank				Federal Protection Status
	USFWS[2]	NC PIF[3]	NAWCP[4]	SAMBI[5]	
Bermuda Petrel	IM	EH	HC	H	Endangered
Black-capped Petrel	IM	EH	H	H	
Fea's Petrel		EH			
Herald (Trinidade) Petrel		EH	HC		
Audubon's Shearwater	IM	H	H	H	
Cory's Shearwater	MA	H	M	M	
Greater Shearwater	MA	PR	HC	HC	
Manx Shearwater	MA		M	HC	
Sooty Shearwater	MA		M	H	
Band-rumped Storm-petrel	MA		H		
Leach's Storm-petrel			L	M	
Wilson's Storm-petrel		PR		L	
Red Phalarope	MA				
Bridled Tern	MA		HC	HC	
Roseate Tern	PR		HC	H	Threatened
Sooty Tern			M	M	
Long-tailed Jaeger			L	M	
Parasitic Jaeger			L	L	
Pomarine Jaeger			L	L	
Northern Gannet	MA			H	
White-tailed Tropicbird			HC	HC	
Common Loon	MA	M		*	
Red-throated Loon	MA			*	

The South Atlantic Migratory Bird Initiative (SAMBI) Pelagic Bird Conservation Plan (2004), while still in draft format, is a key resource to direct conservation and management actions for pelagic bird species in the southeastern United States. The plan identifies information on ecology and status, priority species, species suites, and habitat requirements, population issues, habitat issues, implementation recommendations and opportunities, conservation strategies, inventory and monitoring needs, research needs, education and outreach needs, and potential partners. Key information taken from that report is summarized below. The Partners In Flight bird conservation plan for the South Atlantic Coastal Plain (Hunter et al. 2001) also presents similar information.

Threats

The major issues facing pelagic seabirds in offshore and nearshore waters are 1) conflicts with fisheries, 2) oil and hazardous materials, and 3) debris ingestion and entanglement.

[1] See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

[2] USFWS key (Hunter 2004a): IM = Immediate Management needed; MA = Management Attention needed; PR = Long-term planning and responsibility needed

[3] NC PIF key (Johns 2004): EH = Extremely high conservation concern; H = High conservation concern; M = Moderate conservation concern; PR = Present (or possible) but not a priority for physiographic area; may need further monitoring/research attention in NC, more information on current distribution and trends may be needed in localized areas

[4] NAWCP key (Kushlan et al. 2002): H = Highly imperiled; HC = High concern; M = Moderate concern; L = Low concern

[5] SAMBI key (SAMBI 2004): H = Highly imperiled; HC = High concern; M = Moderate concern; L = Low concern; *added due to inshore bycatch

Conflicts with Fisheries

Marine fisheries exact a significant toll on ocean-feeding birds through incidentally catching and killing seabirds (bycatch). Long line, gillnets, and other fishing gear can prove fatal. In North Carolina, the red-throated loon may be the most heavily impacted by gillnets. Excessive bycatch of forage fish as well as fisheries using the same prey used by waterbirds can reduce the birds' food supplies. Trawls that affect the sea bottom alter the habitat on which the prey of seabirds and coastal waterbirds depend.

Oil and Hazardous Materials

Oil is a major environmental threat to pelagic species, especially along major shipping transportation corridors. Oil may be released during platform construction, offshore drilling, and shipping and spillage. Waterbirds are commonly injured by oil spills, chronic oil discharge in bilge water, and hazardous materials releases. Additionally, lights on drilling structures may disorient, attract, or confuse some pelagic birds, resulting in injury or death.

Debris Ingestion and Entanglement

Seabirds ingest materials and debris as a natural consequence of foraging. Ingesting plastics and other artificial flotsam can be detrimental. Additionally, seabirds are caught in discarded fishing line, nets, and other waste.

Habitat Issues

Major habitat issues for all species include loss and degradation of habitat.

Loss of Habitat

Seabirds congregate throughout the year, and in non-nesting seasons they congregate at roosts and loafing areas. These sites require both protection and management to maintain their value to seabirds.

Degradation of Habitat

Conflicts with fisheries, oil and hazardous material issues, and offshore pollution contribute to the degradation of foraging habitat for many pelagic species, particularly in shipping channels and areas heavily used by the marine fisheries industry. Mass harvest of sargassum would affect forage prey base for pelagic species. Harvest or overharvest of menhaden populations may affect forage prey base for pelagic seabirds.

Conservation Recommendations

Where appropriate, the recommendations put forth in the SAMBI Plan, and included below, should be incorporated into pelagic bird conservation efforts in North Carolina by all partnering agencies and organizations. (*Note:* Some the recommendations are not necessarily attainable in North Carolina, but are included below in order to highlight the need for cooperation and coordination among states and countries to affect change.)

Implementation Recommendations and Opportunities

- Key needs are detailed for black-capped and Bermuda petrels, most of which are centered in the Caribbean (Bermuda, Hispaniola, Lesser Antilles).
- Follow through on all South Atlantic-Caribbean seabird connections as outlined in the forthcoming publication, *Atlas of Breeding Seabirds of the West Indies—an International Workshop*, to set regional priorities for all the West Indies.
- International cooperation on a "Housing Grant" for white-tailed tropicbirds within the West Indies (transportable artificial nesting structures).

Policy

- Seabird conservation efforts should develop partnerships with fishery industries and sport anglers.
- Impacts to seabirds from offshore and inshore fisheries should be addressed in all future fishery plans.
- The policy of elimination of waterbird by-catch in fisheries should be embraced by all fisheries management entities (in North Carolina, appropriate agencies include the Commission, NC Division of Marine Fisheries, NOAA Fisheries, the US Fish & Wildlife Service, and the Atlantic States Marine Fisheries Commission). Two specific issues relevant to North Carolina include:
  - Bird by-catch in gillnets (especially for red-throated loon, common loon, and northern gannet) (Hunter 2004b).
  - Pelagic longline by-catch (especially for black-capped petrel, Bermuda petrel, Audubon's shearwater) (Hunter 2004b).
- Oil effects on seabirds should be minimized through increased enforcement of shipping activities, safe operational procedures, spill clean-up, and rehabilitation of oiled birds.
- Dumping of debris, line, and nets should be prohibited and strictly enforced.
- Non-persistent lines, nets, and traps should be developed.

Inventory and Monitoring

- Species specific monitoring needed for: white-tailed tropicbird, Audubon's shearwater, and roseate tern.
- Death and morbidity of seabirds should be monitored wherever it occurs.
- Important foraging, migrating, and wintering seabird areas should be identified and monitored.
- Increase monitoring of seabird by-catch (*also see above to related policy needs*).
- Seasonal population estimates, distribution, and abundance information for seabirds is needed in the Southeastern United States Continental Shelf.

Research

- Examine the role of commercial fisheries in seabird mortality.
- Determine population level effects of oil and hazardous materials on seabirds.
- Assess mercury loads in seabirds.
- Identify key marine habitats.
- Examine value of sargassum to seabirds.
- Examine effects of sargassum harvest to seabird habitat and populations.
- Along south Atlantic coast beaches, research into the rates of and reasons for wintering common loon mortality should help provide for a better understanding of the risks to seabird populations in this area.
- Establish whether foraging black-capped petrels within the Gulf Stream (especially off of Cape Hatteras, North Carolina) are the same concurrently breeding in Haiti (Hunter 2004b).

Education and Outreach

Follow the recommendations put forth in the North American Waterbird Conservation Plan—"40 ideas for outreach projects" (Kushlan et al. 2002).

Potential Partners and Partnerships

- Partners in Flight
- The Waterbird Conservation Council
- Waterbird Monitoring Partnership – Patuxent
- Circumpolar Seabird Working Group
- Waterbird Society
- Society of Caribbean Ornithology
- International Association of Fish & Wildlife Agencies (Shorebird and Waterbird Working Group)
- National Marine Fisheries Service, National Oceanic and Atmospheric Administration
- South Atlantic Migratory Bird Initiative partners
- National Audubon Society and state Audubon chapters
- Region 4 US Fish & Wildlife Service, Seabird Working Group
- State fish and wildlife agencies
- South Atlantic Fisheries Management Council
- North Carolina State Museum of Natural Sciences
- American Bird Conservancy

References

Hunter, W. C. 2004a. Proposed state lists of priority bird species for FWS Southeast Region States, Commonwealth of Puerto Rico, and U.S. Virgin Islands. U. S. Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C. 2004b. Southeast U.S. Waterbird Conservation Priorities. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M. 2004. North Carolina bird species assessment. NC Partners in Flight, Division of Wildlife Management, North Carolina Wildlife Resources Commission.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

Murphy, M. 2004. Seabirds. South Atlantic Fishery Management Council, Charleston, SC.

National Marine Fisheries Service (NMFS). 2001. United States national plan of action for reducing the incidental catch of seabirds in longline fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

South Atlantic Migratory Bird Initiative (SAMBI). 2004 (DRAFT). South Atlantic Migratory Bird Initiative Pelagic Conservation Plan. US Fish & Wildlife Service.

Marine and Estuarine Species

Surveys, monitoring and research on estuarine and marine species is difficult, making the collection of data, the synthesis of information, and the protection of those species that much more challenging. There have been no recent systematic accounts of species rarity or distribution for marine or estuarine fish species in the state (LeGrand et al. 2004). Some federally protected species, such as sea turtles, receive significant attention when nesting on our beaches, but the majority of their lives are spent at sea. Four agencies have jurisdiction and authority over particular estuarine and marine species in the state: the NC Division of Marine Fisheries, the National Oceanic and Atmospheric Administration (NOAA), the US Fish & Wildlife Service, and the Commission (when the species are in inland waters). There is great need to continue cooperative efforts among these agencies in order to expand our understanding of and protection for those species.

Marine Species Regulation and Management

State Regulations

North Carolina is a member of the Atlantic States Marine Fisheries Commission (ASMFC). The ASMFC represents the 15 Atlantic coast states as a deliberative body, coordinating the conservation and management of the states shared near shore (within state waters) fishery resources—marine, shell, and anadromous—for sustainable use. The ASMFC promotes interstate fisheries management, law enforcement, research and statistics, fisheries, science, and habitat conservation.

The NC Division of Marine Fisheries (NCDMF) is responsible for the stewardship of the state's marine and estuarine fisheries resources. NCDMF jurisdiction encompasses all coastal waters and extends to 3 miles offshore. Fisheries Management Section staff are active in federal and regional management of migratory species, serving as technical advisors and committee members for coast-wide or regional fishery management issues. They work closely with the Commission, as well as with NOAA Fisheries, the Atlantic States Marine Fisheries Commission, and the Mid-Atlantic and South Atlantic Fisheries Management councils on inter-state Fisheries Management Plans (FMPs) (see below for more information). NCDMF is also responsible for preparing FMPs for adoption by the North Carolina Marine Fisheries Commission for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries. State FMPs have been developed for:

- Southern flounder
- Blue crab
- Striped bass
- Red drum
- Oyster
- Hard clam
- Striped mullet

The Habitat Protection Section is responsible for the development of the Coastal Habitat Protection Plan (CHPP) (Street et al. 2004) to conserve and protect important marine fisheries habitat (*further details regarding the CHPP are in the following section*).

Federal Regulations

NOAA Fisheries is responsible for the management, conservation and protection of living marine resources within the United States Exclusive Economic Zone (3-200 miles offshore), including sea turtles, marine and anadromous fish, plants and invertebrates, cetaceans, and pinnipeds[6]. Central to that mission are the objectives to: 1) protect ocean, coast, and Great Lakes resources, 2) recover protected species, and 3) rebuild and maintain sustainable fisheries.

The NOAA Fisheries Office of Protected Resources (OPR) is charged with the implementation of the Endangered Species Act (ESA) of 1973 for marine and anadromous species. OPR develops, implements, and administers programs for the protection, conservation, and recovery of species protected under the ESA. The Office also develops and implements policies, procedures, and regulations for permits to take (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect) listed species according to the ESA. Additionally, the Office establishes cooperative

[6] NOAA Fisheries jurisdiction also extends into state waters for protected marine species.

agreements with states regarding listed species management and protection and identifies endangered species research needs to collect appropriate information for management decisions (e.g., NOAA Fisheries has a cooperative agreement with the Commission regarding sea turtle nesting and strandings on North Carolina beaches).

Under the Marine Mammal Protection Act (MMPA) all marine mammals are protected from take in United States waters and by United States citizens on the high seas, and marine mammals and marine mammal products are prohibited from importation into the United States. NOAA Fisheries grants at-risk marine mammal species a variety of protection levels under the ESA and the MMPA. Among these are endangered status, threatened status and depleted status. Under the MMPA, a species is designated as depleted when it falls below its optimum sustainable population (see Glossary). Once a species has been designated as depleted, a conservation plan is developed to guide research and management actions to restore the health of the species. Take reduction teams (TRTs) are formed and convened with the purpose of developing take reduction plans to assist in the recovery or to prevent the depletion of strategic marine mammal stocks that interact with various fisheries. A strategic stock is one which is listed as endangered or threatened under the ESA, is declining and likely to be listed as threatened under the ESA, is listed as depleted under the MMPA, or has direct human-caused mortality exceeding the stock's Potential Biological Removal level (see Glossary). TRTs consist of a balance of representatives from the fishing industry, fishery management councils, state and federal resource management agencies, the scientific community, and conservation organizations. To date, six TRT's have been established:

- Atlantic Large Whale Take Reduction Team
- Atlantic Offshore Cetacean Take Reduction Team
- Western North Atlantic Coastal Bottlenose Dolphin Take Reduction Team
- Gulf of Maine Harbor Porpoise Take Reduction Team
- Mid Atlantic Harbor Porpoise Take Reduction Team
- Pacific Offshore Cetacean Take Reduction Team

FMPs are developed by Regional Fishery Management Councils for species commercially and recreationally harvested and are implemented by NOAA Fisheries Regional Offices. North Carolina is a member of the Mid-Atlantic Fishery Management Council and the South Atlantic Fishery Management Council.

The Mid-Atlantic Fishery Management Council (MAFMC) is responsible for management of fisheries in federal waters which occur predominantly off the mid-Atlantic coast (North Carolina to New York). FMPs developed and implemented by the MAFMC include:

- Summer Flounder
- Scup
- Black Sea Bass
- Dogfish
- Surf Clam and Quahog
- Atlantic Mackerel
- Squid and Butterfish
- Bluefish
- Tilefish
- Monkfish

The South Atlantic Fishery Management Council (SAFMC) is responsible for the conservation and management of fish stocks within the federal 200-mile limit of the Atlantic off the coasts of North Carolina, South Carolina, Georgia and east Florida to Key West. Within the SAFMC, efforts continued on the development, monitoring, implementation, and revision of FMPs for:

- Blue Crab
- Menhaden
- Striped Mullet
- Shrimp
- Striped Bass
- Spanish Mackerel
- Oyster
- Black Drum
- Red Drum
- Spotted Seatrout
- Bluefish
- Flounder
- Croakers and other bottom fish
- Conch
- Eel
- Sheepshead

The Highly Migratory Species Division of NOAA Fisheries manages Atlantic highly migratory species (HMS), including tunas, sharks, swordfish and billfish, and implements the FMP for Atlantic tunas, swordfish, and sharks. Management of HMS requires international cooperation, and rebuilding programs must reflect traditional participation in the fisheries by United States fishermen, relative to foreign fleets. Along with the Magnuson-Stevens Act, United States fisheries management must be consistent with the requirements of other laws including the Atlantic Tunas Convention Act, Marine Mammal Protection Act, the Endangered Species Act, the Migratory Bird Treaty Act, and several other Federal laws.

Priority Species

The following marine or estuarine species, known to occur currently or historically in North Carolina coastal waters, are listed as:

Federally endangered *(legal protection status under ESA/MMPA*):
- Smalltooth Sawfish (*Pristis pectinata*)
- Shortnose Sturgeon (*Acipenser brevirostrum*)
- Fin Whale (*Balaenoptera physalus*)
- Humpback Whale (*Megaptera novaeangliae*);
- Northern Right Whale (*Eubalaena glacialis*)
- Sperm Whale (*Physeter macrocephalus*)
- West Indian Manatee (*Trichechus manatus*)
- Hawksbill Sea Turtle (*Eretmochelys imbricata imbricate*)
- Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)
- Leatherback Sea Turtle (*Dermochelys coriacea*)

Federally threatened (*legal protection status under ESA*):
- Green Sea Turtle (*Chelonia mydas*)
- Loggerhead Sea Turtle (*Caretta caretta*)

Species of concern (*no legal protection status under ESA; only those species that are being actively considered for ESA listing are also "Candidate Species"; none of the species below are considered "Candidate species"*):
- Dusky Shark (*Carcharhinus obscurus*)
- Sand Tiger Shark (*Odontaspis taurus*)
- Night Shark (*Carcharhinus signatus*)
- Barndoor Skate (*Raja laevis*)
- Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)
- Speckled Hind (*Epinephelus drummondhayi*)
- Goliath Grouper (*Epinephelus itajara*)
- Warsaw Grouper (*Epinephelus nigritus*)
- Nassau Grouper (*Epinephelus striatus*)

Depleted (*legal protection status under MMPA*):
- Western North Atlantic Coastal Bottlenose Dolphin (*Tursiops truncatus*)

State special concern *(legal protection status by the NC Wildlife Resources Commission*):
- Diamondback Terrapin (*Malaclemys terrapin*)

Significantly rare (as of 2001) (*a NC Natural Heritage Program designation carrying no legal protection*)[7]:

- Spinycheek Sleeper (*Eleotris pisonis*)
- Lyre Goby (*Evorthodus lyrinus*)
- Marked Goby (*Gobionellus stigmaticus*)
- Freckled Blenny (*Hypsoblennius ionthas*)
- Opossum Pipefish (*Microphis brachyurus*)

Musick et al. (2000) identified marine, estuarine and diadramous fish stocks at risk of extinction in North America. While the North Carolina coast is not an identified "hotspot" for species at risk, our coastal waters fall within the potential range of 17 species listed in the publication, seven of which do not carry any listing status from above (Table 5C.2).

Table 5C.2. Fish species at risk of extinction in North America, whose current or historical range includes North Carolina coastal or offshore waters (from Musick et al. 2000).

Common Name	Official Status (as of 2004)	Risk Category within Range[8]	Factor(s) that Put Species at Risk[9]
Whale Shark	Protected under an FMP	CD	R,L
Sand Tiger Shark	Species of concern	V	L
Basking Shark	Protected under an FMP	CD	L
White Shark	Protected under an FMP	CD	L
Dusky Shark	Species of concern	V	L
Smalltooth Sawfish	Endangered	E	L
Barndoor Skate	Species of concern	V	L
Shortnose Sturgeon	Endangered	E	V, L
Atlantic Sturgeon	Species of concern	E	V, L
Marbled Grouper	None	V	R, L
Speckled Hind	Species of concern	E	L
Yellowedge Grouper	None	E	L
Warsaw Grouper	Species of concern	E	L
Snowy Grouper	None	V	L
Black Grouper	None	V	L
Gag	None	V	L
Scamp	None	V	L

Some species listed above may also be found in estuarine or inland waters (e.g., diamondback terrapin, manatee, anadromous fish) or on North Carolina beaches (e.g., sea turtles). Others species not directly mentioned above may also use marine or estuarine environments (e.g., beach nesting birds). For those typically marine species that are also associated with coastal estuaries and beaches or that travel into inland waters, we have addressed appropriate conservation needs within those particular habitat types (see 'Beach and dune', and 'Estuarine communities' within the Mid-Atlantic Coastal Plain portion of the Plan, Chapter 5A).

[7] As of 2004, the NC Natural Heritage Program is no longer tracking (nor including on the Watch List) marine and estuarine fishes. This decision is not due to their lack of state listing; rather, they receive few data on such species, survey for such species can be cumbersome, protection of them is difficult if not impossible, and there has been no recent systematic account of the rarity and distribution of the hundreds of such fishes that occur in our salt or brackish waters.

[8] Risk categories: Endangered (E)- high risk of extinction in the wild in the immediate future; Vulnerable (V)- special concern, but not endangered or threatened severely but at possible risk of falling into one of those categories in the near future; Conservation Dependent (CD)- reduced but stabilized or recovering under a continuing conservation plan.

[9] Factors: Rarity (R); Vulnerable habitat (V); Life history limitations (L)

Threats

The successful conservation of marine species will require the mitigation of threats both within North Carolina borders and beyond. Thus, interstate and international partnerships and cooperation are critical components of marine species conservation.

Descriptions of the threats listed below were taken from various marine species recovery plans. Recovery plans can be accessed at http://www.nmfs.noaa.gov/pr/PR3/recovery.html

Nesting threats (these threats primarily impact beach nesting sea turtles and birds)

- Beach erosion – Erosion can result in partial or total loss of suitable nesting habitat; coastal development and associated activities have accelerated erosion rates and interruption of natural shoreline migration.
- Shoreline modifications – Fortifications put in place as a result of shoreline development (including sea wall, rip rap, groins, jetties) can accelerate beach erosion rates and reduce available nesting habitat; improperly placed drift fences can impede nesting attempts and/or trap hatchlings or nesting female sea turtles.
- Beach nourishment – If nourishment occurs during nesting season direct impacts can include burial of nests and nest disturbance; dissimilar sand sources can impact site selection, digging behavior, incubation, and hatchling success; beach nourishment can also result in significant compaction or concretion of the beach.
- Artificial lighting – Lighting associated with beachfront development (condominiums, street lights, vehicles) can severely impact emerging hatchlings by causing disorientation which drastically increases fatalities; artificial lighting causes hatchlings to head in the opposite direction of the water, exposing themselves to predators, entrapment in vegetation, and/or vehicle strikes; adult nesting sea turtles may abort nesting attempts at greater frequencies near lighted areas.
- Beach cleaning – Mechanical raking (using heavy machinery) can compact or destroy nests; disposal of debris near the dune line can cover incubating clutches, entrap emergent hatchlings, and/or alter nest temperatures.
- Increased human presence – Disturbance to nesting sea turtles is the most critical threat caused by human presence on beaches; night-time human activity can cause female turtles to abort nesting attempts.
- Recreational beach equipment (including vehicular driving) – Beach chairs, tents, and other recreational equipment can directly impacting nests (covering or disturbing incubating nests) or indirectly cause disturbance such that female turtles abort nesting attempts; vehicle use on beaches has similar effects as heavy machinery used in beach cleaning efforts (compact or destroy nests, entrap nestlings); vehicle lighting can disorient hatchlings and adults alike.
- Exotic dune and beach vegetation – Non-native vegetation can outcompete native vegetation such as sea oats and dune grass; often less-stabilizing, non-native vegetation can lead to erosion and degradation of nesting habitat.
- Nest depredation – Predation by ghost crabs, raccoons, foxes, or fire ants is a significant threat to eggs and hatchlings (both sea turtle and shorebirds); disorientation of emergent hatchlings by artificial lighting increases their chances of being depredated by one of these animals.

Marine threats (these threats may impact sea turtles, fish species, and marine mammals)

- Vessel interactions (including collisions) – Propeller and collision injuries are a significant threat, especially to marine mammals and sea turtles; these types of injuries are reported at higher frequencies in areas that have heavy boating and vessel traffic.
- Oil and gas exploration – Oil spills have been shown to impact respiration, blood chemistry and salt-gland function in sea turtles; spills in the vicinity of nesting beaches can place nesting adults, eggs, and or hatchlings in significant risk; oil deposits on the ocean floor can reduce food sources for all marine species and result in ingestion of tar balls.

- Dredging – Dredging can result in direct destruction or degradation of habitat and/or incidental take of marine species; channelization of inshore and nearshore habitats can result in the disposal of dredge material on beaches and shallow habitats, impacting nesting success or foraging grounds.
- Pollution – Pesticides, polychlorinated biphenyls, and heavy metals have been detected in marine species, though levels that result in adverse effects are difficult to quantify.
- Fisheries – By-catch of marine organisms occurs in a number of different fisheries, including trawl, purse seine, hook and line, gill net, pound net, long-line, and trap fisheries; these interactions often lead to serious injury or death.
- Power plant entrapment – Saltwater cooling intake systems at coastal power plants have been reported to entrap marine species.
- Underwater explosions – Use of underwater explosives to remove abandoned oil platforms, for military activities, or for oil exploration can result in injury or death to marine species in the vicinity of the explosion.
- Entanglement – Marine species can become entangled in a variety of materials other than active fishing gear, including steel or monofilament line, synthetic or natural rope, or discarded plastic material, often resulting in injuries which can lead to weakened individuals who are more susceptible to death by other factors, or to direct mortalities.
- Ingestion of marine debris – Marine species may ingest a variety of potentially harmful debris materials, including plastic bags, balloons, Styrofoam, and tar balls; effects of debris ingestion can include obstructions of the gut, absorption of toxic byproducts, reduced absorption of nutrients.
- Poaching – Illegal harvest of marine species has declined considerably since the development and enforcement of protection regulations, however arrests are still made for illegal capture and possession of marine species.
- Noise – The impacts of noise from shipping, industrial, or military activities on the communication, behavior and distribution of whales and other marine species remains unknown but is suspected to be significant.

Conservation Recommendations

The following recommendations apply broadly to all efforts towards marine mammal and fish conservation:

- Continue and expand cooperation between NOAA Fisheries and the appropriate state agencies to facilitate marine species management, protection, and research, especially for listed species.
- Support the implementation of FMPs to manage and protect marine species.
- Support and assist in the attainment of the goals, objectives, strategies, and performance measures set forth in the NOAA Fisheries Strategic Plan (NOAA 2003).
- Support the recommendations put forth in the CHPP (Street et al. 2004) to promote fisheries habitat protection in North Carolina and to facilitate the necessary policy decisions.

Directed marine conservation needs relative to North Carolina include:

- Development of more precise population estimates for all marine taxa.
- Genetics research to further understand stock structure in North Carolina and beyond (e.g., bottlenose dolphin and pilot whale).
- Examination of pollution effects on coastal and estuarine species.
- Coordination between NOAA Fisheries and NC Division of Marine Fisheries to look at gear modifications to reduce dolphin by-catch in fisheries; SeaGrant Fisheries Resource Grants and NOAA Fisheries support much of this work.

- Public education and other efforts to reduce discarded "ghost" fishing gear to reduce marine species entanglement; potential development of a fishing line recycling program (potential to model from Florida's existing monofilament recycling program).
- Improved communications and coordination with other NOAA offices, state and federal marine resource agencies, and universities to combat common threats and develop efficient and effective conservation strategies for all marine species and their habitats.
- Continued cooperation with fisheries resource managers, commercial fisherman, and regulatory agencies to reduce by-catch and unintentional take of protected marine resources (e.g., explore diamondback terrapin by-catch in crab pots).

Additional Resources

- FMPs can be found at each Regional Fisheries Management Council website:
  - Mid-Atlantic Fisheries Management Council: http://www.mafmc.org/mid-atlantic/mafmc.htm
  - South Atlantic Fisheries Management Council: http://www.safmc.net/fmpro?-db=content&-format=default1.html&-view
- FMPs are available for Atlantic Tunas, Swordfish, and Sharks (highly migratory species) at: http://www.nmfs.noaa.gov/sfa/hms/hmsdocuments.html#fmps.
- Recovery plans are available, or are in development, for the following listed species (*list is limited to those species that can inhabit North Carolina coastal or offshore waters*) and can be accessed at http://www.nmfs.noaa.gov/prot_res/PR3/recovery.html:
  - Green Sea Turtle
  - Hawksbill Sea Turtle
  - Leatherback Sea Turtle
  - Loggerhead Sea Turtle
  - Kemp's Ridley Sea Turtle
  - Right Whale
  - Humpback Whale
  - Sperm Whale (*in development*)
  - Fin/Sei Whale (*draft*)
  - Shortnose Sturgeon
- Marine mammal stock assessment reports for all Atlantic species can be found at: http://www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/individual_sars.html
- Take Reduction Plans can be accessed at http://www.nmfs.noaa.gov/pr/PR2/Fisheries_Interactions/TRT.htm

References

LeGrand, H. E., S. P. Hall, and J. T. Finnegan. 2001. Natural Heritage Program list of the rare animal species of North Carolina. NC Natural Heritage Program. NC Department of Environment and Natural Resources, Raleigh, NC.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. NC Natural Heritage Program, Office of Conservation and Community Affairs, NC Department of Environment and Natural Resources, Raleigh.

Musick, J. A., M. M. Harbin, S. A. Berkeley, G. H. Burgess, A. M. Eklund, L. Findley, R. G. Gilmore, J. T. Golden, D. S. Ha, G. R. Huntsman, J. C. McGovern, S. J. Parker, S. G. Poss, E. Sala, T. W. Schmidt, G. R. Sedberry, H. Weeks, and S. G. Wright. 2000. Marine, estuarine, and diadramous fish stocks at risk of extinction in North America (exclusive of pacific salmonids). Fisheries 25:6–30.

National Oceanic and Atmospheric Administration (NOAA). 2003. NOAA Fisheries Strategic Plan for FY 2003–FY 2008. U.S. Department of Commerce, National Oceanic and Atmospheric Adminstration, National Marine Fisheries Service.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Coastal Habitat Protection Plan

We were fortunate that the development of the Plan overlapped with the development of a complimentary report focused on the long-term enhancement of coastal fisheries associated with coastal habitats in North Carolina, the Coastal Habitat Protection Plan (CHPP) (Street et al. 2004) (see Figure 5C.1). Specific to in-shore marine fish, we have used the recommendations and information compiled in the CHPP to develop the following section.

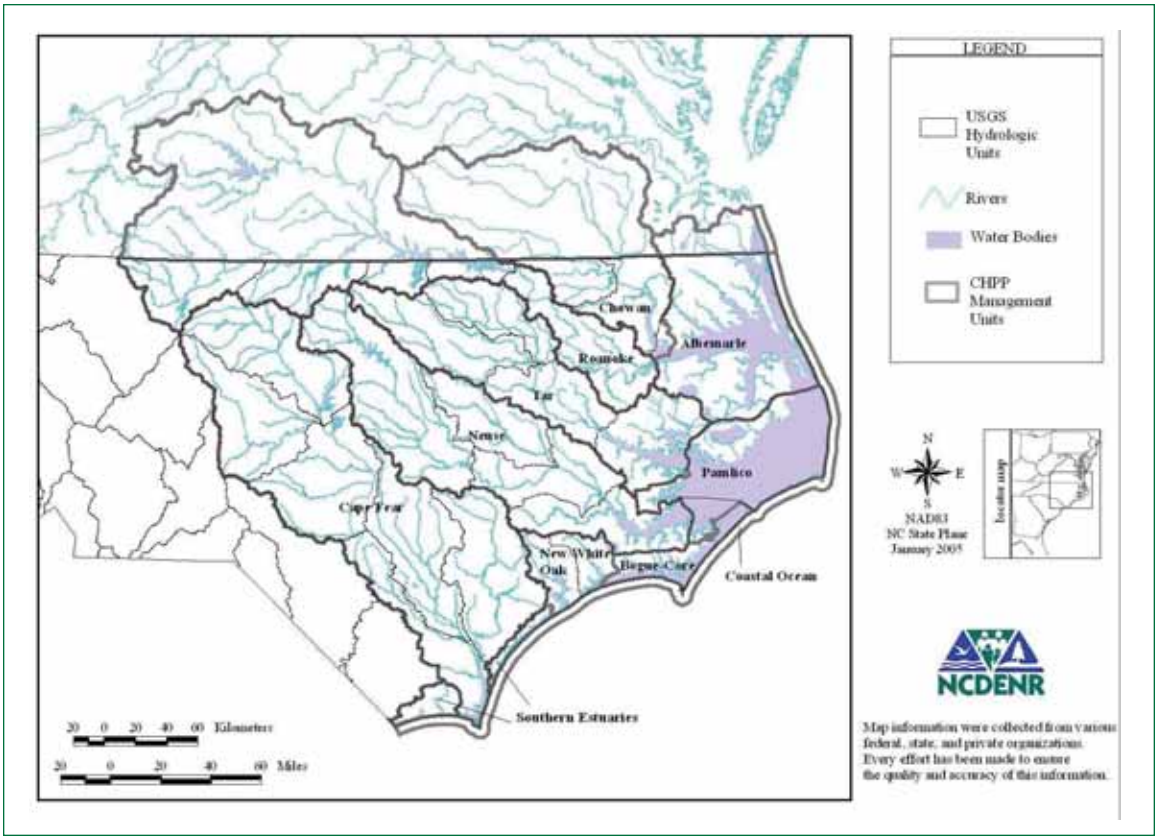


Figure 5C.1. Coastal Habitat Protection Plan management units (source: NC Division of Marine Fisheries, 2004).

Development of the CHPP was a provision of the 1997 Fisheries Reform Act. The CHPP was completed in 2004, and was adopted in 2005 by the three regulatory commissions who oversee coastal and marine resources in the state (the Environmental Management, Coastal Resources, and Marine Fisheries Commissions) to ensure a coordinated management approach. The CHPP includes information on habitat descriptions, distribution, ecological role and function for fish species, status and trends, threats, and management needs. The CHPP identifies recommendations to meet four goals for protection of coastal fisheries habitat:

1. Improve effectiveness of existing rules and programs protecting coastal fisheries habitats
2. Identify, designate, and protect all Strategic Habitat Areas
3. Enhance habitat and protect it from physical impacts
4. Enhance and protect water quality

During 2005, each commission will develop a Coastal Habitat Protection Implementation Plan, which will use the threats, management needs, and recommendations identified in the CHPP to develop specific priorities, actions, and measures of success.

We have relied on the CHPP to develop the following habitat sections. While the CHPP is not focused on "species in greatest need of conservation," it is the most comprehensive resource on coastal and marine habitat protection available in the state and it provides critical direction for protection of coastal and marine resources. The final CHPP document is more than 600 pages in length, far too lengthy to simply insert here for use as a planning tool. So in the following sections **we have inserted text from the CHPP that provides key information related to the focus of the Plan**[10]. Readers should refer to the original document (Street et al. 2004) for follow-up on any points made herein. The complete CHPP report can be downloaded in its entirety, or chapter by chapter, at: http://www.ncfisheries.net/habitat/index.html.

Fisheries and Protected Species in the CHPP

Within the CHPP, the term "fish" is used to include "All marine mammals; all shellfish; all crustaceans and all other fishes" [G.S. 113-129 (7)]. Coastal fish species are grouped into three overlapping classes based on management considerations: 1) fisheries species, 2) forage species, and 3) protected species.

- Fisheries species are those finfish, crustaceans, and mollusks that may be harvested in North Carolina's Coastal and Inland Fishing Waters (MFC 2003) by commercial and recreational fishermen. ***Habitats supporting fishery species are the primary focus of the CHPP***.
- Forage species make up a significant portion of the diet of fishery species (e.g., killifish, grass shrimp, menhaden, mullet).
- Protected species meet two criteria: 1) listed according to state law [G. S. 113-331] or through the federal Endangered Species Act by the relevant state or federal agency or protected under the federal Marine Mammal Protection Act, and 2) require aquatic or wetland habitat within North Carolina's coastal river basins or nearshore ocean waters at some point in their life cycle. Protected species are important in the CHPP process because they can be indicators of ecological stress (Ricklefs 1993). In addition, their habitat needs provide support for designating strategic habitat in locations where the distribution of fishery and protected species overlap, as well as in upstream areas important for maintaining estuarine water quality.

Habitats[11]

Water Column

The water column habitat surrounds and supports all aquatic organisms and connects all coastal fish habitats. Consequently, clean and healthy waters are critical to the overall viability of coastal fish habitats and aquatic organisms. The general distribution of fish within the water column is determined by the physical and chemical properties of each unique water body (i.e., salinity, temperature), while the abundance, diversity, and health of coastal fish and invertebrates are strongly influenced by water quality conditions (i.e., oxygen, turbidity, nutrients). The water column provides the necessary medium for spawning and transport of eggs and larvae to habitats favorable for survival and growth. In addition, coastal waters are an important source of primary production, providing food for the survival of early life stages of aquatic organisms. Another critical function of the water column is to support other important food sources for pelagic species, such as river herring, bluefish, and Spanish mackerel, and to serve as a critical corridor for migration. Particularly important areas of the water column include inlets, shallow estuarine nursery areas, anadromous fish spawning and nursery areas, and the nearshore surf zone.

Well-documented occurrences of low oxygen events, fish kills, and harmful algal blooms during the 1980s and 1990s provided visible indicators that coastal waters were declining in quality. Although severe water quality problems are variable and appear to have diminished in recent years, many coastal waters remain impaired. The primary threats to the water column are hydrological modifications and water quality degradation (Table 5C.3).

[10] See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

[11] Text taken directly from habitat chapter summaries, Street et al. 2004.

The hydrology of North Carolina has been altered dramatically, with over 2,000 dams obstructing and modifying water flow to the coast, numerous surface water withdrawals, and extensive channelization of streams. Physical obstructions in streams from structures such as dams and road crossings (fill causeways, culverts), as well as alteration of flow conditions, are a major threat to anadromous fish species, some of which are classified as Overfished by NCDMF (American shad, the central/southern stock of striped bass, and the Albemarle Sound stock of river herring). Removing obstructions and restoring flow in streams and rivers have been highly successful in some areas for restoring striped bass and American shad populations and should continue to be a high priority.

Water quality degradation affects aquatic organisms in many ways. Excessive sediment loading increases turbidity and sedimentation, which can result in a decrease in biological productivity, clogging of fish gills, reduced recruitment of invertebrates, increased mortality, and filling in of rivers and creeks.

Important fishery and prey species in North Carolina that are impacted by alterations or degradation of the water column include pelagic-oriented species such as blueback herring, American shad, striped bass, Atlantic menhaden, bluefish, and anchovies. The condition of the water column also influences other coastal fish habitats. For example, waters depleted of oxygen can result in extensive mortality of individuals inhabiting shell bottom and soft bottom communities. Moreover, excess sedimentation and turbidity can shade submerged vegetation, while the associated sediment can smother hard bottom communities.

Primary sources of sediment are nonpoint runoff from land disturbance associated with building and road construction and agricultural drainage. A predicted increase in the rate of sea level rise will accelerate coastal erosion and impact sedimentation-related issues. NCDWQ data show the greatest impairment to coastal freshwater streams is due to not only excessive sediment loading but also low dissolved oxygen.

Low dissolved oxygen has been responsible for many fish kills in coastal river basins, especially the Neuse, Cape Fear and Tar-Pamlico. The estuarine species most frequently affected by fish kills have been menhaden and flounder; the most frequently reported freshwater species have been sunfish and catfish. Such oxygen depletion can occur naturally, but is greatly aggravated and intensified by eutrophication. This excessive loading of nutrients can also contribute to toxic algal blooms and may contribute to *Pfiesteria* outbreaks. Primary sources of excessive nutrients in the water column include point source wastewater discharges, and nonpoint runoff from crop agriculture, animal operations, urban development, and air emissions from industries and vehicles. Another serious concern for estuarine and ocean water quality is bacterial contamination, both for habitat and health reasons. Fecal coliform contamination in estuarine waters is a major cause of water quality impairment, originating primarily from nonpoint sources. Bacterial contamination has resulted in consistent increases in shellfish harvest closures over time, including closures in Outstanding Resource Waters, North Carolina's highest quality waters (over 1,000 acres closed in ORW waters since 1990). When stormwater is discharged on ocean beaches, it contaminates the surf zone with not only bacteria, but also a variety of other toxins. Runoff from roads, agriculture, and marina-related activities are common sources of toxins in coastal waters.

While toxins are a concern to the water column, these pollutants tend to settle and become incorporated into soft bottom habitat relatively quickly, where they can be resuspended or can adversely affect organisms in the bottom sediments. Sediment, nutrient, bacteria, and toxin loading must be reduced by addressing multiple sources. These include improvement and continuation of urban and agricultural BMPs, more stringent sediment controls on construction projects, and additional buffers along coastal waters.

Water column habitat is required for the survival, growth and reproduction of fish and it greatly influences all other coastal fish habitats. Therefore, efforts are needed to minimize threats and enhance water quality wherever possible, particularly within and adjacent to designated Strategic Habitat Areas.

Table 5C.3. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Hydrologic modifications Flow regulation Dams/impoundments	Restoration efforts through removal or modification of dam structures that impede migration of anadromous fish should remain a high priority to continue in North Carolina, focusing on the lowermost structures in rivers or streams, and advancing upstream. In particular, the Cape Fear system (i.e., Lock and Dam #1) should be a high priority, since striped bass, shortnose sturgeon, and Atlantic sturgeon have not recovered
Hydrologic modifications Flow regulation Water withdrawals	More research is needed to assess the impact of water withdrawals on water column habitat and fish populations in the affected river basins. Assessments of groundwater water supplies in coastal counties should be made to determine what the environmental consequences will be if the increase in water withdrawals continues. Until standards are implemented and effective exclusive technology is available, withdrawals should be reduced as much as possible during and following spawning season in areas known to be used by eggs, larvae, and early juveniles. This would include NCDMF designated PNAs and anadromous fish spawning and nursery areas that are currently being mapped by NCDMF staff.
Hydrologic modifications Flow regulation Status and trends in flow regulation	New dam construction should be avoided whenever possible or designed and sited to minimize impacts to anadromous fish use and to maintain appropriate flow conditions. Flow alterations that may significantly change the temporal and spatial features of inflow and circulation that are required for successful spawning of anadromous fish should be prohibited. A process that fully evaluates cumulative impacts from water withdrawals and other hydrological modifications should be developed and implemented.
Hydrologic modifications Road fill and culverts	Through the EEP process, additional focus on restoring stream flow and fish habitat through the replacement of culverts with bridges should be accelerated. Funding should be allocated for replacing filled channels and streams with "fish friendly" culverts or bridges and upgrading existing culverts to "fish friendly" structures, prioritizing structures that are known to impede anadromous fish migration to spawning grounds or have been found to be particularly problematic to the natural hydrology of a system.
Hydrologic modifications Channelization and ditching	De-snagging of woody debris from streams for navigation or other purposes should be minimized to enhance water column habitat value. New channelization projects should not be constructed unless found to be absolutely necessary and designed to minimize or adequately mitigate any negative habitat and water quality impacts. Dechannelization of streams, particularly in areas historically utilized as fish nurseries, implementation of alternative drainage control practices, and acceleration of innovative BMP development are needed where feasible. Increased funding and educational outreach to farmers and other landowners are also needed for such projects. Additional monitoring, paid for by the party responsible for the ditching, is needed to better assess impacts where extensive areas of wetlands were drained. More NCDWQ staff are needed to inspect for compliance with the wetland draining policy.
Hydrologic modifications Dredging (navigation channels and boat basins)	New dredging in shallow, nearshore areas with fine sediment and low flushing should be discouraged. Areas where dredging could enhance habitat should be identified for habitat restoration efforts.
Hydrologic modifications Mining	Log salvage operations may also need to be restricted from anadromous fish nursery areas.
Hydrologic modifications Jetties	Construction of new or expanded jetties or groins along North Carolina's ocean shoreline should not be allowed until field research has been completed to assess the impact of jetties on successful larval passage through inlets into estuaries, particularly in Pamlico Sound where inlets are limited. Environmental outreach to the public, particularly commercial and recreational fishermen, regarding the effect of inlet stabilization on coastal fish habitat is needed to educate the public on this issue and gain support for maintaining natural barrier island processes.

Threat	Management Need
Hydrologic modifications Shoreline stabilization	The state should enforce the prohibition of hardened structures on the oceanfront. In addition, existing seawalls and hardened structures on the oceanfront should be removed if they are more than 50% damaged and if removal will be beneficial to coastal fish habitat. Where shoreline stabilization structures such as rock revetments, sills, or bulkheads are allowed adjacent to fringing wetlands, permit conditions should require openings in the structures to allow adequate fish ingress and egress and water circulation. To minimize impacts to the water column and its functions, CRC estuarine shoreline stabilization regulations should be modified.
Water quality degradation Land cover and water quality	The estuarine shoreline Areas of Environmental Concern (AEC) should be widened and extended inland beyond the Inland Water jurisdictional line to at least the upstream boundary of coastal wetlands. Establishment of development setbacks within AECs should also be considered as a tool in protecting water quality. To more effectively manage development in a manner that minimizes impacts to coastal fish habitat, a process to fully evaluate cumulative impacts of coastal development needs to be developed and implemented by the regulatory agencies. Coast-wide mapping of impervious cover is needed to evaluate watershed condition. The coast-wide mapping of impervious surfaces should be supplemented with data on local hydrology and on-site stormwater controls to more accurately reflect potential degradation of water quality. Water quality problems associated with development and excessive impervious cover will continue to worsen unless improved land-based strategies that reduce nonpoint source pollution are voluntarily utilized at a local level. Such voluntary strategies could include providing incentives for low impact development, improved BMPs and other techniques. Rule-making strategies may also be necessary to adequately retain stormwater on-site. This could be achieved through site design, construction of engineered storm water controls, or lower maximum amounts of impervious surfaces on developments choosing the low-density option for stormwater control. Phase II stormwater rules already recognize the need to limit impervious surfaces. The EMC and CRC should consider 1) modifying rules regarding limits of built-upon area (low-density option) to be consistent with the scientific literature regarding water quality protection needs, or 2) modifying stormwater rules to require adequate retention or treatment of stormwater on-site, through alternative effective techniques. Mandatory buffer zones, of scientifically based and effective widths and configurations that protect habitat and water quality, should be required along all streams draining to coastal fish habitat in North Carolina. Requiring professional foresters to be involved with the implementation of logging BMPs, even on small private forests, would enhance proper use of BMPs. In addition, notifying the Division of Forest Resources prior to initiating logging operations would facilitate BMP inspections and, hopefully, improve overall compliance. Educating owners of small non-industrial forests would also improve BMP implementation and success.
Water quality degradation Nutrients	Loading of nutrients into coastal waters from mechanical failures, spills, and inadequate treatment must be reduced. This will require additional funding to upgrade plants and infrastructure. Increased inspections of sewage treatment facilities, collection infrastructure, land disposal sites, and onsite wastewater treatment facilities is necessary to identify and prioritize sites needing upgrades. More funding is needed to buy out or relocate additional animal operations from environmentally sensitive areas. The moratorium should remain in effect until alternative waste treatment is implemented that will reduce pollutant loading to streams and nitrogen release into the air. In addition EMC should phase out use of waste lagoons or reclassify waste lagoon systems from nonpoint to point source discharges, and be permitted accordingly, as recommended in NCDENR's Neuse River Nutrient Sensitive Waters Management Strategy (NCDWQ 1997). Some environmentally superior alternatives to the current lagoon and spray field systems were identified in the Smithfield Agreement. The early implementation of these superior alternatives should be encouraged. A greater portion of agricultural conservation funds should be allocated to the buy out or relocation of animal operations from sensitive areas, and for the purchase of conservation easements. Additional measures to reduce inputs from agriculture should be considered by the CRC, EMC, MFC, and NRCS, such as removing their exclusion of agriculture from CRC and EMC regulations, expansion of funding for BMPs and cost-share programs for nonpoint pollution control.

Table 5C.3 *(continued)*. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Water quality degradation Nutrients *(continued)*	The Division of Air Quality and NCDENR should implement the planned expansion of car inspections as soon as possible. In addition, North Carolina legislators, state agencies, and local governments should adopt coast-wide or state-wide "Smart Growth" policies to provide incentives and direct growth into more highly developed areas and preserve rural land uses. Additional education is needed on proper application of fertilizers to reduce runoff of nutrients into coastal waters, targeting homeowners, golf course owners, and landscape businesses. BMPs, including vegetated buffers, detention ponds, and wetland areas, should be required on all new and existing golf courses draining to coastal waters to help reduce nutrient concentrations. Areas like Futch or Pages Creek, that have relatively good water quality condition and are important nursery and shellfish producing areas, should be a high priority for water quality maintenance and protection through stormwater control BMPs, such as vegetative buffers and impervious surface limits and land conservation. Comprehensive sampling, similar to that done in the Tidal Creeks Program in New Hanover County, is needed for other tidal creeks in Brunswick, Pender and Onslow counties that are highly important nursery and shellfish areas.
Water quality degradation Oxygen depletion and fish kills	Coastal research and monitoring needs to continue to improve our understanding of the processes of hypoxia and anoxia and the effect on fish populations. Efforts to reduce nutrient loading from point and nonpoint sources in the Neuse, Tar-Pamlico, and Cape Fear river systems, where the largest number of fish kills have occurred, should continue and be increased as necessary. Implementation of mandatory riparian buffers along the Cape Fear, as well as other strategies, should be considered.
Water quality degradation Sediments	Updated and accurate coast-wide estuarine erosion rates are needed for the CRC and EMC in determining adequate development guidelines and regulations along the coast. More stringent sediment controls on construction projects are still needed to reduce sedimentation in coastal waters. Implementation of mandatory vegetated buffers along all coastal waters should be considered as a strategy for reducing sediment loading, the largest pollutant in North Carolina coastal waters. Width and configuration of the buffers should be scientifically based and may need to be larger adjacent to strategic habitat areas.
Water quality degradation Fecal coliform bacteria	Any steps taken to reduce nonpoint sources of bacteria loading will at the same time reduce loading of other pollutants into coastal waters and improve water quality and habitat conditions. The effect of shellfish filtering capacities on water quality parameters, such as bacteria, nutrients and sediments, should be determined. Additional funds and process changes are needed to allow local communities to more rapidly address repairs and upgrades to all aspects of the municipal waste systems, including collection and treatment systems. To prevent fecal coliform contamination from on-site sewage systems, periodic inspections of on-site systems should be conducted at frequencies recommended by the North Carolina Division of Environmental Health. In addition, siting of subsurface disposal systems in soils adjacent to coastal waters should be reevaluated and revised if necessary to protect water quality. Modification of local or state stormwater rules limiting built upon area for new development adjacent to all coastal waters to less than approximately 12% (for the low density option) would be a scientifically based means of preventing additional water quality degradation. Scientifically based performance standards regarding the quantity and quality of stormwater coming off a site could be established, but careful maintenance and monitoring would be necessary. Restoration efforts to reduce fecal coliform levels should target concentrated areas of shell bottom or other Strategic Habitat Area. Focusing on areas less degraded (conditionally approved areas, recently experiencing increased closures), rather than areas that have been permanently closed for many years, could also result in a greater success in habitat enhancement.

Threat	Management Need
Water quality degradation Fecal coliform bacteria (*continued*)	New or expanded stormwater outfalls to coastal shellfishing waters should be prohibited by the EMC and existing outfalls should be phased out. Coordination and enhancement of rule enforcement and compliance review capabilities within NCDENR agencies is needed to fully enforce existing statutes and rules and minimize further water quality degradation. Given the role of public infrastructure (i.e., sewage treatment capacity) in coastal development, the siting process for infrastructure should be restricted from areas that would impact sensitive fish habitats and supporting areas. Offshore wastewater discharges should be prohibited in North Carolina to minimize water quality degradation to the water column. Additional permits for stormwater outfalls on ocean beaches or nearshore waters should be prohibited by the EMC or the stormwater should be treated to acceptable water quality levels prior to discharging. Alternative stormwater management strategies should be implemented, similar to the efforts underway by Emerald Isle, to phase out existing stormwater outfalls and encourage land application. More detailed monitoring is needed to assess the extent oceanfront septic systems are causing degradation to nearshore coastal waters.
Water quality degradation Toxic chemicals	More research is needed on the subject of hormone-altering chemicals in surface waters. Because pollutants associated with roads, parking lots, and associated transportation are a significant source of toxins and other pollutants to the water column, efforts should be taken by NCDOT to minimize impacts by 1) designing roads to retain stormwater runoff in natural and vegetated upland or wetland areas; 2) designing roads and parking lots to minimize impervious surfaces; 3) improving water flow through transportation structures; 4) monitoring of BMPs; and 5) incorporating BMP design criteria to enhance control of bacteria. Determining the distribution and concentration of heavy metals and other toxins in bottom sediments throughout the coast is needed to comprehensively assess potential threat to the water column. Any new wood preservative products should be evaluated for impacts to marine benthos, including oysters. Ultimately, research is needed to determine if marina basins in freshwater and low-salinity areas actually produce enough toxic chemicals, at the right time, to impact fish populations. The impact of chronic oil pollution on nursery areas is unknown and needs future research. To protect anadromous fish spawning and nursery areas from marina impacts, dredging for new marina construction and other marina-related activities that negatively impacts these fish functions should be restricted. Waters designated as Inland PNAs by NCWRC should be considered for reclassification to HQW by EMC, as was done for MFC-designated PNAs. Formal criteria need to be developed to classifyand protect anadromous fish spawning areas that will be recognized by DWQ. Designation of specific anadromous fish spawning and nursery areas and possibly additional Inland PNAs needs to be completed along the entire coast to provide protection from marina development and other potential threats. Studies are needed to compare use of both upland and open water basins by young fish. Development of a comprehensive marina policy to address appropriate design, siting, operation and maintenance procedures, and cumulative impacts is needed to thoroughly address these and other impacts of marinas. This should consider, among other things, requiring the use of oil-absorbing materials around fuel and docking stations and shoreline habitat (i.e., wetlands, soft bottom). Support of the Clean Marinas Program through additional staff resources and incentives would benefit coastal fish habitat. The cumulative impact of clustered marinas should also be assessed. NCDENR should consider a temporary moratorium on all new small docking facilities (1-10 slips) and marinas, excluding individual private docks, until a comprehensive marina management system for all counties is developed. There is a need to study the cumulative impact of small docking facilities and associated development on toxic chemical concentrations in the water column. The study should also compare higher and lower salinity nursery areas.

Table 5C.3 *(continued)*. Summary of threats and management needs for the Water Column (Street et al. 2004).

Threat	Management Need
Water quality degradation Toxic chemicals *(continued)*	Pesticides should always be applied according to label instruction, regardless of whether a permit is required or not. Research is needed to identify those pesticides safe for spraying over open waters and, for those pesticides whose toxicity is impacted by salinity, appropriate application rates for controlling mosquitoes. Although safeguards are in place, the North Carolina Pesticide Board's policies on drift should be assessed and modified if necessary to ensure adequate protection of aquatic life and water quality.
Water quality degradation Other sources of WQ degradation	Research is needed to determine if effluent from desalination plants could create isolated pockets of higher salinity water with very low diversity of species. Basic water quality parameters (flow, temperature, pH, and DO) should be identified for permit applicants to monitor (<http://h2o.enr.state.nc.us/NPDES/documents.html>, 2004). If the data indicate the presence of pollutants in the discharge water, toxic chemical monitoring and toxicity testing should be required. Nutrients and ammonia should be monitored if a mass balance approach indicates excess nutrients. Finally, biological monitoring of the macrobenthic community should be required on facilities discharging more than 0.5 million gallons per day. Incentives are needed to encourage removal and proper disposal of derelict fishing gear. In addition, public education is needed to discourage littering from land or water based activities.
Non-native/nuisance species	Until treatment of ballast water is required and implemented, monitoring of port waters for algal blooms is recommended to minimize risks of introduction elsewhere.

Shell Bottom

Shell bottom habitat is unique because it is the only coastal fish habitat that is also a fishery species (oysters). The ecological value of shell bottom has only recently been recognized to be as or more significant than the fishery itself, since it provides numerous habitat and water quality functions that are vital for fishery and non-fishery species. The ability of shell bottom to withstand moderate turbidity levels allows oysters to clear the water column, encouraging growth of submerged aquatic vegetation (SAV) and benthic microalgae.

Oysters, SAV, and benthic microalgae quickly process dissolved and suspended material from the water column, thus facilitating the estuaries' role in storage and cycling of nutrients. This process reduces the likelihood of coastal eutrophication and its detrimental effects on fish and fisheries. Oyster beds also increase shoreline complexity, can alter circulation patterns, and enhance fish use of marsh edge habitat. Shell bottom also provides hard structure for attachment of diverse invertebrate species and protective cover for small mobile finfish and invertebrates. Gobies, blennies, hard clams, mud crabs, blue crabs, anchovies, oyster toadfish, and sheepshead are a few of the typical residents of oyster reefs. Research has shown that abundance and production of numerous fishery and prey species are enhanced more by shell bottom than by the surrounding soft bottom. Some of the important fishery species whose production is enhanced by shell bottom include hard clam, black sea bass, gag, tautog, and southern flounder. Shell bottom is federally designated as a Habitat Area of Particular Concern for estuarine dependent snapper-grouper species. The restoration of living oyster beds is therefore critical to the proper functioning and protection of surrounding coastal fish habitats and numerous fishery species.

Shell bottom habitat declined for most of the 20th century. The current distribution of shell bottom has shrunk to a mere fraction of its historical range, when oyster rocks were so abundant that they were considered a hazard to navigation. Anecdotal information suggests that oyster beds have been displaced roughly 10–15 miles (16–24 kilometers) downstream in the Pamlico and Neuse estuaries and completely covered by sediment in other areas. Furthermore, North Carolina's commercial oyster landings have declined about 90% from 1889 to today's low harvest. Most shell bottom losses have been subtidal beds in Pamlico Sound, where NCDMF has also found declines in spatfall. Although mechanical harvesting of oysters has been greatly restricted, reefs have not recovered, possibly due to stress from water quality degradation and increased occurrence of disease (Dermo, MSX). The loss of habitat could be particularly damaging to fishery stocks associated with shell bottom that are classified as Overfished by NCDMF, such as southern flounder, black sea bass south of Cape Hatteras, or the central/southern stock of striped bass.

Oyster dredging, beginning in 1889, is believed to be the major cause of the initial decline in shell bottom (*for a summary of threats and management actions, see Table 5C.4*). Today the dredge harvest has greatly diminished in North Carolina, although about 42% of shallow estuarine bottom (where oysters could live) is still open to mechanical harvest methods, all in Pamlico Sound. Dredging removes oysters and reduces the vertical profile of oyster rocks, increasing the susceptibility of remaining shell bottom at that location to low dissolved oxygen and possible mortality. Hand harvest methods for oysters and clams can also be destructive, but on a much smaller scale. Other bottom disturbing fishing gears, such as trawls, prevent the establishment of oyster reefs in areas within their historic range. Dredging for navigation channels or marina basins also impacts shell bottom. The downstream displacement of oysters in the Neuse and Pamlico rivers is probably the result of extensive drainage networks designed to increase the flow of stormwater (fresh water) into coastal waterways, decreasing salinity in the downstream portions of those rivers. While drainage for agriculture has changed little, drainage for urban/suburban development is increasing steadily. Runoff from agriculture, urban/suburban development, and transportation infrastructure carries sediment, nutrient, and toxic chemical pollutants. Sediment, the number one pollutant of waterways in the United States, clogs oyster gills and buries shells. Excess nutrients can fuel algal blooms and low dissolved oxygen events, and in turn, cause mortality of benthic organisms on deep, subtidal shell bottom. Heavy metals, petroleum products, pesticides, and other toxic chemicals in the runoff can kill sensitive oyster larvae.

To offset the decline in oyster habitat, restoration efforts were begun in 1958, and some protected areas have been established. While almost all work in the past has focused on restoring oysters for harvest, some recent efforts have been designed to restore or enhance shell bottom for habitat purposes. However, the magnitude of losses still greatly exceeds gains from restoration. Large areas of shell bottom habitat are still unprotected from direct physical removal or damage via human-related activities, as well as from indirect damage from water quality degradation. In order to restore shell bottom habitat, the destruction of oyster beds from fishing practices, channel or marina dredging, and pollutant loading must be reduced and oyster habitat restoration must increase significantly.

Submerged Aquatic Vegetation

Submerged aquatic vegetation is an extremely valuable fish habitat that occurs in North Carolina's coastal estuarine and freshwater systems. Because light is the primary limiting factor affecting its distribution, SAV is restricted to relatively shallow waters. Submerged aquatic vegetation provides ecosystem functions similar to shell bottom, such as enhancing water quality through stabilizing and trapping sediment, reducing wave energy, cycling nutrients within the system, and providing structure for invertebrate attachment and refuge from predators. Seagrasses also produce large quantities of organic matter, which supports a complex food base for coastal fishes and other organisms. This habitat is especially valuable as a nursery and refuge from larger predators for the young of many important commercial and recreational fishery species. Bay scallops, pink shrimp, hard clams, gag, black sea bass, summer flounder, and others are typically associated with high salinity SAV. Juvenile striped bass, striped mullet, brown and white shrimp, Atlantic croaker, and others frequently use low salinity grasses.

Red drum and blue crabs are among several species that rely upon both low and high salinity grasses at different stages of their life cycles. The high fisheries value of this habitat has been well established by the scientific community, and SAV is federally designated as a Habitat Area of Particular Concern for penaeid shrimp, blue crab, and red drum.

Historical accounts indicate that there have been large-scale losses of SAV in North Carolina's low salinity tributaries on the mainland side of Pamlico Sound and along much of the shoreline of western Albemarle Sound, while the high salinity grass beds to the east appear relatively stable. Loss of low salinity SAV habitat could negatively affect stocks of striped mullet, Atlantic croaker, and blue crab, which were classified as Concern by NCDMF in 2003. Impacts to high salinity SAV beds could be especially detrimental to bay scallops and black sea bass (south of Hatteras), which are currently listed as Overfished. Protection, enhancement, and restoration of this habitat are high priorities for recovery of those species and for sustained health of many others.

The major threat to SAV is large-scale nutrient enrichment and sediment loading, which increases turbidity, reduces light penetration, and subsequently impacts SAV growth, survival, and productivity (Table 5C.5). In North Carolina, most of the low salinity areas that have experienced large reductions in SAV coverage are also designated Nutrient Sensitive Waters. Major contributors of nutrients and sediments include point source discharges, nonpoint runoff (from crop agriculture, animal operations, urban and road construction, and impervious surfaces) and resuspended sediments (from bottom disturbing fishing gear and channel dredging). There are also activities that threaten the physical structure of SAV. Dredging for navigational channels, marinas, or infrastructure such as bridges or cables can result in large, direct losses of SAV. Docks constructed over SAV can cause immediate loss during construction or gradual loss due to shading effects. Boating activity in shallow vegetated waters can damage SAV from propeller damage to SAV. Bottom disturbing fishing gears used within or near SAV habitat, such as oyster and crab dredges, hydraulic clam dredges, clam trawls, and bull rakes, may cause significant damage to SAV habitat. As human population, boating activity, fishing pressure, and shoreline development increase, losses of SAV are likely to continue if steps are not actively taken to protect SAV and maintain suitable water quality conditions. State and local managers need to ensure that 1) SAV habitat is not physically impacted by water-dependent activities and 2) water quality (especially clarity) is enhanced to allow persistence of existing SAV and re-colonization of former habitat.

Table 5C.4. Summary of threats and management needs for the Shell Bottom (Street et al. 2004).

Threat	Management Need
Physical threats Mobile bottom disturbing fishing gear	Construction of oyster sanctuaries in locations of historic abundance and restriction of trawling over restored shell bottom is necessary to restore shell bottom in these northern subtidal areas. Oyster dredging in these areas should also be prohibited. Stronger penalties are needed for trawling over oyster rocks, where prohibited by the MFC. Additional marking of productive shell bottom would provide increased protection of this habitat from destructive fishing gears. However, additional law enforcement resources are necessary to mark and enforce increased closed areas.
Physical threats Hand harvest	Creation of additional Shellfish Management Areas would reduce habitat damage and enhance spatfall of oysters and clams in areas where hand-harvesting activity is intense. More enforcement would also be needed to enforce the restrictions associated with Shellfish Management Areas.
Physical threats Water-dependent development	Oyster beds in closed shellfishing waters are particularly vulnerable to loss and degradation from marina dredging. These areas should be evaluated for protection as Strategic Habitat Areas. A variety of working groups have recommended the development of a coastal marina policy that encompasses all associated regulatory activities conducted within the NCDENR. Development of this policy continues to be a management need. Evaluation of the impact of dock-associated boating on shell bottom habitat is therefore a research need. Prohibiting construction of docks or replacement of severely damaged docks (>50%) in documented shellfish beds may be required to minimize degradation and loss of habitat.
Water quality degradation Sediment	Improved voluntary and regulatory land use strategies must be implemented to reduce nonpoint source pollution in coastal waters and subsequent habitat degradation. Mitigation should be required from upstream development projects that result in habitat loss downstream.
Water quality degradation Nutrients	Nitrogen, phosphorus and sediment loading from waste treatment facilities, animal operations and other sources must be reduced upstream of shell bottom habitat to minimize mortality to shellfish and associated organisms. Construction of high profile oyster reefs in deeper waters is needed to serve as refuge areas during low oxygen events. Efforts in wetland restoration, shoreline conservation (vegetative buffers, setbacks), and stormwater management should be a priority in watersheds draining to shell bottom habitat, particularly where oxygen and nutrient problems have been documented. Nutrient loading from point sources must also be reduced through increased inspections and maintenance of sewage treatment facilities, collection infrastructure, and on-site wastewater systems. In systems with an abundance of "black waters" (or swamp water), such as the lower Cape Fear River, investigations should focus on separating nutrient impacts on DO from impacts due to inflow of low DO swamp waters.
Water quality degradation Toxic chemicals	Any new wood preservative products should be evaluated for impacts to marine benthos, including oysters.
Disease	Maintenance of high-profile oyster rocks is critical for subtidal oysters to perform their ecological functions, as well as provide resources for harvest. The relative contribution of channel deepening to saltwater intrusion and subsequent oyster mortality must be evaluated in order to determine appropriate management action. Establishment of oyster sanctuaries seeded with disease-resistant brood stock or allowed to naturally develop disease-resistant oysters would enhance the oyster's ability to survive and provide disease-resistant broodstock for repopulating highly impacted areas.
Introduced and nuisance species	The NCDMF Fishery Management Plan for Oysters recommended that testing continue on aquaculture use of non-spawning, non-native oysters before decisions are made opposing or supporting introduction. The recommendations provided by the National Research Council (2003) should be considered in developing a comprehensive oyster restoration plan.

Table 5C.5. Summary of threats and management needs for Submerged Aquatic Vegetation (Street et al. 2004).

Threat	Management Need
Physical threats Channel dredging	The NCDMF and MFC should continue to use existing permit review authorities and CRC and EMC should provide more protection to SAV within existing permitting authority to prevent or limit as much as possible direct or indirect impacts to SAV from all dredge and fill projects.
Physical threats Infrastructure	Infrastructure projects that require SAV impacts should be avoided. Where impacts are unavoidable, SAV losses should be minimized and adequately compensated through mitigation, using methods recommended by NMFS for SAV restoration or creation. Such projects should be monitored over time to determine persistence of restored SAV beds.
Physical threats Boating activity	Educational outreach is needed to increase awareness by the boating public of the ecological value of SAV and the damaging effects of boat propellers to SAV habitat. The level of damage to SAV from prop scarring should be assessed periodically. In areas where boating activity is found to cause significant SAV impacts, navigational markers should be installed to clearly delineate navigational channels to be used or SAV beds to avoid.
Physical threats Marinas and docks	Direct, indirect, and cumulative impacts to SAV and other habitats from marina and dock siting should be minimized. Development of a comprehensive state marina policy is needed to achieve this objective. Research is needed to determine if adequate light is available beneath North Carolina docks, given the current CRC dock siting criteria. These criteria should be evaluated to determine if existing requirements are adequate for SAV survival and growth and what changes would be needed to allow at least the minimum amount of light beneath docks. The permit requirements for docks and piers may need to be changed accordingly. Any research and modeling effort conducted on dock impacts should address the cumulative impact of shading, turbidity, boater access, and other impacts on the quality and quantity of SAV beds.
Physical threats Fishing gear impacts	Research is needed to determine where there is suitable potential SAV habitat along the mainland shorelines of the Albemarle-Pamlico system for the purpose of establishing defined SAV restoration goals. Once determined, oyster dredging should be prohibited from areas targeted for SAV restoration. Research should be conducted to determine whether gear impacts or other factors are causing the decline observed in bay scallop landings that was discussed in the Status and Trends section. If current bay scallop harvesting methods are found to negatively impact SAV and bay scallop populations, the NCDMF and MFC should consider rotation of fishing areas, or other fishery management techniques. Turbidity impacts to SAV at this new location and other existing mechanical harvest areas should be assessed through water quality monitoring. Field studies are needed to assess the effect of shrimp and crab trawling on SAV in North Carolina, particularly in Core and Bogue sounds. In addition, the boundaries of No Trawl Areas should be evaluated and adjusted, if necessary, to adequately protect all high salinity SAV beds and provide a buffer of unvegetated area to reduce turbidity impacts. Additional law enforcement may be needed to enforce buffers around SAV.
Water quality degradation Nutrients and sediments	Modifications may be needed to regulations and monitoring programs to improve their effectiveness for SAV protection. A review of current chlorophyll, total suspended solids, and turbidity standards should be conducted to determine if they are appropriate for the protection of SAV in North Carolina waters. NCDENR should work with NOAA Fisheries to determine what levels of total suspended solids, chlorophyll a and other parameters are needed to achieve desired water clarity. The need and feasibility (scientific defensibility and "implementability") for a water quality standard for light attenuation should be investigated to provide a pro-active target or standard for protection and restoration of SAV. Once the appropriate water quality conditions for protection of SAV are determined, NCDWQ should evaluate whether current sampling locations and methods are sufficient in estuarine waters to monitor the suitability of water quality conditions for SAV survival and growth. Monitoring should be conducted in waters with SAV habitat to ensure that the standards and conditions are being met. If additional monitoring is needed, establishment of continuous monitoring stations should be considered. In either case, priority should be given to those areas already classified Nutrient Safe Waters.

Threat	Management Need
Water quality degradation Nutrients and sediments (*continued*)	Since some SAV is present in the shallow portions of the Neuse and portions of the White Oak river basins, and water quality data indicate some level of eutrophication exists, nutrient levels may be limiting survival or expansion of SAV in these areas. These areas should be a high priority for monitoring of SAV and water clarity. To restore SAV habitat in fresh and estuarine systems where it historically occurred, management strategies should focus on water quality improvements at the edges and upstream of SAV occurrence. Nonpoint source loading of nutrients and sediment could be reduced through multiple strategies, including preservation and restoration of upland and wetland riparian habitats, modifications in land use regulations and agricultural BMPs. Conservation priorities should be set for land acquisition programs which will aid in protecting Strategic Habitat Areas. Nutrient and sediment reduction goals should be established by the EMC to achieve the minimum of 15-25% light availability at depth requirement for SAV growth. An increase in staffing to fully implement and enforce existing stormwater and other nonpoint source-related regulations is needed to achieve this goal. The New River nutrient management strategy [EMC rule 15A NCAC 02B.0223] was heavily focused on point sources and should be revisited to determine what additional controls, such as buffers, might be necessary to achieve continued water quality improvements. An approach similar to that used in Indian River Lagoon and the Chesapeake Bay, where the condition of water quality, SAV, and fish populations are linked in monitoring and management, would be useful for protection of SAV habitat in North Carolina.
Water quality degradation Toxic chemicals	Permitting for chemical removal of European watermilfoil and other non-native vegetation should be carefully restricted where native species co-occur to prevent non-target impacts. More education on the value of SAV to the health of North Carolina's estuaries and fisheries is needed to modify attitudes toward this habitat and improve individual and community stewardship of SAV.
Introduced and nuisance species	Long-term management and restoration of SAV habitat should include replacement of Eurasian watermilfoil with native species. NCDENR should coordinate with the Division of Water Resources to ensure that native species are not targeted for removal. Research is also needed to determine the relative fishery value of Eurasian watermilfoil compared to native vegetation. Non-native species may also be introduced through unintentional releases from aquaculture and live bait facilities. Policies should be developed by state agencies overseeing aquaculture and bait facilities to prevent such releases into coastal waters.
Other threats	Submerged grasses need to be monitored on a regular basis to assess the status of wasting disease and its association with human-induced stresses.

Wetlands

Wetland habitat is unique among the coastal fish habitats because it is not entirely submerged but occurs in and above the water. There are many different types of wetlands throughout the coast, many bordering the rivers and sounds, while others are hydrologically isolated. While each wetland type is unique, these different types provide similar ecological functions. Wetlands are highly effective and well recognized for their value as a natural filter, trapping and filtering pollutants from upland runoff; as well as serving to buffer the effects of floods by storing, spreading, and slowing stormwater runoff. Like SAV, wetlands are highly productive biologically, but because of their expansive coverage and biomass, produce much more organic matter, which is broken down and utilized by multiple species adjacent to wetlands and elsewhere. It has been estimated that over 95% of the United States' commercially harvested finfish and shellfish are wetland dependent. The combination of shallow water and thick vegetation provides excellent nursery habitat for juvenile fish. The majority of MFC-designated Primary Nursery Areas consists of wetlands and adjacent shallow water and soft bottom. Fish found commonly in or near freshwater marshes and swamps include bluegill, largemouth bass, river herring, and striped bass. In and adjacent to estuarine wetlands, killifish, spot, red drum, flounder, penaeid shrimp, striped mullet, pinfish, blue crab, and other species are abundant. In addition to supplying food and acting as nursery habitat for numerous species, riparian wetlands also provide a relatively safe corridor for fish moving among the other nearshore habitats.

It is estimated that as much as 40-50% of North Carolina's original wetland coverage has been lost, primarily due to ditching, channelization, and filling for agriculture and development. From the early 1800s to the early 1900s, agriculture accounted for the majority of wetland losses. From about 1950 to the 1990s, development accounted for two-thirds of wetland impacts, with forestry and agriculture associated with the remainder. Although the rate of wetland loss has slowed, losses continue to occur. Mitigation for permitted losses and voluntary restoration efforts in some areas have partially offset some recent losses, but the type of wetland gained is often not equivalent to what was lost. Degradation and loss of wetlands can impact many species, including overfished stocks of river herring and southern flounder, as well as stocks designated with the Concern status such as blue crab and striped mullet.

There are multiple threats to wetland habitat today, primarily due to physical destruction and hydrological alteration (Table 5C.6). Ditching and draining for development, construction of new dams, mining activity, and filling for new development accounted for the majority of permitted wetland losses in recent years. Construction of roads, infrastructure, and water dependent-development, including dredging for marinas and navigation channels, also results in smaller, site-specific losses and contributes to cumulatively large wetland losses. Estuarine shoreline stabilization causes gradual, long-term wetland loss by limiting sediment inputs needed for maintenance and expansion of wetlands, and by blocking landward migration as sea level rises. Because wetlands are critical to a large number of fishery species, but have been greatly reduced in spatial coverage from their original extent, ongoing initiatives such as wetland restoration, land acquisition and preservation, and agricultural cost-share BMPs need to be enhanced. There should also be additional initiatives implemented to protect and enhance wetland habitat. The many fishery and water quality functions provided by wetlands make their preservation and restoration along North Carolina's coast a high priority for protection of all coastal fish habitats.

Table 5C.6. Summary of threats and management needs for Wetlands (Street et al.2004).

Threat	Management Need
Physical threats Land use and wetland alteration	Additional monitoring is needed to better assess impacts where extensive areas of wetlands were drained. More NCDWQ staff are needed to inspect for compliance with water quality standards, including wetland draining. Any ditching activity resulting in nonpoint source pollution in North Carolina's rivers and sounds should require an NPDES permit. The EMC's constraints on discharges in SA waters could then be extended to drainage projects, in addition to traditional point source discharges (i.e., wastewater treatment plants). Eventually, the EEP should include mitigation planning for upland development and other approaches to habitat enhancement, restoration, and preservation.
Physical threats Shoreline stabilization	Better criteria to define an "erosion problem" and aid in proper utilization of erosion control structures are needed and should be developed by the NCDCM and CRC. There is a need to more accurately assess where and how much of the estuarine shoreline is hardened. With more accurate information, the level of impact to marine resources can be assessed. The methodology used for assessing shoreline hardening (examination of aerial photographs) could be used for a larger portion of the coast to spatially delineate and quantify where and how much of the shoreline is hardened. The CRC should revise estuarine shoreline management rules using best available scientific information, including the recommendations from the Estuarine Shoreline Biological and Physical Processes Work Group to minimize impacts to natural shoreline and nearshore fish habitat functions. As part of the process of modifying shoreline management rules, accurate estuarine shoreline erosion rates are needed to aid in identifying "erosion problems," determining adequate shoreline setbacks, and determining appropriate erosion control methods where necessary. Wherever possible, sections of estuarine, non-vegetated shoreline with very little hard stabilization should remain unaltered to provide "new" sediment for shallow water habitats. Some consideration should also be given to the type of material used in rock structures because oysters more readily colonize oyster cultch material or limestone marl, than granite.

Threat	Management Need
Physical threats Channelization and ditching	Dechannelization of streams, restoration of wetland hydrology, use of alternative drainage techniques, and on-site BMPs are therefore needed to maintain and restore wetlands, flows and salinity patterns in downstream areas. In addition, increased funding and educational outreach to farmers and other landowners are needed for projects that restore natural stream and wetland functions.
Physical threats Boating	There is a need to amend NCWRC no wake zone authority to include consideration for erosion in strategic wetland areas. There should also be increased public awareness of the impact of boat wakes on wetland shorelines.
Water quality degradation	The susceptibility of freshwater wetlands to sulfate pollution should be evaluated in coastal North Carolina. Results should provide the measure of iron concentrations in wetland sediment necessary to evaluate susceptibility.
Sea level rise and storm events	Buyers and owners of coastal property should be aware of sea level rise and the potential for loss of wetlands and property. Updated and accurate coast-wide estuarine erosion rates are needed for the CRC and EMC to determine adequate development guidelines and rules along the coast. Priorities for coastal wetland protection should also acknowledge sea level rise, and protect gently sloping areas upland of coastal wetlands to allow for landward migration of coastal wetlands with sea level rise. Research is needed on site-specific erosion and accretion rates and their relationship with sea level rise and storm events. Specific research is also needed to determine processes that control the upper limits of peat accumulation, which is the foundation of coastal wetland development in the Albemarle-Pamlico system.

Soft Bottom

Soft bottom habitat is the unvegetated bottom sediment in all coastal systems, and includes features such as inlets, shoals, channel bottoms, intertidal ocean beaches, and cape shoals. Soft bottom plays a key role in primary productivity in shallow estuarine and marine systems. This habitat strongly influences the water column through dynamic cycling processes, storing and releasing nutrients and chemicals over time. Other ecosystem functions of soft bottom include the reduction of physically destructive storm effects on oceanfront beaches, and providing sand sources for barrier island and inlet migration. Soft bottom habitat is particularly important as a foraging area for all size ranges of bottom feeding fish and invertebrates, such as blue crabs, shrimp, flounders, striped mullet, spot, croaker, and kingfish. Burrowing mollusks (e.g., hard clams, coquina clams), flatfishes (e.g., southern flounder, hogchoker) and baitfish (e.g., striped mullet) are highly associated with shallow soft bottom, while larger benthic feeding predators (e.g., weakfish, coastal sharks, sturgeons) typically utilize deeper soft bottom areas. Valued fishery species that depend on healthy soft bottom habitat include hard clams, shrimp, blue crabs, southern flounder, Atlantic croaker, striped mullet, kingfish, and spot. Of these, the NCDMF stock status of Atlantic and shortnose sturgeons, southern flounder, and coastal sharks was Overfished. Striped mullet and Atlantic croaker were listed as Concern. The Atlantic sturgeon, which is classified as Overfished, has been under a fishing moratorium since 1991 but has not shown signs of recovery. Coastal inlets have been federally designated as Habitat Areas of Particular Concern for blue crab, estuarine-dependent snapper and grouper, penaeid shrimp, and red drum.

Inadequate data are available to clearly indicate the current condition of soft bottom habitat. Fortunately this habitat is relatively resistant to a changing environment. This is the most abundant submerged coastal fish habitat, and estuarine acreage of soft bottom has undoubtedly increased over time as shell bottom, SAV, and wetland habitats have declined.

Threats of greatest concern include large-scale alterations such as dredging of productive shallow bottom areas, construction of marinas and docks, bottom dredge and trawl fisheries in estuarine waters, and large-scale beach nourishment (Table 5C.7). Depletion of oxygen and toxic contamination of bottom sediments are the major water quality concerns since those conditions can cause mortality or poor recruitment of benthic invertebrates, which in turn can affect food availability for numerous benthic feeding invertebrates and fish. Therefore, minimizing dredging of productive shallow bottom, properly managing beach nourishment to maintain healthy benthic communities in the surf zone, and reductions in nutrient and toxin loading in all coastal waters are the primary management needs for soft bottom.

Table 5C.7. Summary of threats and management needs for Soft Bottom (Street et al. 2004).

Threat	Management Need
Physical threats Dredging	More research is needed to assess direct and indirect dredging impacts on blue crabs and inlet spawning species. Commenting and permitting agencies should continue to use their existing authorities to a) minimize new dredging of shallow soft bottom habitat, b) prevent direct impacts from dredge and fill projects, and c) limit as much as possible indirect impacts to shallow soft bottom or other habitats.
Physical threats Dredge material disposal on subtidal bottom	A state policy on dredge material management that a) minimizes impacts to coastal fish habitat, including soft bottom habitat, and b) is consistent with federal existing guidelines, should be developed.
Physical threats Marinas and docks	Stringent efforts are needed to prevent toxic contamination of sediments from marinas to reduce impacts to soft bottom productivity. Toxic sources at marinas should also be addressed. Dock siting criteria should include a minimum water depth to prevent boats or floating docks from sitting directly on soft bottom or other benthic habitats. A comprehensive dock and marina policy is needed to address appropriate design, siting, operation, and maintenance procedure and cumulative impacts to minimize impacts to soft bottom and other fish habitats. Research on the impacts of these parameters is needed.
Physical threats Shoreline stabilization	A comprehensive examination and revision of current CRC shoreline stabilization rules using best scientific information is still needed to minimize impacts from this activity to soft bottom, particularly intertidal estuarine shorelines. Research is needed to determine if and how oyster shell could be utilized as an alternative to rock or wooden stabilization structures to create "living shorelines" that are effective in stabilizing the shoreline while also providing habitat value. Any new wood preservative products should be evaluated for toxicity to marine benthic organisms and juvenile fish. When formulating revisions to CRC's shoreline stabilization regulations and guidelines, CRC should take into account the impact of sediment contamination and potential toxicity of wood preserved bulkheads on marine organisms. Prohibition of shoreline hardening of the oceanfront should continue to be enforced for overall protection of barrier island processes, nearshore soft bottom communities, and associated fish species. The effectiveness and cumulative impact of beach bulldozing should be assessed and appropriate guidelines should be included in a coastal beach management plan. When mine areas are necessary for beach nourishment projects, guidelines should strongly encourage siting protocol that maximizes biological recovery rates and does not degrade critical fish foraging areas. More specific minimum and maximum grain size standards are needed to minimize biological impacts (re: beach renourishment). Because of the potential impact of beach nourishment and dredge disposal on soft bottom communities, there is a need for a coast-wide Beach Management Plan that carefully reviews cumulative impacts of activities and provides ecologically based guidelines, including sediment compatibility standards, to minimize cumulative impacts. The CRC's beach nourishment rules should be evaluated and modified in a comprehensive manner as needed to minimize overall impacts from this activity. Additional research is also needed to more clearly quantify the cumulative impact of nearshore dredge disposal on fish populations. Adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important as the number of beach nourishment projects increase and should be required for all large-scale or long-term nourishment projects. To adequately and correctly assess the direct and cumulative impacts of beach nourishment activities on fish, their habitat, and biological recovery rates, thorough monitoring must be conducted. Because the demand for beach nourishment has increased in recent years, due in part to the state's prohibition of shoreline hardening, there is a need to complete a comprehensive beach management plan to provide guidelines to minimize long-term impacts. In addition, multi-agency efforts should be made to educate local government officials and the general public (since these groups initiate and drive the demand for beach nourishment) on natural hazards and other factors associated with dynamic coastal systems.

Threat	Management Need
Physical threats Fishing gear impacts Dredging	Because less habitat damaging methods are available for harvesting crabs, MFC should prohibit crab dredging.
Physical threats Fishing gear impacts Bottom trawling	Further analysis is needed to identify the location, duration, and initiation of trawling over soft bottom habitat as well as over structured habitats, such as shell bottom and SAV. It is also important to quantify the effects of trawling on the habitat. Further analysis is needed to spatially quantify where, how often, and when trawling occurs in specific areas of soft bottom habitat. Primary nursery areas and inlets are described as "recruitment bottlenecks" for estuarine dependent species. Since larval flounder, shrimp, and Atlantic croaker must pass through inlets and recruit to shallow PNAs, trawling impacts in inlets and PNAs could be greater than trawling in ocean waters. Protection of these "recruitment bottlenecks" from trawling or other impacts is therefore very important for estuarine dependent fish and invertebrates. Shallow areas where trawling is currently allowed should be re-examined to determine if additional restrictions are necessary. Further studies are needed to more accurately assess if trawling is having a negative effect on soft bottom habitat and justify if additional closures are necessary for habitat concerns. Large-scale long-term experiments with and without fishing pressure are needed, rather than short-term small-scale studies, to examine and better quantify cumulative fishing impacts and recovery patterns in ocean waters.
Water quality degradation Toxic chemicals	More information is needed on the in situ effects of various contaminant levels, in combination with other contaminants and existing environmental stressors, to many important fish species in North Carolina. To better determine if contaminated sediment is a significant threat to coastal fish habitat, the distribution and concentration of heavy metals and other toxic contaminants in freshwater and estuarine sediments need to be adequately assessed and areas of greatest concern need to be identified. Continued minimization of point and nonpoint sources of toxic contaminants is vital for protecting not only soft bottom but also the other fisheries habitat.
Water quality degradation Nutrients	Long-term monitoring is required, in combination with management actions that reduce discharge concentrations, to determine effectiveness and future management needs.
Water quality degradation Oxygen depleted sediment	More information is needed to understand the consequences on the estuarine food web and to what extent anoxia is impacting the soft bottom community. Efforts are needed to reduce anthropogenic nutrient loading, particularly in systems that have a history of hypoxia and anoxia.

Hard Bottom

Hard bottom is valuable to fish because it provides structural complexity for foraging and refuge in marine waters. The presence of ocean hard bottom, along with appropriate water temperatures, allows for the existence of a temperate-to-subtropical reef fish community and a snapper-grouper fishery in North Carolina. Many economically important species and many non-fishery species spawn on nearshore hard bottoms, including black sea bass, Atlantic spadefish, sheepshead, tomtate, white grunt, pinfish, pigfish, damselfish, blennies, sand perch, and inshore lizardfish. Nearshore hard bottoms within North Carolina's ocean waters also serve as important nursery areas for these species as well as provide important secondary nursery habitat for estuarine-dependent fish, such as gag, and black sea bass, as the fish move between estuarine areas and offshore reef areas. All nearshore hard bottoms have been federally designated as Habitat Areas of Particular Concern for the snapper-grouper complex.

Although the current distribution of hard bottom habitat has been mapped, little is known about the biological condition of specific hard bottom sites or how it is changed over time. Wrecks and artificial reefs are beneficial since they add to the total amount of hard structure available to marine organisms and may reduce fishing pressure on natural reefs.

Because of the lack of baseline information on the biological functioning of nearshore hard bottom, the primary management needs for this habitat are continued research and monitoring to determine specific functional importance, determination of status and trends, and protection of existing hard bottom habitats from degradation or destruction. Threats to nearshore hard bottom in North Carolina include beach nourishment, channel dredging, bottom-disturbing fishing gear, and water quality degradation (Table 5C.8). Channel dredging can directly remove hard bottom habitat or increase turbidity to damaging levels. Sand transported from nourished beaches can cover up hard bottom structure. Bottom-disturbing fishing gear and related equipment, such as bottom trawls and boat anchors, can uproot coral and damage the structure of hard bottom. Excess nutrients, sediments, or toxins can impact growth or survival of the invertebrates living on hard bottom structure. Water quality degradation to hard bottom originates from nonpoint sources, such as oil and gas from boating activity, oil spills, and nutrient, sediment, or toxin loading from estuarine and riverine discharges. The quality of estuarine waters discharging into marine waters may have the largest overall effect on hard bottom, and can be addressed through the management needs discussed in the other estuarine habitat sections.

Table 5C.8. Summary of threats and management needs for Hard Bottom (Street et al. 2004).

Threat	Management Need
Dredging and beach renourishment	The transport of sand from nourished beaches over time should be monitored. Future research should attempt to determine if the probability or extent of burial are affected by sand volume, type, or grain size, by the time-of-year of project initiation, or by the distance between nourished beach and hard bottom. A NCDENR Beach Management Plan should be developed and implemented which includes specific guidelines to minimize impacts to hard bottom from nourishment projects.
Fishing and diving Commercial fishing	While there is potential for damage, research is needed to determine if and to what extent hard bottom is being damaged by trawling activity in North Carolina, particularly shrimp trawls in the southern portion of the coast. The specific locations of trawl trips should be mapped. To assess potential effects of trawling, experimental trawls of predetermined duration, magnitude and frequency should be conducted in a previously untrawled hard bottom location. The MFC should consider designating nearshore ocean hard bottoms as Strategic Habitat Areas due to their importance as secondary nursery habitat and corridors for gag, black sea bass, and other fisheries resources.
Fishing and diving Recreational fishing	Monitoring of hard bottom is needed to assess the level of impact from hook and line fishing. Educating anglers on the impacts of anchor damage, lost fishing gear and discarded litter to hard bottom habitat and associated species would be helpful in reducing those impacts.
Infrastructure	North Carolina should coordinate with ASMFC, other states, and thecommunications companies to manage the placement of fiber optic cables in North Carolina offshore waters in a manner that minimizes impact to hard bottom and minimizes conflicts with existing activities.
Water quality degradation	It would be beneficial for the state to develop and implement a policy to prohibit oil and gas drilling in North Carolina's coastal waters, to ensure protection of hard bottom and water column habitats. Adequate monitoring should be conducted prior to creation and during use of the Ocean Dredge Material Disposal Site (off the mouth of the Cape Fear River) to determine its effect on hard bottom habitat. Current state (EMC) policies prevent wastewater discharge into the Atlantic Ocean. The only exception to this restriction is the discharge off Oak Island of heated flow-through, non-contact cooling water from a nuclear power plant. Because nearshore hard bottoms are so vulnerable to damage from physical and water quality changes, this policy should be maintained. Monitoring of hard bottom should be initiated and coordinated with UNC-W or other ocean water quality monitoring programs to determine the effects of estuarine water quality, particularly nutrient and sediment loading, on hard bottom. Additional water and tissue sampling at hard bottom sites are needed to determine if the benthos of the hard bottom community or the surrounding waters exhibit levels that exceed designated levels of concern.

Management Recommendations[12]

The discussions of the six major habitat types demonstrate the importance of coastal fish habitats, threats to those habitats, and the need to take actions to achieve the stated goal of the CHPP as provided by the North Carolina General Assembly: "long-term enhancement of coastal fisheries associated with each coastal habitat." Management recommendations are based on scientific studies cited in CHPP chapters 2–7, deliberations of the Environmental Management, Coastal Resources, and Marine Fisheries commissions, and citizen input (verbal comments received in person or by telephone; written comments received in person or via mail and e-mail) from two series of well-attended public meetings (20 in all) held during the summers of 2003 and 2004, as well as additional comments obtained during the CHPP process.

The public cited coastal development as the issue most needing immediate attention, followed by enforcement of existing statutes, rules, and permit conditions, and then environmental education and research. Threats associated with development included polluted stormwater runoff, wastewater discharges, and wetland filling. Meeting attendees agreed that existing laws and rules might be sufficient for habitat protection, but that they are not adequately enforced largely due to insufficient staffing and resources. Educating the public about the importance of coastal habitats and the threats they face was repeatedly mentioned as being critical for successful habitat protection and enhancement.

Threats

The CHPP law specifically requires identification of "existing and potential threats to the habitats" and "actions to protect and restore the habitats" (G.S. 143B-279.8). Threats to coastal fish habitat come from many sources and usually affect more than one habitat. Table 5C.9 (reproduced from Table 9.1, Ch. 9, Street et al. 2004) provides a listing and evaluation of the principal threats to the six types of coastal fish habitats identified previously in (the CHPP report). The water column and shell bottom are the most threatened habitats (shell bottom because there is so little of it, and the water column because there are so many pollution sources). All habitats are subject to multiple threats.

Recommendations

The CHPP development process identified hundreds of management needs (summarized in Tables 5C.3–5C.8 above). The members of the three Commissions reviewed the issues, along with suggested management actions to address those needs. The Commissions selected four general goals and a series of recommended actions to reach each goal, as shown below (and in Table 9.2, Ch. 9, Street et al. 2004). The goals and recommendations shown below are not listed in any kind of priority order. Implementation of any of the recommendations below through specific rules or policies may involve further discussion with stakeholders and, in some cases, the balancing of competing ecological and economic values.

GOAL 1. Improve Effectiveness of Existing Rules and Programs Protecting Coastal Fish Habitats

Every year, an average of more than 100 acres of Outstanding Resource Waters (the highest quality waters in North Carolina) are closed permanently to shellfish harvest, and miles of previously unaltered estuarine shoreline are artificially hardened with vertical shoreline stabilization structures. Thousands of acres of farmland and forests are uprooted, developed, and paved annually, and nutrient-contaminated Public Trust waters suffer from low oxygen events and fish kills. Existing rules and programs have had only limited success in protecting and enhancing coastal fish habitats and fisheries resources. The following non-regulatory actions must be taken for existing management strategies to be effective:

- Enhance enforcement of, and compliance with, Coastal Resources Commission, Environmental Management Commission, and Marine Fisheries Commission rules and permit conditions.
- Coordinate and enhance water quality, physical habitat, and fisheries resource monitoring (including data management) from headwaters to the nearshore ocean.

[12]Text taken directly from Ch. 9, Street et al. 2004.

Table 5C.9. Evaluation of specific threats to coastal fish habitats based on hydrologic, physical, and water quality alterations. Darker shading indicates greater impact[13](Street et al. 2004).

Activity Type	Threat/Activity	Coastal Fish Habitats					
		Water Column	Shell Bottom	SAV	Wetlands	Soft Bottom	Hard Bottom
Agriculture/ Aquaculture related	Animal operations						
	Aquaculture (incl. discharges, exotic species)						
	Cropland						
	Forestry						
Water control	Dams						
	Water withdrawal						
Development related	Urban/suburban construction activities						
	Urban stormwater runoff (impervious surface)						
	On-site wastewater disposal						
	Permitted industrial wastewater discharges						
	Permitted domestic wastewater discharges						
	Waste disposal (landfills, ocean dumping)						
	Fiber optic cables/utility pipelines						
	Estuarine shoreline stabilization						
	Ocean shoreline hardening						
	Ocean beach renourishment						
Transportation related	Impervious roadways						
	Culverts, bridges, and fill (physical blockages)						
Fishing related	Bottom trawl						
	Clam trawl (clam kicking)						
	Toothless dredge (bay scallop)						
	Toothed dredge (crab and oyster)						
	Long haul seines						
	Pots (crab)						
	Rakes, tongs						
	Rod and reel						
Navigation related	Marinas and docks (construction, assoc. NPS)						
	Ports (incl. exotic species via ballast water)						
	Boating activity						
	Channel and inlet dredging						
	Dredge material disposal (on submerged land)						
Mining related	Phosphate and other minerals						
	Log salvage						
	Oil and gas exploration/drilling						
Other	Sea level rise						
	Storm events						
	Disease						
	Introduced or nuisance species						
	Marine debris/litter						

[13]Impact rating: Dark green – severe; Medium green – moderate; Light green – minor; White – none, unknown or potential

- Enhance and expand educational outreach on the value of fish habitat, threats from human activities, effects of non-native species, and reasons for management measures.
- Coordinate rulemaking and enforcement among regulatory commissions and agencies.

GOAL 2. Identify, Designate, and Protect Strategic Habitat Areas

Growing resident and visitor populations in coastal North Carolina will further stress productive coastal habitats and fisheries resources through expansion of support services and infrastructure. Inland development degrades the water quantity and quality of streams that flow to the coastal sounds, as do increased boating and some fishing activities. Certain areas are especially important to fish production, and others are particularly vulnerable to these threats. Greater protection for these "Strategic Habitat Areas" must be a high priority in order to maintain a healthy coastal ecosystem. The following regulatory and non-regulatory management actions should be implemented:

- Evaluate potential Strategic Habitat Areas by:
  a) Coordinating, completing, and maintaining baseline habitat mapping (including seagrass, shell bottom, and other bottom types) using the most appropriate technology.
  b) Selective monitoring of the status of those habitats.
  c) Assessing effects of land use and human activities on those habitats.
- Identify and designate Strategic Habitat Areas using ecologically based criteria.
- Analyze existing rules and enact measures needed to protect Strategic Habitat Areas.
- Improve programs for conservation (including voluntary actions) and acquisition of areas supporting Strategic Habitat Areas.

GOAL 3. Enhance Habitat and Protect It from Physical Impacts

Studies estimate that up to 50% of North Carolina's original wetlands have been destroyed since colonial times. Development continues to cause degradation and permanent loss of coastal and non-coastal wetlands. Significant negative impacts to wetlands may occur through a combination of larger projects that require state and federal permits and numerous small, unrecorded actions. Regardless of magnitude, each impact contributes to the cumulative loss of habitat functions and biological productivity. Shell bottoms (oyster reefs) in coastal North Carolina were decimated by uncontrolled fishing methods more than a century ago, and later by construction of the Atlantic Intracoastal Waterway in the 1930s. Since that time, hurricanes, mechanical harvest methods, small scale dredging and filling projects, and diseases and parasites have continued to reduce remaining shellfish bottoms, particularly subtidal oyster beds in the Pamlico Sound system, and impede establishment of new shell bottoms. Submerged aquatic vegetation (SAV, seagrass) in low salinity areas, such as Albemarle Sound and western Pamlico Sound, has all but disappeared. Submerged aquatic vegetation is highly vulnerable to physical disturbances, as well as to water quality degradation, especially turbidity. Strong management actions are necessary to reverse historic and current habitat losses and restore wetlands, shellfish beds, and SAV. The following regulatory and non-regulatory measures are recommended:

- Greatly expand habitat restoration, including:
  a) Creation of subtidal oyster reef no-take sanctuaries.
  b) Re-establishment of riparian wetlands and stream hydrology.
- Prepare and implement a comprehensive beach and inlet management plan that addresses ecologically based guidelines, socio-economic concerns, and fish habitat.
- Protect Submerged Aquatic Vegetation, shell bottom, and hard bottom areas from fishing gear effects through improved enforcement, establishment of protective buffers around habitats, and further restriction of mechanical shellfish harvesting.
- Protect fish habitat by revising estuarine and public trust shoreline stabilization rules using best available information, considering estuarine erosion rates, and the development and promotion of incentives for use of alternatives to vertical shoreline stabilization measures.

- Protect and enhance habitat for anadromous fishes by:
  a) Incorporating the water quality and quantity needs of fish in surface water use planning and rule making.
  b) Eliminating obstructions to fish movements, such as dams, locks, and road fills.

GOAL 4. Enhance and Protect Water Quality

Because all fish habitats are connected through the water column, maintaining and restoring water quality is the basic component of habitat protection and enhancement. Runoff from developed lands (structures, parking lots, roads, residential yards), agricultural fields and facilities, and some intensively managed forests carries excess nutrients into surface waters, which can lead to algal blooms that reduce water clarity and lower dissolved oxygen in the water column. Turbidity from runoff can suppress SAV growth, cause low oxygen events leading to fish kills, and cause mortality of organisms in the bottom community, including oysters. Excess sediment clouds the water, reduces SAV growth and survival, fills in creeks and small water bodies with silt, and degrades spawning and nursery habitats. Heavy metals and pesticides transported into the water with storm water can accumulate in the bottom sediments and organisms. Through the food chain, such pollutants may contaminate fish, affecting their survival and growth, and making them unsafe for human consumption. Runoff also carries fecal material to surface waters after rain events, requiring closure of tens of thousands of acres of shellfishing waters to harvest in order to protect human health.

Spills and other failures of municipal and on-site wastewater treatment facilities and infrastructure often send sewage pollution downstream, contributing to algal blooms, and causing shellfishing closures and restrictions on swimming in public waters. Some coastal towns dispose of stormwater on the ocean beaches, while others drain it to the ocean or estuaries. These discharges degrade water quality, leading to shellfishing closures and notifications warning of possible public health dangers from contact with contaminated water. These warnings have a detrimental effect on tourism. Marinas also degrade water quality and restrict use of Public Trust waters via mandatory shellfish harvest closures. Large-scale animal farming expanded rapidly in eastern North Carolina in the 1990s, and management of hog waste became a major environmental problem. Current methods generally used for hog waste management can greatly increase nutrient loading to adjacent waters through excessive spraying on fields, aerial deposition, and spills. The following regulatory and non-regulatory management measures are necessary to address a diversity of point and non-point pollution sources:

Point Sources

- Reduce point source pollution from wastewater by:
  a) Increasing inspections of wastewater treatment facilities, collection infrastructure, and land disposal sites.
  b) Providing incentives for upgrading all types of wastewater treatment systems.
- Adopt or modify rules or statutes to prohibit ocean wastewater discharges.
- Prohibit new or expanded stormwater outfalls to coastal beaches and to coastal shellfishing waters (EMC surface water classifications SA and SB) except during times of emergency (as defined by the Division of Water Quality's Stormwater Flooding Relief Discharge Policy) when public safety and health are threatened, and continue to phase-out existing outfalls by implementing alternative stormwater management strategies.

Non-point Sources

- Enhance coordination with, and financial/technical support for, local government actions to better manage stormwater and wastewater.
- Improve land-based strategies throughout the river basins to reduce non-point pollution and minimize cumulative losses to wetlands and streams through voluntary actions, assistance, and incentives, including:
  a) Improved methods to reduce sediment pollution from construction sites, agriculture, and forestry.
  b) Increased on-site infiltration of stormwater.
  c) Documentation and monitoring of small but cumulative impacts to wetlands and streams from approved, un-mitigated activities.
  d) Incentives for low impact development.
  e) Increased inspections of onsite wastewater treatment facilities.
  f) Increased water re-use and recycling.
- Improve land-based strategies throughout the river basins to reduce non-point pollution and minimize cumulative losses to wetlands and streams through rule making, including:
  a) Increased use of effective vegetated buffers.
  b) Reduction of impervious surfaces where feasible and reduction of the level of impervious surface allowable in the absence of engineered stormwater controls.
  c) Expansion of CAMA Areas of Environmental Concern upstream and landward.
  d) Consideration of erosion rates as an additional factor in the siting of structures along estuarine and public trust shorelines.
- Develop and implement a comprehensive coastal marina and dock management plan and policy for the protection of shellfish harvest waters and fish habitat.
- Reduce non-point source pollution from large-scale animal operations by the following actions:
  a) Support early implementation of environmentally superior alternatives to the current lagoon and spray field systems as identified under the Smithfield Agreement and continue the moratorium on new/expanded swine operations until alternative waste treatment technology is implemented.
  b) Seek additional funding to phase-out large-scale animal operations in sensitive areas and relocate operations from sensitive areas.
  c) Use improved siting criteria to protect fish habitat.

(Also see Table 9.2 in Street et al. 2004).

References

National Research Council. 2003. Non-native oysters in the Chesapeake Bay. The National Academic Press, Washington, DC.

N.C. Division of Water Quality (NCDWQ). 1997. Neuse River Basinwide Water Quality Management Plan. North Carolina Division of Water Quality, Water Quality Section, Raleigh, NC.

Ricklefs, R. E. 1993. The economy of nature, 3rd edition. W. H. Freeman. New York, NY.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

CHAPTER 6.

SYNTHESIS OF CONSERVATION PRIORITIES

Criteria to Set Conservation Priorities

Throughout the preceding basin and habitat sections, we detail many specific conservation priorities, such that within a particular basin or habitat, a reader can assess the most pressing needs and actions. But we also wanted to assess cross-cutting strategies that provide straightforward direction among and across basins and habitats, over the first cycle of Plan implementation. This chapter is dedicated to doing just that. In order to assess priorities among basins and habitats, Technical Committee team members developed the following model (Figure 6.1). The criteria described below can be applied to individual species, groups of species, habitats, or ecosystem processes (i.e., an "element").

Tier 1 – *Ideal criteria to assess ("what's most important?"):*

- **Risk/threat**: *Immediacy and/or severity of threats to element.*
- **Need**: *Conservation needs not being adequately addressed by an existing program or funding source*
- **Knowledge**: *Knowledge gaps or deficiencies necessary to making a conservation decision*

Tier 2 – *Realistic considerations to assess ("what will produce the best results?"):*

- **Feasibility (cost/ benefits analysis)**: *Degree to which initiating conservation actions will be worth the cost/effort; degree to which actions can mitigate a threat, impact a solution*
- **Benefit**: *Degree, longevity, and magnitude of conservation benefits (ecological, educational, social, and/or economic)*
- **Funding**: *Match opportunities*
- **Partnerships**: *Partnership opportunities, ability to leverage resources*
- **Opportunity**: *Reducing reactive opportunities, promoting/enhancing proactive opportunities*

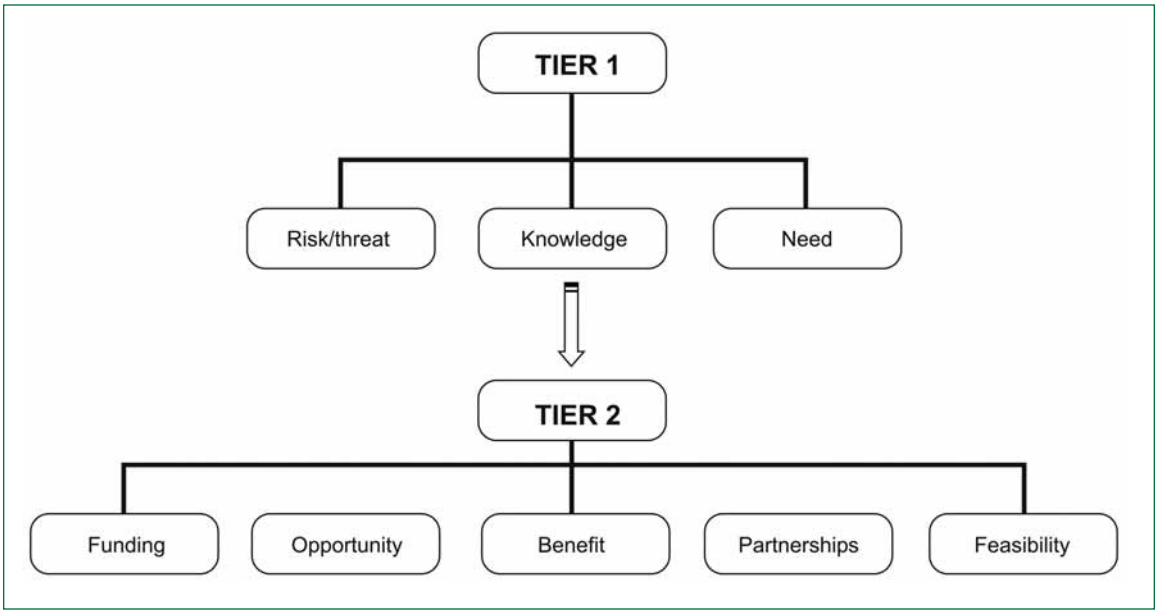


Figure 6.1. Conceptual conservation action priorities model.

Priority Conservation Actions

Prioritized conservation actions will be implemented across multiple individual projects during Plan implementation. In order to develop a logical framework for prioritizing specific conservation actions and performance indicators, we first grouped conservation actions and potential indicators into generic categories (Table 6.1).

Table 6.1. Generic conservation actions and potential performance indicators for each.

Generic Conservation Action Category	Potential Performance Indicators
Surveys, research	# of areas surveyed, # of new survey sites, # of species/populations located, # of species trapped/tagged/located, compilation of new data collected, new information on distribution, population size estimates, measures of life history metrics, survival, competition, predation, response to management
Monitoring	# of new monitoring sites or species protocols established, # of species for which trend information can be assessed, # of species for which population targets can be assigned, compilation of habitat trend information, # of projects for which monitoring information led to adaptive management, identification of causal factors in population change, # of adaptive management decisions (as a result of monitoring)
Land protection (acquisition, easements, buffers)	# of acres protected in buffers/conservation easements/purchase, # of sites posted, # of cooperative habitat protection projects, quantitative changes in degree of habitat fragmentation, connectivity
Habitat and watershed management	# of acres/miles of stream length restored or managed, measures of flow/water quality/habitat quality improvements, measures of species diversity/composition
Population management	# of individuals removed/added to a site, evidence of new colonization, # of restoration plans initiated
Data standards development, data management	# of species tracked, # of species with new data available, # of users, # of data exchanges, # of new data sources, user evaluations/comments
Program coordination, cooperation	# of partnerships developed, # of information exchanges (e.g., meetings, reports, data), # of Memorandum's of Agreement/Understanding
Education/outreach products, programming, surveys	# of media/outreach products developed, # of audiences reached, # of participants in programs, # of presentations given, # of programs offered, # of reports/presentations/publications given, # of positive/negative comments from public, # of surveys/polls initiated, # of public interactions/educational opportunities
Technical guidance, permit review	# of sites visited, # of plans/permits commented on, % of recommendations implemented, measures of degree of compliance and quality of compliance, # of project partnerships established, # of permits commented on, # of best management practice (BMP) recommendations made

Next, biologists on the Technical Committee applied the model above (Figure 6.1) to synthesize and prioritize across the individual habitat and river basin sections and to identify cross-cutting conservation actions (considering the 5-year time frame for the next revision of the Plan). Stakeholders were then called upon to help refine and revise conservation actions, objectives, and performance indicators through review and comment.

Starting with our broadest organizing theme, the Plan goals, we have organized cross-cutting priority conservation actions to fit with the following 'step-down' framework (Figure 6.2) (also see Tables 6.2–6.6):

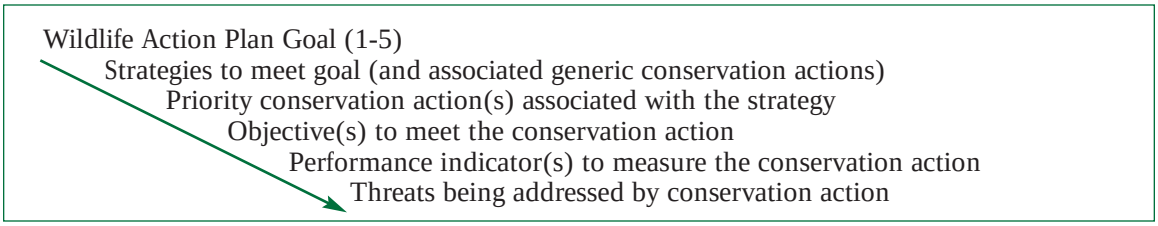


Figure 6.2. Step-down framework for organizing cross-cutting conservation action priorities.

This level of organization is not meant to supersede the conservation actions identified within the preceding sections of Chapter 5. Rather, this organizational framework takes a broader-scale approach to synthesizing those needs. We anticipate that those who will use this Plan as a resource and planning guide will look to the habitat or basin-specific conservation actions as much as they will use this broader-brush approach.

Table 6.2. Goal 1: Improve our understanding of the species diversity of North Carolina and enhance our ability to make conservation management decisions for all species.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Expand information base for priority species (surveys, research)	Establish baseline status and distribution information for priority species, and their habitats, to facilitate long-term monitoring and to fill critical data gaps	Inventory and survey for poorly understood priority species (*see priority species tables in Chapter 2 for indication of knowledge*): • Amphibians • Reptiles • Mammals • Birds • Fish* • Mollusks* • Crayfish* **especially recently recognized taxa* Determine distribution of potentially injurious non-native species (e.g., red swamp crayfish).	# of species for which baseline data has been collected # of species for which 'knowledge' scores (Species Prioritization process) improve # of species for which threats are conclusively identified	• Limited knowledge • Data gaps
	Conduct research to resolve questions of life history, productivity, and mortality factors for priority species	Obtain data on mortality factors impacting priority species groups (e.g., in the Coastal Plain, sea birds, landbirds, sea turtles, snakes) Focus productivity studies on early successional waterbirds on estuarine islands, and landbirds utilizing high priority habitats Initiate northern flying squirrel genetics and habitat assessment research Expand research on priority fish, mollusk, and crayfish species to improve basic understanding of population dynamics, life history, and habitat requirements	# of species for which explored factors (e.g., mortality, life history) could be assessed # of management plans/ conservation actions influenced by research results	• Limited knowledge • Data gaps • Inability to determine vulnerability to or mitigate against threats • Declining productivity • Declining populations levels
	Resolve taxonomic problems that potentially affect conservation priorities	Pursue formal descriptions for known or putative undescribed species Improve ability to identify cryptic or narrowly differentiated taxa	# of species or taxa assessed/verified	• Limited knowledge • Misinformation • Data gaps

Table 6.2 (*continued*). Goal 1: Improve our understanding of the species diversity of North Carolina and enhance our ability to make conservation management decisions for all species.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Expand information on long-term trends across species groups, habitats, and management actions (monitoring)	Continue and expand monitoring of high priority species and species groups to inform priority status revisions, conservation priority revisions, and management decisions	Expand or continue long-term monitoring of select species/groups, e.g.: • Sea turtle nesting and stranding • Red-cockaded woodpecker nesting • Landbird population trends • Waterbird populations • Northern flying squirrels • Peregrine falcons • Bald eagles Establish monitoring protocol, schedule, and sites to determine population trends for other priority aquatic and terrestrial species (e.g., standardized aquatic monitoring stations, bird species not adequately sampled in existing efforts- nocturnal species, landbirds not easily tracked by BBS, waterbirds) Monitor spread and impacts of potentially injurious non-native species	# of populations/ sites/species monitored # of routes/sites surveyed # of new monitoring programs/protocols initiated Progress towards assessing population targets	• Limited knowledge • Data gaps
	Improve understanding of habitat trends and key habitat associations for priority species	Improve habitat mapping capabilities Expand participation in collaborative habitat trend monitoring Identify threats to key habitats	# of habitats accurately mapped # of habitats for which trends can be assessed # of threats decisively identified for key habitats	• Limited knowledge • Data gaps • Missed acquisition opportunities
	Monitor the implementation of specific conservation actions	Assess aquatic species restoration efforts Assess habitat restoration efforts (e.g., dredge island renourishment, hydropower remediation, stream/wetland/riparian restoration or mitigation)	# of assessment projects	• Habitat degradation • Declining populations/ productivity

Table 6.3. Goal 2: Conserve and enhance habitats and the communities they support.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Promote and support habitat protection efforts (land acquisition, easements, buffers)	Identify priority areas for habitat conservation and restoration through acquisition and easements (also see Chapter 4C)	Protect (fee title or easement) additional quality habitats of the following types: • Beach/estuarine islands • Maritime forest • Longleaf pine forest • Floodplain forest • Early successional habitats • Small wetland communities • Mountain bogs • Rock outcrops • Caves and mines • High elevation forest • Streams and riparian zones • Other strategic parcels (e.g., unfragmented tracts >1000 ac.) Prioritize aquatic sites, considering: • Species diversity • Rare and/or endemic species • Specific areas critical to the survival of priority species (e.g., particular streams or spawning sites) and, • Areas recognized by previous prioritization efforts (e.g., areas identified in Smith et al. 2002, NC Natural Heritage Program SNHAs) Influence consideration of broader conservation priorities (e.g., aquatic and terrestrial habitat priorities identified in the Plan) by the Commission Coordinate prioritization of conservation acquisitions among all conservation partners (e.g., local, state, and federal government agencies, land trusts, etc.)	# of acres acquired or protected # of long-term cooperative habitat protection projects # of completed site inventories Adoption of a standardized procedure for Commission land acquisition # of acquisition processes that incorporated considerations/ priorities identified in the Plan	• Habitat conversion • Habitat loss • Incompatible forestry and farming practices • Pollution and sedimentation • Inappropriate development
Manage and restore terrestrial and aquatic habitats to maintain ecological function (habitat and watershed management)	Reintroduction and continued use of prescribed fire, especially in dry coniferous woodlands, longleaf pine, pocosin, and wet pine savanna habitats	Work with private landowners to encourage and facilitate burning on their properties in fire-dependent ecosystems Continue burning lands in conservation ownership (e.g., Game Lands) on a regular rotation Cooperate with non-governmental organizations and governmental agencies to encourage, facilitate, and/or provide technical guidance on prescribed fire Educate the public about the importance and role of fire in coastal ecosystems	# of acres burned # of technical guidance interactions # of educational efforts	• Fire suppression • Incompatible management practices

Table 6.3 (*continued*). Goal 2: Conserve and enhance habitats and the communities they support.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Manage and restore terrestrial and aquatic habitats to maintain ecological function (habitat and watershed management) (*continued*)	Actively manage habitats that can support stable or growing populations of key priority species groups. This can occur both directly (on Commission lands) and indirectly (through partnerships with state/federal agencies, non-governmental organizations, private landowners)	Actively manage (as needed) the following important habitats: • Beach/dune • Longleaf pine • Early successional habitat • Bogs/wetlands • High elevation forest • Riparian zones • Fire maintained ecosystems (*see conservation action above*) Increase adoption of farming and forestry management practices that positively affect grassland and shrubland priority species Increase adoption of wildlife-friendly Farm Bill programs, especially within CURE focal areas	# of acres/miles of stream positively affected by management Population response to management Measures of habitat quality/water quality improvements	• Land conversion • Inappropriate development • Fire suppression • Successional changes • Incompatible management practices
	Pursue restoration of wetland and early successional habitats	Promote wetland restoration projects (key for wetland breeding amphibians) Promote restoration of Piedmont Prairies through native seed propagation, acquisition of sites with appropriate soils, and active management	# of acres/sites restored Population response to restoration	• Land conversion • Development • Wetland drainage • Fire suppression • Successional changes
	Incorporate aquatic and riparian habitat conservation and restoration priorities in land and water use planning and practice	Incorporate aquatic conservation priorities in Commission Watershed Enhancement Program and Game Lands management Influence management and restoration efforts of other state and federal programs, and non-governmental organizations, regarding aquatic conservation priorities Influence county and regional land and water use planning to conserve and restore riparian habitats, water quality and quantity, and hydrology	# of technical guidance interactions # of decision making protocols changed to include aquatic conservation priorities	• Aquatic habitat degradation • Habitat loss • Species diversity loss • Pollution and sedimentation • Lack of information/consideration of aquatic conservation priorities
Manage and restore populations to maintain sustainable communities of species (population management)	Reintroduce or augment priority species populations in areas where water quality and/or habitats have recovered sufficiently to support them	Re-establish fish and mollusk populations within species' historic range Establish means and protocol for bog turtle captive breeding program Develop plans for bog turtle reintroductions Improve long-term sustainability of imperiled species by increasing population numbers, strengthening metapopulation structure, and reducing vulnerability to isolated catastrophic events or genetic problems Pursue augmentation/reintroduction to fulfill recovery goals for federally listed species	# of populations established Proof of reproduction/increased productivity rates Federal or state-listed species de-listing or down-listing	• Species diversity loss • Reduced productivity • Unsustainable population sizes

Table 6.4. Goal 3: Foster partnerships and cooperative efforts among natural resource agencies, organizations, academia, and private industry.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Improve data collection, management, and dissemination within and among agencies (data standards development, data management)	Enhance Commission data standards, management and coordination/sharing in order to facilitate improved data accuracy and precision through access to all available and relevant data	Expand comprehensive species database to include additional Species Viability Tool fields as data and resources allow [*developed by Jeff Holmes(TNC) and adapted by South Carolina and Arkansas for use in their Strategies*] Work to integrate NC Natural Heritage Program database upgrades and the species database Standardize existing database output specific to current research projects to improve summarization of data for 'big-picture' analyses and ease information exchange with partners (e.g., NC Natural Heritage Program) Develop and maintain a database of existing species and habitat conservation plans for easy reference and future revisions, including parameters such as population objectives, priority species listings, habitat priorities, management recommendations, etc. Develop and maintain a centralized project tracking database to facilitate straightforward monitoring of progress towards conservation actions and, ultimately, Plan goals (*see Chapter 8 for further discussion*) Develop comprehensive agency permitting database and mechanisms for data incorporation derived through agency permits Pursue development of web-based information systems to facilitate data exchange among partners, with appropriate limitations on access and use Develop and distribute metadata for existing databases Improve ability to be spatially explicit (map species locations, habitat coverages) and link spatial (GIS) data to the species database to connect distribution and habitat information (cooperate with NC Natural Heritage Program) Improve ability to assess habitat/land-use trends over time	# of species/species groups tracked # of data users Extent of new data sources, analyses possible # of data requests/ exchanges	• Data gaps • Inefficient use of data • Insufficient knowledge that data already exists

Table 6.4. (*continued*). Goal 3: Foster partnerships and cooperative efforts among natural resource agencies, organizations, academia, and private industry

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Support partnerships to achieve common goals, improve efficiency and prevent duplication of efforts (coordination, partnerships)	Pursue cooperation and collaboration with other state and federal agencies, non-governmental organizations, colleges and universities and other conservation groups to facilitate implementation of priority conservation actions and Plan goals	Expand and reinforce relationships between natural resource agencies and local entities (e.g., bird clubs, Project Bog Turtle, NC Herpetological Society) Support and pursue partnerships to reach shared priorities through ongoing conservation initiatives in North Carolina, e.g., • Coastal Habitat Protection Plan • One North Carolina Naturally Initiative • Albemarle-Pamlico National Estuary Program • Onslow Bight Conservation Forum • Triangle Greenprint Increase communication, cooperation and collaboration among conservation partners at the state, regional, and nation scales via partnerships and working groups, e.g., • Atlantic Coast Joint Ventures • Appalachian Mountains Bird Conservation Region • Partners in Flight • Robust Redhorse Conservation Committee • South Atlantic Migratory Bird Initiative • Partners in Amphibian and Reptile Conservation • US Fish & Wildlife Service Ecosystem Teams Develop new partnerships to coordinate conservation efforts and address conservation needs in the Yadkin-PeeDee corridor, Uwharrie Mountain region, and in the northern tier counties of the Piedmont	# of active partnership efforts # of new partnerships developed # of information exchanges (e.g., meetings, reports, data) Project specific results of collaborative efforts	• Redundant efforts • Inefficient use of resources (potentially leading to missed opportunities) • 'Reinventing the wheel'

Table 6.5. Goal 4: Support educational efforts to improve understanding of our wildlife resources among the general public and conservation stakeholders.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Disseminate information to selected audiences through appropriate media (education, outreach) (also see Chapter 4D)	Improve, maintain, and develop new web-based resources to share with partners	Provide accessible information on distribution, biology, status, threats, etc. for priority species groups (cooperate with the NC Natural Heritage Program) Update online crayfish and mussel atlases Complete on-line fish atlas w/federal and state listed species	# of web-products developed/updated # of audiences/ partners reached	• Lack of information • Inefficient information exchange
	Build education and outreach components into project implementation to facilitate information exchange and education in appropriately timely and geographically focused ways	Develop and disseminate print media, including: stand alone documents, press releases, newspaper and magazine articles, and displays Increase volunteer opportunities on projects Develop programming and public presentations to advertise agency projects/initiatives/results	# of media/outreach products # of audiences reached, programs given # of reports/ publications distributed # of participants/ volunteers	• Lack of information • Fear/misunderstanding • Misinformation • Public indifference
Identify public perceptions towards wildlife resources (human dimensions surveys)	Support and assist in implementation of surveys and polling to assess North Carolina resident attitudes and knowledge of specific wildlife resources highlighted in the Plan	Identify specific survey needs and target population subsets (e.g., urban residents, private landowners) Initiate public/user group polls, stakeholder/ focus group meetings Develop response actions targeting needs identified from surveys	# of surveys/polls initiated # of survey returns	• Misinformation • Lack of wildlife knowledge • Fear/misunderstanding
Promote and expand public participation in agency programs (education, outreach)	Increase efforts of volunteer recruitment when possible	Obtain useful data from volunteer projects	# of new volunteers # of in-kind support hours	• Inefficient volunteer recruitment

Table 6.6. Goal 5: Support and improve regulations and programs aimed at improving and protecting habitats and communities.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Increase efficiency and effectiveness of guidance and review processes aimed at minimizing negative impacts on species and habitats (technical guidance, permit review)	Provide direct technical guidance to private landowners, state and federal land managers, and regulatory agencies on key habitats and species	Provide technical guidance for bald eagle, red-cockaded woodpecker, waterbirds, sea turtles, peregrine falcon, bog turtle, bats, landbirds, and other priority species Focus technical guidance for aquatic species on conserving and restoring water and habitat quality, especially in priority aquatic areas	# of landowner/ agency contacts # of projects reviewed % of recommendations implemented Measures of degree of compliance	• Lack of information • Misinformation • Poor/improper management techniques
	Participate in planning and implementation processes by providing supporting information, conservation priorities, and other technical guidance	Work through the Federal Energy Regulatory Commission relicensing process and other opportunities to mitigate negative impacts from hydropower development Support establishment of riparian buffers along streams, implementation of low impact development, and better stormwater management (e.g., secondary and cumulative impacts) through program coordination, cooperative projects, and technical guidance Support incentive and information programs that help reduce sedimentation and erosion (e.g., fencing livestock from streams, improve tilling practices), minimize pesticide and herbicide use, and modernize wastewater treatment facilities	# of projects/review processes participated in # of cooperators # of technical guidance interactions % of recommendations implemented Measures of degree of compliance	• Lack of information • Misinformation • Poor/improper management techniques
Increase efficiency and effectiveness of statutes, rules, regulations and review processes affecting priority species and habitats (rules and regulations)	Support and utilize species listing processes and associated programs to conserve imperiled species and their habitats	Standardize the species listing process under the state Endangered Species statutes Provide information and technical guidance to the federal species listing processes Improve coordination with US Fish & Wildlife Service to focus Section 6 (US Endangered Species Act) activities on priorities for listing and recovery Investigate, implement, and support (as appropriate) programs that are directed at listed species recovery (e.g., Habitat Conservation Planning, Landowner Incentive Program, Safe Harbor)	Changes/standards applied to the listing process Efficiency of coordination among agencies # of landowner agreements/ participants in programs aimed at listed species recovery	• Species imperilment/ loss factors • Inefficient listing procedures • Inefficient coordination/ recovery activities
	Support review of and improvements to existing regulations aimed at protecting species and habitats	Analyze and promulgate appropriate regulations to minimize negative affects of activities detrimental to wildlife populations (e.g., 2004 turtle regulations) Support water quality rules and watershed designations (e.g., Outstanding Resource Waters and High Quality Waters) that conserve habitats for priority aquatic species.	Adherence to schedules for rules review and updates # of regulation change proposals # of species protected from unregulated use or impact # of regulation changes that enhance or protect wildlife or habitat Amount of habitat affected	• Inefficient volunteer recruitment

Table 6.6 (*continued*). Goal 5: Support and improve regulations and programs aimed at improving and protecting habitats and communities.

Strategies that Address Goal (associated generic conservation actions)	Priority Conservation Action(s)	Objective(s)	Performance Indicator(s)	Threat(s) Addressed by Conservation Action
Improve coordination with local and regional land-use planning efforts and regulatory agencies (coordination, technical guidance)	Protection of unfragmented landscapes and key habitats through land use planning. This is especially critical in these regions: • PeeDee river/Uwharrie region • The northern tier of Piedmont counties (Stokes, Rockingham, Caswell, Person) • Lands identified in the Triangle Greenprint report (NCDPR et al. 2002) • Lands identified by the Sandhills Conservation Partnership (Nelson 2004) • Lands identified by the Onslow Bight Conservation Forum (OBCDC 2004)	Identify highest priority lands within priority regions for open space protection (in coordination with partners) Encourage the adoption of growth management plans by county/municipal governments Work with zoning and planning boards to steer development away from priority areas and habitats	# of local/regional conservation plans created # of partners in the planning and implementation process # of counties that adopt or positively amend growth management plans # of zoning regulations influenced	• Habitat conversion • Habitat loss • Inappropriate development

References

N.C. Division of Parks and Recreation (NCDPR), Triangle J Council of Governments, and Triangle Land Conservancy. 2002. Triangle GreenPrint regional open space assessment. Raleigh, NC.

Nelson, L. 2004. Final draft site conservation plan for the North Carolina Sandhills. Unpublished.

Onslow Bight Conservation Design Committee (OBCDC). 2004 (DRAFT). Onslow Bight conservation design plan. North Carolina Onslow Bight Conservation Forum.

Smith, R. K., P. L. Freeman, J. V. Higgins, K. S. Wheaton, T. W. FitzHugh, K. J. Ernstrom, and A. A. Das. 2002. Priority areas for freshwater conservation action: a biodiversity assessment of the Southeastern United States. The Nature Conservancy.

CHAPTER 7.
STATUS AND TRENDS MONITORING

Purpose and Value of Monitoring and Evaluation

Monitoring and evaluation are tools that provide measures of change in species or habitat status, or the effects of activities, over time and allow for the interpretation of those measured changes. These tools allow an agency or organization to assess:

- Species population trends, estimates of population size, relative abundance, shifts in distribution, habitat use, response to management
- Habitat availability and condition over time
- Effects of management prescriptions
- Progress in implementation activities
- Progress towards intended goals, objective, and outcomes
- Adaptive management responses

Assessing changes in populations and habitats over time, especially in response to applied conservation actions, requires monitoring at multiple levels (e.g., species, guilds, natural communities, implementation activities) and across multiple scales (e.g., local, statewide, regional). Monitoring is therefore a critical component of any conservation program, necessarily linked to management objectives.

Species-specific monitoring is critical to assessing population status and trends over time. Monitoring of individual species, when coordinated at the appropriate level, contributes to the conservation of species at scales far beyond individual state boundaries. Monitoring actions at the species guild level (e.g., ephemeral pond amphibians) are essential to tracking and assessing habitat-level impacts over time. Monitoring at this level allows us to measure the effectiveness of habitat-based management activities. Habitat and natural community monitoring is necessary to track landscape-level trends and to anticipate future needs as threats change. Monitoring of the implementation of conservation activities is needed to measure success and advancement towards goals, and to adapt conservation actions to respond appropriately to new information or changing conditions (*see Chapter 8 for a discussion of implementation and effectiveness monitoring*).

Monitoring of North Carolina's Wildlife and Habitats

Extensive species and habitat monitoring already take place in North Carolina (Table 7.1). Much of this monitoring, especially at the species and guild level, is accomplished through cooperative partnerships among agencies. The Commission coordinates a great deal of species status and population monitoring, ranging from requirements of species recovery plans, to species trend assessment following baseline survey work. Monitoring is also a standard component of many other agency planning efforts (e.g., US Forest Service Land and Resource Management Plans, Department of Defense Integrated Natural Resource Management Plans). It is key that future monitoring efforts build on and utilize these existing systems.

Table 7.1. Existing species monitoring efforts underway in North Carolina.

Lead Agency/ Organization[1]	Monitoring Efforts Underway[2]	Cooperators[3]	Time Frame (annual unless otherwise noted)
STATE AGENCIES			
NC Wildlife Resources Commission	Anuran monitoring (to begin in 2005)	NC Herpetological Society, NCMNS, NCPARC, universities, USGS, volunteers	
	Breeding Bird Survey	USGS, volunteers	
	Monitoring Avian Productivity and Survivorship	Institute of Bird Population Studies, volunteers	
	Bird migration monitoring	Partners in Flight, volunteers	Spring/fall
	Breeding and winter songbirds on Commission Game Lands and CURE areas		
	Colonial waterbird inventory (estuarine surveys)	NC Audubon Society, NCDPR, NPS, USACE, USFWS	Every 2-3 years
	Breeding shorebirds (Piping plover)	NC Audubon Society, NCDPR, NPS, USFWS	
	Breeding shorebirds (American oystercatcher and Wilson's plover)	NC Audubon Society, NCDPR, NPS, USFWS	Every 2-3 years
	Nonbreeding shorebirds	NPS, USFWS	
	Bald eagle	NCDPR, NCNHP, USACE, USFWS, USMC, timber companies	
	Red-cockaded woodpecker	DoD, NCDFR, NCDPR, private consultants, Sandhills Ecological Institute, TNC, USFS, USFWS	
	Peregrine falcon	NCDPR, USFS, volunteers	
	Sea Turtle Nesting Beach Monitoring Program	BHIC, DoD, NC Audubon Society, NCDPR, NPS, USACE, volunteers	
	Sea Turtle Stranding And Salvage Network	BHIC, DoD, Duke University, NC Aquariums, NC Audubon Society, NCDMF, NCDPR, NCSU Vet School, NERR, NOAA Fisheries, NPS, USACE, volunteers	
	Bog turtle	NPS, Project Bog Turtle, TNC, USFS, USFWS, volunteers	Periodic (moving towards triennial)
	Green salamander	USFS, USFWS, universities, volunteers	Periodic
	State-listed salamanders (western region)	Land trusts, NCMNS, NPS, USFS, universities	Periodic
	Western region bats	Flittermouse Grotto of the National Speleological Society, USFS, USFWS, volunteers	Periodic (some species biennial)
	Northern flying squirrel	NPS, USFS, universities	
	State- listed small mammals (western region)	Land trusts, NCMNS, universities, USFS, USNPS, volunteers	Periodic
	Black bear populations	DoD, private timber companies USFS, USFWS	
	White-tailed deer (check stations, harvest data, DMAP)	DoD	
	Raccoon field trial survey - population trend	Participating raccoon hunting clubs	

[1] In some cases, there may be multiple lead agencies involved in a given monitoring effort depending on location (e.g., red-cockaded woodpecker), but for simplicity, the monitoring effort has been listed just once in the table above.

[2] NC Partners in Flight maintains a detailed listing of ongoing bird research and monitoring efforts in North Carolina, many of which are so specific/ selective they have not been listed in the table above. See Johns 2004 for the complete list.

[3] See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

Lead Agency/ Organization[1]	Monitoring Efforts Underway[2]	Cooperators[3]	Time Frame (annual unless otherwise noted)
NC Wildlife Resources Commission, *continued*	All furbearers, nongame and foxes - trapper harvest/effort survey	Mail survey to all licensed trappers	Every 5 years
	All furbearers, nongame and foxes-Distribution survey	All Division of Wildlife Management field biologists	
	Total take by WDCA's and Gov. Animal Control-all species	WDCA's, all long-term depredation permitees	
	Nest box monitoring (waterfowl)	USFWS	
	Quail count and covey surveys on NCWRC Gamelands		
	Avid Quail Hunter Survey and Avid Grouse Hunter Survey	Volunteers	
	Dove, tundra swan counts		
	Wild Turkey Summer Brood Survey	NCDFR, private individuals, USFS, USFWS	
	Grouse and turkey drumming counts	USFS	
	Riverine Index of Biotic Integrity sampling		Variable (most rivers every 2-3 years)
	Anadramous fish (American shad, hickory shad, striped bass)	NCDMF	
	Game fish community and reservoir stock assessments [black basses, black and white crappie, striped bass and Bodie bass, walleye, muskellunge (river and reservoir environments)]	Duke Power, NCSU (Gaston Reservoir), Progress Energy, USFS	Variable (stock dependent)
	Brook, brown, and rainbow trout reproducing populations	NPS, USFS	
	Annual mussel and fish surveys		
	Mussel relocation project monitoring		Variable (project dependent)
	Cheoah River restoration project monitoring (fish, mussels, crayfish, salamanders)	APGI, NCDOT, USFS, USFWS	Annual, bienniel, and 5-year intervals
	Pigeon River fish restoration project monitoring	BRPP, NCWDQ, TNDEC, TVA, UT-K, WCU	Annual
	Western crayfish monitoring	NCDWQ, NCMNS, NPS	Periodic[4]
	State and federally-listed species monitoring, including candidates and species of concern.	LTWA, NCDOT, NCDWQ, NCNHP, NCSU, TVA, USFWS, USFS	Variable (species, locality dependent)
NC Division of Water Quality	Fish communities, fish kill investigations, benthic macro-invertebrate Index of Biotic Integrity monitoring	NCWRC	5-year cycle, per basin
NC Museum of Natural Science	Yellow-bellied sapsuckers (S. Appalachian breeding population)	Mars Hill College, NPS, NCWRC, USFS, USFWS, others in multi-state work group	
	Carolina Gopher Frog	NCDPR, NCNHP, TNC, SCDNR, SREL, USFWS	
	Southern Hognose Snake	NC Herpetological Society, NCNHP, NCWRC	
NC Division of Marine Fisheries	Extensive fisheries monitoring, including all Fisheries Management Plan species (too many to list)	NOAA-Fisheries, NCWRC	

[4]Development of a more regular monitoring schedule in progress (as of 2005).

Table 7.1 (*continued*). Existing species monitoring efforts underway in North Carolina.

Lead Agency/ Organization[1]	Monitoring Efforts Underway[2]	Cooperators[3]	Time Frame (annual unless otherwise noted)
NC Natural Heritage Program	Summer butterfly counts	Volunteers	
NC Division of Parks and Recreation	Nest box monitoring (multiple species), eagle counts, waterfowl counts	USACE, volunteers	
FEDERAL AGENCIES			
US Fish & Wildlife Service	International Shorebird Surveys	NPS, NCWRC	
	Wood ducks (banding program and nest box monitoring)	NCWRC	
	Mid-winter waterfowl surveys	NCWRC	
	Tundra swan productivity	NCWRC, other mid-Atlantic states	
	Mourning dove call count survey	NCWRC	
	Migratory game bird harvest estimates	NCWRC	
	Breeding bird counts, species specific surveys, waterfowl banding and surveys at multiple National Wildlife Refuges		
	Cerulean warbler monitoring (Roanoke River NWR)	Volunteers	
US Forest Service	Management Indicator Species		
	Songbirds on USFS land		
	Index of Biotic Integrity		
National Parks Service	Blue Ridge Parkway permanent plots	Mars Hill College	
	MAPS banding stations	Volunteers	
NOAA Fisheries	FMP species; federally listed and depleted marine species	NCDMF, NCWRC	
US Department of Defense	Various monitoring efforts outlined in base-specific INRMPs (e.g., listed species, other game and nongame species, natural communities)	Volunteers	
OTHER			
Mecklenburg County Parks and Recreation	Grassland songbirds, raptor nest boxes, Project Feederwatch, migration banding stations, MAPS, nest productivity, waterfowl counts	Volunteers, Cornell University	
North Carolina Audubon	Christmas Bird Count	Volunteers	
	Golden-winged warbler Atlas Project	Cornell University	
	Important Bird Area monitoring		
International Paper	G1 and G2 Natural Heritage Program ranked species occurrences on International Paper land		Variable (species dependent)

Lead Agency/ Organization[1]	Monitoring Efforts Underway[2]	Cooperators[3]	Time Frame (annual unless otherwise noted)
Weyerhaueser Company	G1 and G2 Natural Heritage Program ranked species occurrences on Weyerhaueser land	Coastal Land Trust, NCNHP, TNC	Variable (species dependent)
	Cool Springs Environmental Education Center: annual reptile and amphibian monitoring, stream water quality and aquatic invertebrate monitoring, migration monitoring for neotropical songbirds		
Tennessee Valley Authority	Fish and benthic macroinvertebrate Index of Biotic Integrity monitoiring (In TN river tributary basins only; for watershed/HUC quality assessment)	NCWRC	Variable (5-year cycle for most HUCs, 2-year for Fixed Stations)
Progress Energy	Fish and benthic invertebrate sampling in rivers/ reservoirs with Progress Energy facilities	NCWRC	
Duke Power	Fish community sampling near all Duke Power facilities (trace element sampling near some)	NCWRC	
Robust Redhorse Conservation Committee	Robust redhorse monitoring (Georgia, South Carolina, North Carolina)	RRCC Signatory members	
Davidson College Herpetology Lab	Catawba River Corridor Coverboard Program	Annie Springs Close Greenway, CCARI, Catawba Lands Conservancy, Catawba Valley Land Trust, Duke Power, Iredell Co. Parks and Recreation, Mecklenburg Co. Parks and Recreation, NCWF, SCDNR, SCDPRT, SCWF, The Home Depot	
	Drift fence monitoring and snake population monitoring on the Davidson College Ecological Preserve		
	Semi-aquatic turtle monitoring		
	Box turtle population monitoring (Davidson, NC)		
	Urban amphibian population monitoring		
	Evaluation of detectability of anurans		
Howell Woods Environmental Learning Center	MAPS banding stations, migration banding stations, Project Feederwatch, point counts	Cornell University, volunteers	
Weymouth Woods State Nature Preserve	Migration banding stations	Volunteers	

However, Table 7.1 is only a basic framework from which to initiate a more formalized inventory of monitoring programs in North Carolina; this is a critical first step to strengthening monitoring efforts. Many other monitoring efforts are conducted in the state on smaller scales or for more species-specific needs, by universities, private organizations, and others (especially for birds). As stipulated in species-specific recovery plans, state and federally-listed species receive regular monitoring attention, as coordinated through efforts among the Commission, the US Fish & Wildlife Service, and NOAA Fisheries (see Appendix I for a list of species recovery plans).

In North Carolina, the majority of publicly owned lands are controlled by the following agencies, each of whom conducts monitoring of species and habitats on their properties statewide. The Commission should continue coordination with these groups to identify shared priorities and facilitate efficient monitoring and data synthesis:

- Department of Defense – Integrated Natural Resource Management Plans stipulate monitoring needs for each installation:
  - Camp Lejeune Marine Base
  - Cherry Point Marine Air Station
  - Fort Bragg Army Base
  - Seymour Johnson Air Force Base
  - Pope Air Force Base
- US Forest Service – Land and Resource Management Plans identify monitoring needs related to each forest's Management Indicator Species and communities:
  - Croatan National Forest
  - Uwharrie National Forest
  - Nantahala and Pisgah National Forests
- US Fish & Wildlife Service – Comprehensive National Wildlife Refuge (NWR) Plans[5]:
  - Alligator River NWR
  - Pea Island NWR
  - Mackay Island NWR
  - Currituck NWR
  - Mattamuskeet NWR
  - Cedar Island NWR
  - Swanquarter NWR
  - Pee Dee NWR
  - Pocosin Lakes NWR
  - Roanoke River NWR

Importance of Collaborative Monitoring Efforts

The value of coordinated monitoring efforts within and among states cannot be overstated. In North Carolina, for example, coordinated efforts have helped to sustain and strengthen monitoring programs on sea turtles and colonial nesting waterbirds. Commission participation in local planning initiatives such as the Sandhills Partnership (see Chapter 4C case study), regional planning teams such as the South Atlantic Migratory Bird Initiative, and cooperative agreements such as the North Carolina Colonial Waterbird Cooperative Agreement (with 12 state and federal agency and non-profit signatories) give credence to the success and importance of such collaborations. At a regional and national level, coordinated efforts such as the Breeding Bird Survey have contributed greatly to assessing long-term population trends among birds nationwide.

In the face of limited resources and often wide-ranging species, there is increasing need to strengthen and expand collaborative monitoring efforts. With collaborative monitoring efforts come the need for strong data standards and a centralized system for housing and managing data and analyzing results. The needs addressed in this, and other state Strategies, may point to opportunities to improve regional monitoring standards. Agencies may face challenges in favoring protocols that are best for addressing local needs, but that are not compatible with data collected elsewhere, or conversely, in favoring protocols that are compatible with data elsewhere, but not applicable at the local level. Standardized techniques must, at least indirectly, work to provide local management relevance (Hunter 2000). It will be important to use/improve data collection techniques that are compatible with larger-scale or with counterpart monitoring efforts to ensure data can be integrated appropriately (Atkinson et al. 2004).

Regional and national coordination is needed to evaluate the capacity of existing state-programs to combine and monitor populations across their range. This may be a role that the Status and Trends Program of the US Geological Survey initiates post-Plan approval. Where necessary, existing programs should be strengthened and new, comprehensive monitoring programs developed. Specific to bird monitoring recommendations, the recently drafted Coordinated Bird Monitoring Workgroup

[5] As of early 2005, all are still in development – contact Bob Glennon at the US Fish & Wildlife Service (Bob_Glennon@fws.gov) for details.

of IAFWA report (2004) will facilitate discussions on coordinated bird monitoring among representatives of the US Fish & Wildlife Service, the US Geological Survey, and the North American Bird Conservation Initative, which will facilitate trickle-down to state entities, etc. There is also a need to establish a 'protocols' library. Again, there is potential that this will coordinated at a regional or national level through the Status and Trends Program of the US Geological Survey.

Bird Monitoring Efforts as a Model

The efforts of the various North American Bird Conservation Initiative (NABCI) programs form a base from which to expand and improve 'All-bird monitoring' and coordination efforts in the state and the southeast region as a whole, as well as a model on which to build coordinated monitoring efforts for other taxa. Through the monitoring infrastructures developed by the various NABCI programs, our state-specific monitoring efforts for birds contribute to regional, national, and even international bird conservation efforts. The monitoring recommendations put forth in the various NABCI program reports are echoed throughout our Plan. We will continue to integrate the recommendations of these reports, which address monitoring at different scales, during implementation:

- **National**
  - o Regional

North American Bird Conservation Initiative

  - o South Atlantic Migratory Bird Initiative (SAMBI) Pelagic Bird Conservation Plan (SAMBI 2004, DRAFT)
  - o SAMBI Implementation Plan (Watson and McWilliams 2004, DRAFT)
- US Shorebird Conservation Plan (Brown et al. 2001)
  - o Southeastern Coastal Plains-Caribbean Regional Shorebird Plan (Hunter et al. 2000)
- North American Waterbird Conservation Plan (Kushlan et al. 2002)
  - o Southeastern US Region Waterbird Conservation Plan (Hunter 2004, DRAFT)
- North American Waterfowl Management Plan (NAWMP Committee 2003)
  - o Atlantic Coastal Joint Venture Strategic Plan (ACJV 2004)
- PIF North American Landbird Conservation Plan (Rich et al. 2001)
  - o Southern Blue Ridge (Hunter et al. 1999)
  - o Piedmont (Cooper and Demarest 1999)
  - o South Atlantic Coastal Plain (Hunter et al. 2001)

Box 1: The National Biological Information Infrastructure (NBII)

The NBII is an electronic information network coordinated by the US Geological Survey that provides users access to biological data and information about plants, animals, and ecosystems across the United States. Data and information maintained by federal, state, and local government agencies, and private-sector organizations are linked through the NBII and made accessible to a variety of audiences. Implementation of the NBII is proceeding through a network of nodes that serve as interconnected entry points to the NBII and information maintained by partners (www.nbii.gov).

The following nodes are applicable to North Carolina and could be considered as a potential system to house or disseminate information collected during implementation of the Plan.

- Bird Conservation Node
- Fisheries and Aquatic Resource Node
- Southern Appalachian Information Node (SAIN). Current projects within this node include:
  - Oriental Bittersweet in North Carolina – occurrence and extent of the invasive plant
  - Appalachian Inventory and Monitoring Information Synthesis – SAIN's Appalachian Inventory & Monitoring Information Synthesis project will provide access, synthesize, and disseminate information from inventory and monitoring activities of various agencies and organizations throughout southern Appalachia.
  - Southern Appalachian Volunteer Environmental Monitoring – a Southern Appalachian Man and the Biosphere program that trains volunteers from around the southern Appalachian area to monitor ecological health in their community (e.g., invasive exotic plant surveys, water quality monitoring). Resulting data can be used to determine the best approaches for effective management, as well as improve public awareness of the threats. Ongoing projects include: Upper Little Tennessee River project; Brook trout population status; All Taxa Biodiversity Inventory of the Great Smoky Mountain National Park.

Habitat/Natural Community Monitoring

Ongoing habitat monitoring conducted by the Commission is largely associated with habitat restoration activities in order to gauge success in pre- vs. post- restoration treatments, though other efforts coincide with regular species monitoring (e.g., habitat monitoring is a component of biennial colonial waterbird monitoring). Common performance indicators include acres managed (e.g., burned, planted, clearcut, thinned), linear feet managed (e.g., planted, stabilized), and usable habitat indices (e.g., vegetation diversity, structure). Habitat monitoring is a critical component of projects such as:

- CURE Program areas (areas that are being restored to quality early successional habitat)
- Game Lands management activities
- Watershed Enhancement Program activities
- Waterfowl Management Areas/impoundments
- Hydropower remediation/Federal Energy Regulatory Commission relicensing efforts

As related to larger-scale habitat monitoring efforts, the number of agencies and organizations tracking trends associated with particular habitat types or regions of the state makes coordination and statewide assessments difficult. There is variability in terms of what is actually monitored, the indicators and criteria that are measured, and ways of measuring those indicators. A key improvement might be the establishment of a statewide clearinghouse of information for assessing habitat status and environmental trends information across North Carolina. Still, this would require substantial document of 'who-is-measuring-what-and-how' so that imprecise or incorrect correlations or data comparisons aren't made.

In addition, the vast majority of land in North Carolina is in private ownership, emphasizing the importance of refining and strengthening remote sensing techniques when direct access to lands may not be feasible.

Given the varied habitat monitoring efforts going on across North Carolina, it is impossible to use a single trend to make a gross assessment of changes in habitat quality and quantity. A variety of indicators used in combination, however, could provide an indication of habitat and ecosystem conditions (i.e., "canaries in the coal mine"), such as forest conversion rates, land development rates, wetland losses, percent impervious surface changes by watershed or river basin, and/or Impaired Waters listings.

Habitat Monitoring Efforts Underway

- Coastal wetlands inventories and functional assessments as well as beach erosion rates are conducted by the NC Division of Coastal Management. Annual wetland and stream buffer losses and gains are tracked by the Wetland/401 Unit of the NC Division of Water Quality. Wetlands mitigation site monitoring is conducted by the Wetlands Restoration Program, now housed within the Ecosystem Enhancement Program (a joint effort between the NC Department of Transportation, the Army Corps of Engineers, and the NC Department of Environment and Natural Resources).
- The US Forest Service, Forest Inventory and Analysis (FIA) Work Unit conducts periodic forest surveys of North Carolina (and nationwide) to provide statistics for measuring changes and trends in the extent and condition of forest land, associated timber volumes, and rates of timber growth, mortality, and removals. North Carolina contains four forest survey regions, the Mountains, Piedmont, Northern Coastal Plain, and Southern Coastal Plain. The most recent survey, which compares 2002 data to 1990 data, highlights trend changes across the following topics: forest land area, ownership, forest type, stand size, stand treatment, softwood volume, hardwood volume, growth, mortality, and removals. Although the previous and current inventories are similar in scope, they differ in sampling design and intensity, standards and definitions, and in methods used to determine key attributes such as stocking, forest type, and stand-size class. Recent changes in methods, plot design, and sampling intensity were necessary to increase national

consistency between FIA Research Work Units. These changes complicate the comparison of data between surveys and make detection of genuine resource trends difficult, but will improve consistency in future analyses.

- The Natural Resource Conservation Service's National Resources Inventory (NRI) program collects and disseminates information on a state, regional and national level about the status, condition, and trends of soil, water, and related resources in the United States, including land use, erosion, nonfederal and federal lands inventory, cropland use, prime farmland, and wetlands and deepwater habitats. From 1977–1997, the NRI was conducted every 5 years, but since 1997 it has been conducted annually.
- The NC Division of Water Quality conducts extensive Index of Biotic Integrity monitoring for their basin-wide planning efforts, including lake assessments, phytoplankton monitoring, physical and chemical water quality monitoring, and aquatic toxicity monitoring (as well as fish and benthic macroinvertebrate monitoring mentioned about in Table 7.1). The Division also designates and maintains a list of impaired waters [305(b) and 303(d) Reports] and tracks percent impervious surfaces by basin.
- NOAA Fisheries (formerly known as the National Marine Fisheries Service) conducts submerged aquatic vegetation (SAV) mapping and monitoring in coordination with the Environmental Protection Agency and the NC Division of Water Quality. According to the Coastal Habitat Protection Plan, however, no quantified trends analysis is available for the state as currently there is only one complete SAV mapping dataset (1983–1991) (Street et al. 2004).
- The NC Natural Heritage Program tracks Significant Natural Heritage Areas using a 'scorecard' analysis to monitoring, as well as compare, the relative quality of these high quality habitats/natural communities through time.
- Gap Analysis Project (GAP) land cover data provides a potential source with which to assess land cover trends over time. However, due to differences in methodologies between the 1992 North Carolina land cover and the 2001 North Carolina land cover, it is inaccurate to do a direct comparison between the two data sets. The National GAP office has developed a change detection methodology to handle these differences and to prevent misuse of GAP land cover data. However, there are no plans at the state level to employ this methodology on the 1992 and 2001 data, due to lack of funding. Regional GAP efforts across the southeast (www.segap.org) do present potential opportunities for land cover change detection analyses in the future. (*For more about the North Carolina and regional GAP efforts, see Appendix K*).

Box 2: Habitat monitoring guidelines

In 2005 Defenders of Wildlife commissioned a habitat monitoring guidelines project conducted by Illahee (a consulting firm in Portland, Oregon). Habitat monitoring: an approach for reporting status and trends for state Comprehensive Wildlife Conservation Strategies (Schoonmaker and Luscombe 2005) is a tool to guide future habitat monitoring advances in states across the nation. The paper provides guidance for monitoring wildlife habitats and conservation programs to ultimately determine the collective effectiveness of conservation actions, and to adapt proposed conservation actions as needed in response to new information and changing conditions. The authors offer suggestions for developing conservation goals, building baseline data on the distribution and status of habitats across large landscapes, and detecting changes over time to measure outcomes, thereby providing a mechanism for implementing adaptive management strategies. They identify the following six basic elements of a successful habitat monitoring program:

1. Identify the decision-makers, partners, and resources needed for a fish and wildlife habitat monitoring group to track conservation actions, adaptive management hypotheses, and longer term changes in habitat distribution, condition, and conservation status.
2. Work with partners to identify available information sources, determine whether existing data are adequate to establish a meaningful baseline, and secure and/or enhance GIS data layers. Data can include for example: statewide registry of conservation actions, present land use /land cover map, aquatic resources map, historic vegetation map, existing conservation network areas, priority habitats identified in the Plan, existing conservation projects.
3. Determine what elements of the Plan are suitable for monitoring by agencies, organizations and citizens. Set up systems to train field naturalists and citizen volunteers to collect data, using consistent protocol.
4. Evaluate the impact of conservation actions periodically and make adjustments as necessary within an adaptive management framework.
5. Update the land use - land cover data every five to ten years to track changes, both positive and negative, affecting habitat.
6. Develop an efficient and effective communication system for reporting and disseminating information to decision-makers and other stakeholders, including the public.

The recommendations and guidance set forth in Schoonmaker and Luscombe (2005) should be considered in future advances made to habitat and conservation action monitoring in North Carolina.

Monitoring Needs Synopsis

Broad monitoring needs, as mentioned above, include:

- **Formal inventory of existing monitoring efforts (following a standardized set of criteria to facilitate coordination among agencies and states)** – "What are we monitoring now?" This will facilitate answering the questions "where are there opportunities to better coordinate on this monitoring?" and "where are there monitoring gaps?" USGS Status and Trends Program may assist.
- **A monitoring protocols library/clearinghouse** – The US Geological Survey has committed to developing such a library for their own protocol development; opportunities are present to expand this site to include submissions by other agencies, organizations, with proper vetting.
- **Better intra-state coordination on monitoring efforts** – Potential partners include the Commission, US Fish & Wildlife Service, US Geological Survey, US Forest Service, NOAA-Fisheries, Department of Defense, and NC Division of Water Quality.
- **Strengthening of regional and national approaches to species and habitat status monitoring** – The best opportunities to facilitate these approaches are through coordination by representative groups (e.g., Partners in Amphibian and Reptile Conservation, US Geological Survey, NABCI efforts).

In North Carolina, birds and sea turtles are the only vertebrate groups that receive established and standardized long-term monitoring efforts. This fact emphasizes the importance of continuing these monitoring efforts to further strengthen trend and population estimates, and the importance of establishing monitoring efforts across all other taxa groups, as baseline inventory and survey data allow.

Monitoring needs of particular species, guilds, and habitats were detailed throughout individual sections of Chapter 5. The text below summarizes those needs. Individual species may not be named in all cases, but specific information can be found in the appropriate preceding habitat/basin sections.

General (Aquatic)

- Many aquatic species in North Carolina (especially crayfish and snail species) are still in dire need of distribution, survey, and inventory attention, in order to establish baseline data on which to build. For these groups, established monitoring priorities are not yet attainable.
- For those taxa and species with adequate baseline data, there is strong need to improve long-term monitoring across species groups, habitats, and management actions. Important partners (statewide) to engage in aquatic species and habitat monitoring include the NC Division of Water Quality, the NC Museum of Natural Sciences and the US Fish & Wildlife Service (basin-specific partners are identified within each basin section). Three fundamental monitoring needs include:
  - Long-term monitoring to identify population trends of priority species.
    - Work with partners to establish appropriate protocol, schedule, and sites for long-term population monitoring.
    - Currently, the western region basins may provide the most opportunity to initiate monitoring for selected fish and mussel species.
  - Special purpose monitoring to assess performance of specific conservation actions, including stream restoration projects, hydropower remediation, and species restoration projects.
  - Non-native species impacts: monitor populations of potentially injurious non-native species and impacts on priority species; specific non-native species are identified within the appropriate basins.

General (Terrestrial)

- As bird monitoring efforts are by far the most advanced and established of any species group, the establishment of protocol for other species groups (e.g., small mammals, amphibians, reptiles) should be developed with strong consideration of the lessons learned through the various monitoring efforts of NABCI.
- Expand monitoring efforts on public lands and initiate monitoring protocols on key private lands (especially industrial forest land).
  - Expand and refine standard bird monitoring protocols.
  - Develop appropriate protocol for amphibians, reptiles, and mammals (especially bats and small mammals).
  - Key partners include the US Forest Service, Department of Defense, US Fish & Wildlife Service, and private timber companies.

Birds

- Continue ongoing monitoring coordination and adhere to recommendations put forth in reports of the national and region entities of NABCI (e.g., Partners in Flight regional and state plans, Southeastern Migratory Bird Conservation Initiative, North American Waterbird Conservation Plan) and the Continental Bird Monitoring Workgroup of IAFWA to strengthen coordinating bird monitoring efforts. (*See 'Bird monitoring efforts as a model' above for more information on protocol and programs adhered to in North Carolina*).
- Continue to participate in ongoing monitoring research that NC State University (Dr. Ted Simons) and the US Geological Survey Patuxent Wildlife Research Center are conducting to evaluate monitoring protocols for standard point counts and Breeding Bird Survey (estimation of detectability).
- Expand current bird monitoring across the state, especially Monitoring Avian Productivity and Survivorship and migration banding stations, as training opportunities and technical assistance allow, to improve population status information for birds not adequately sampled under existing protocol (e.g., Breeding Bird Survey).
  - Consider establishing 'surrogate' species where possible- species who may be representative of the habitat needs of a particular guild of species and are widespread enough to allow for population-level monitoring.
  - Key species (or species groups) include: Swainson's warbler, cerulean warbler, Henslow's sparrow, Bachman's sparrow, other grassland specialists, Wayne's black-throated green warbler, painted bunting, hawks, ground-nesters, cavity-nesters, owls.
  - Key habitats include longleaf pine, floodplain forest, early successional habitats, high elevation forest, pocosin, nonalluvial wetlands, and maritime forest. Ideally, monitoring should continue to be expanded across all habitats in order to strengthen trend data for all species.
- Continue established shorebird and waterbird monitoring efforts along all coastal and estuarine habitats; expand monitoring of secretive marshbirds along estuarine, lake, and tidal swamp habitats using established protocol (Conway 2004).
- Continue monitoring for recovering species such as bald eagles and peregrine falcons in their key habitats.

Mammals

- Develop and initiate standardized monitoring protocol for small mammals and bats. Key habitats to focus monitoring efforts in include: (for small mammals) floodplain forest, early successional habitats, mesic and oak forest, dry coniferous woodlands; (for bats) caves, floodplain forest, mesic forest dry coniferous woodlands.
  - Consider North American Bat Conservation Partnership (NABCP) monitoring recommendations (see http://www.batcon.org/nabcp/newsite/index.html, NABCP Strategic Plan):
    - Initiate long-term status trend monitoring at key bat roosting locations (e.g., caves, mines, bridges).
    - Use reliable and reproducible techniques, evaluating new population-monitoring techniques as needed.
    - Define population units relevant for conservation planning and research.
  - Consider coordination of bat monitoring efforts in North Carolina (and throughout the southeast) through a unifying body (e.g., Southeastern Bat Diversity Network or US Geological Survey).

Amphibians and Reptiles

- Continue coordinated nesting and stranding monitoring of sea turtles with partners (NOAA-Fisheries, US Fish & Wildlife Service).
- Develop and initiate monitoring protocol for amphibians (especially wetland breeding anurans and salamanders) and reptiles (especially secretive snakes, priority turtle and terrapins). The following habitats are especially key in which to initiate amphibian and reptile monitoring efforts: longleaf pine, pocosin, wet pine savanna, floodplain forest, early successional habitats, dry coniferous woodlands, wetlands (including isolated wetlands, riparian corridors and bogs), maritime forest, estuarine habitat, rock outcrops.
  - Use North Carolina Partners in Amphibian and Reptile Conservation (NC PARC) as the umbrella program in North Carolina to foster establishment of protocol. NC PARC is initiating annual anuran surveys among partnering organizations beginning in 2005.
  - Work with the Southeastern PARC (SE PARC) organization to facilitate regional standards and data compatibility. SE PARC is currently (as of 2005) drafting 'Regional inventory and monitoring guidelines for reptiles and amphibians of the Southeast').
  - Consider the work in process to develop reptile monitoring guidelines akin to existing amphibian guidelines developed by Heyer et al. (1994) (project coordination by US Forest Service and PARC).

Estuarine/Marine Habitats

The recently completed Coastal Habitat Protection Plan (CHPP; Street et al. 2004) includes a broad recommendation to coordinate and enhance water quality, physical habitat, and fisheries resource monitoring from headwaters to the nearshore ocean (key partners include the NC Department of Environment and Natural Resources, NC Division of Marine Fisheries, NC Division of Water Quality, NC Division of Coastal Management, and the NC Wildlife Resources Commission). The CHPP also identifies a number of key monitoring needs across specific coastal fisheries habitats:

Water Column

- Additional monitoring, paid for by the party responsible for the ditching, is needed to better assess impacts where extensive areas of wetlands were drained.
- Coastal research and monitoring needs to continue to improve our understanding of the processes of hypoxia and anoxia and the effect on fish populations.
- More detailed monitoring is needed to assess the extent oceanfront septic systems are causing degradation to nearshore coastal waters.

- Basic water quality parameters (flow, temperature, pH, and DO) should be identified for wastewater permit applicants to monitor. If the data indicate the presence of pollutants in the discharge water, toxic chemical monitoring and toxicity testing should be required. Nutrients and ammonia should be monitored if a mass balance approach indicates excess nutrients. Biological monitoring of the macrobenthic community should be required on facilities discharging more than 0.5 million gallons per day.
- Until treatment of ballast water is required and implemented, monitoring of port waters for algal blooms is recommended to minimize risks of introduction elsewhere.

Submerged Aquatic Vegetation (SAV)

- Since some SAV is present in the shallow portions of the Neuse and portions of the White Oak river basins, and water quality data indicate some level of eutrophication exists, nutrient levels may be limiting survival or expansion of SAV in these areas. These areas should be a high priority for monitoring of SAV and water clarity.
- Submerged grasses need to be monitored on a regular basis to assess the status of wasting disease and its association with human-induced stresses.

Wetlands

- Additional monitoring is needed to better assess impacts where extensive areas of wetlands were drained.

Soft Bottom

- Adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important as the number of beach nourishment projects increase and should be required for all large-scale or long-term nourishment projects.
- To adequately and correctly assess the direct and cumulative impacts of beach nourishment activities on fish, their habitat, and biological recovery rates, thorough monitoring must be conducted.
- Long-term monitoring is required, in combination with management actions that reduce discharge concentrations, to determine effectiveness and future management needs.

Hard Bottom

- Monitoring of hard bottom is needed to assess the level of impact from hook and line fishing.
- Monitoring of hard bottom should be initiated and coordinated with UNC-Wilmington or other ocean water quality monitoring programs to determine the effects of estuarine water quality, particularly nutrient and sediment loading, on hard bottom.
- Some habitats are ephemeral in nature (e.g., early successional habitats) thereby making it more difficult to track the extent of those types.

Box 3: Monitoring Protocol Resources

This listing represents some of the standard monitoring programs and protocols applicable to North Carolina. However, it is not a comprehensive synthesis of all protocols. A key need is to expand this basic list into a more comprehensive library of available protocols to facilitate standards among states and agencies.

Birds

Conway, Courtney J. 2004. Standardized North American marsh bird monitoring protocols. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit.

DeSante, D. F., and K. M. Burton. MAPS Manual: Instructions for the establishment and operation of stations as part of the Monitoring Avian Productivity and Survivorship program. The Institute for Bird Populations. Point Reyes Station, CA.

Howe, Marshall, Jon Bart, Stephen Brown, Chris Elphick, Robert Gill, Brian Harrington, Catherine Hickey, Guy Morrison, Susan Skagen, and Nils Warnock, eds. 2000. A comprehensive monitoring program for North American shorebirds. Manomet Center for Conservation Sciences. http://www.Manomet.org/USSCP/files.htm

Hunter, W.C. 2000. Bird population survey, inventory, and monitoring standards for National Wildlife Refuges and partners in the Southeastern U.S. US Fish & Wildlife Service, Atlanta, GA.

Steincamp, M., B. Peterjohn, V. Byrd, H. Carter, and R. Lowe. 2003 (DRAFT). Breeding season survey techniques for seabirds and colonial waterbirds throughout North America. Waterbird Monitoring Partnership of the Waterbird for the Americas Initiative, U.S. Geological Survey, Patuxent Wildlife Research Center.

(continued on next page)

Ongoing Monitoring Efforts

Currently, at the state, region, and national levels, there are numerous projects underway involving research or guideline development to improve monitoring efforts and facilitate better standards. Recommendations or analyses eventually produced through these efforts should be considered in future monitoring program improvements.

State

- NC State University research (Dr. Ted Simons) with US Geological Survey Patuxent Wildlife Research Center evaluating monitoring protocols for standard point counts and Breeding Bird Survey protocols related to estimation of detectability in birds.

Regional

- Regional inventory and monitoring guidelines for reptiles and amphibians of the Southeast in development by SE PARC.
- Southern Appalachian Man and the Biosphere (part of NBII SAIN) - the Citizen Environmental Monitoring in Appalachia conference (Nov. 2004) focused on citizen environmental monitoring of water, invasive and exotic species, and forest health and sustainability.
- Southeast Gap Analysis Project - this regional initiative may provide an opportunity to assess habitat changes over time across the southeast region (http://www.basic.ncsu.edu/segap/).

National

- US Forest Service Multiple Species Inventory and Monitoring program (http://www.fs.fed.us/research/monitoring_vertebrate.html)—objectives of the program are to: 1) develop and evaluate sampling designs, detection protocols, and analysis procedures for multiple species of vertebrates and their habitats at ecoregional scales, and 2) develop national guidance in the form of a National Forest System technical guide that outlines how to monitor populations and habitats of multiple species in one integrated design.
- US Geological Survey Technical Report: Designing monitoring programs in an adaptive management context for regional multiple species conservation plans (Atkinson et al. 2004)—stepwise procedures for developing effective regional monitoring programs in an adaptive management context.
- Defenders of Wildlife/Illahee project (Schoonmaker and Luscombe 2005 DRAFT) – ongoing work among many western states to develop a potential habitat monitoring frame work for use in all state Strategies to track habitat changes over time.

Box 3: Monitoring Protocol Resources (*continued*)

Amphibians and Reptiles

Amphibian and Reptile Monitoring Initiative (ARMI). USGS Patuxent Wildlife Research Center. http://armi.usgs.gov/index.asp

Dodd, C. Kenneth. 2003. Monitoring amphibians in Great Smoky Mountains National Park. 2003. U.S. Geological Survey Circular 1258.

Handbook for sea turtle volunteers in North Carolina. N.C. Wildlife Resources Commission. Raleigh, NC.

Heyer, W. R., M. A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster (eds.). 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

North American Amphibian Monitoring Program (NAAMP). USGS Patuxent Wildlife Research Center. http://www.pwrc.usgs.gov/NAAMP/protocol/

Southeast Amphibian and Reptile Monitoring Initiative (SE ARMI). Florida Integrated Science Center. Gainesville, FL. http://cars.er.usgs.gov/armi/

Mammals

Measuring and monitoring biological diversity: standard methods for mammals. 1996. Editors: D.E. Wilson, F.R. Cole, J.D. Nichols, R. Rudran, M.S. Foster. Smithsonian Institution Press, Washington, DC.

Aquatics

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biotic integrity in running waters: a method and its rationale. Illinois Natural History Survey, Champaign, IL.

Strayer, D.L., and D.R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society, Monograph 8, Bethesda, MD.

Multiple Species

Manley, P. N., B. V. Horn, and C. Hargis. 2004 (DRAFT). Multiple species inventory and monitoring technical guidance. FSM Technical Guide. USDA Forest Service.

- US Geological Survey Status and Trends Program - coordination of state Plan monitoring needs/standardized protocol development; the focus of the program is to develop mechanisms to monitor status and trends of biological resources.
- Coordinated Bird Monitoring Group of IAFWA (2004) - this report is intended to be a springboard for comprehensive discussions among NABCI partners on coordinating bird monitoring.

References

Atlantic Coast Joint Venture (ACJV). 2004. Atlantic Coast Joint Venture strategic plan. North American Waterfowl Management Plan.

Atkinson, A. J., P. C. Trenham, R. N. Fisher, S. A. Hathaway, B. S. Johnson, S. G. Torres, and Y. C. Moore. 2004. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. U.S. Geological Survey Technical Report. Western Ecological Research Center, Sacramento, CA.

Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. U.S. shorebird conservation plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Conway, C. J. 2004. Standardized North American marsh bird monitoring protocols. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit.

Cooper, R. J., and D. Demarest. 1999. Partners in Flight bird conservation plan for the Southern Piedmont. Partners in Flight.

Coordinated Bird Monitoring Group of IAFWA. 2004. Monitoring avian conservation: rationale, design, and coordination. International Association of Fish and Wildlife Agencies, Washington, D.C.

Hunter, W.C. 2000. Bird population survey, inventory, and monitoring standards for National Wildlife Refuges and Partners in the Southeastern U.S. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C. 2004 (DRAFT). Southeast U.S. region waterbird conservation plan. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., R. Katz, D. Pashley, and B. Ford. 1999. Partners in Flight bird conservation plan for the Southern Blue Ridge. American Bird Conservancy.

Hunter, W. C., J. Collazo, B. Noffsinger, B. Winn, D. Allen, B. Harrington, M. Epstein, and J. Saliva. 2000. Southeastern Coastal Plain – Caribbean regional shorebird plan, Version 1. US Fish & Wildlife Service, Atlanta, GA.

Hunter, W. C., L. Peoples, and J. Collazo. 2001. Partners in Flight bird conservation plan for the South Atlantic Coastal Plain. American Bird Conservancy.

Johns, M. 2004. NC Partners in Flight research, monitoring and conservation activities summary. N.C. Wildlife Resources Commission, Raleigh, NC.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, D.C.

North American Waterfowl Management Plan Committee (NAWMP). 2003. North American Waterfowl Management Plan strategic guidance. US Fish & Wildlife Service, Arlington, VA.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2001. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY.

Schoonmaker, P. and W. Luscombe. 2005. Habitat monitoring: an approach for reporting status and trends for state Comprehensive Wildlife Conservation Strategies. Illahee, Portland, OR.

South Atlantic Migratory Bird Initiative (SAMBI). 2004 (DRAFT). South Atlantic Migratory Bird Initiative pelagic conservation plan. US Fish & Wildlife Service.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2004. Coastal habitat protection plan. N.C. Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Watson, C., and K. McWilliams. 2004 (DRAFT). South Atlantic Migratory Bird Initiative implementation plan: an integrated approach to conservation of "all birds across all habitats." US Fish & Wildlife Service, Charleston, SC.

CHAPTER 8.

IMPLEMENTATION MONITORING, ADAPTIVE MANAGEMENT, & REVIEW AND REVISION PROCEDURES

Introduction

Our Plan has identified priority species and their habitats, described threats to those species and habitats, prioritized appropriate conservation actions to mitigate those threats, and addressed status and trends monitoring. The resultant product is a roadmap for implementing species conservation and habitat management. To be successful, however, we must develop effective ways to monitor not only particular species and species groups (detailed in Chapter 7), but also the conservation actions being implemented, their effects on habitat, and eventually the results that those actions have on priority species. The product of this monitoring effort will provide a measure of project and program success that can be used to determine if our goals and objectives are being met. Monitoring feedback is a critical piece of the adaptive management process that will keep both projects and the program on task and goal-oriented.

Plan implementation will be a dynamic process through time, involving management of the monitoring process, performance assessment, adaptation as new information dictates, and refocusing to new tasks and projects as appropriate. The goals of the Plan must remain visible as personnel and organizational shifts occur both within the Commission and across the broader conservation community. Maintaining communication and input from the broader conservation community will be critical to the success of the Plan and its implementation.

Eventually, the Plan will require a more formal review and revision to make sure it remains relevant to its core purpose. We propose a process for incorporating monitoring, maintenance activities, adaptive management, and review and revision within a five-year cycle (Figure 8.1).

Our monitoring, adaptive management, and review and revision protocols have primary importance to the Commission, as the agency ultimately responsible for review and revision. Yet in order for this process to be an efficient and meaningful way to measure advancement towards the goals we have outlined for our Plan, it is important that it be clear and easy to understand for all partners involved in Plan implementation.

> *Note:* After October 2005, each state and territory in the country will have 55 other Plan examples to review and draw inspiration from. The next few cycles of implementation, review and revision will be the most critical in terms of working out kinks, testing methods that are as of yet just theoretical, and improving aspects of the Plan that aren't working well. For this reason, the five-year interval of Plan revision may be shortened for the first few rounds of revision.

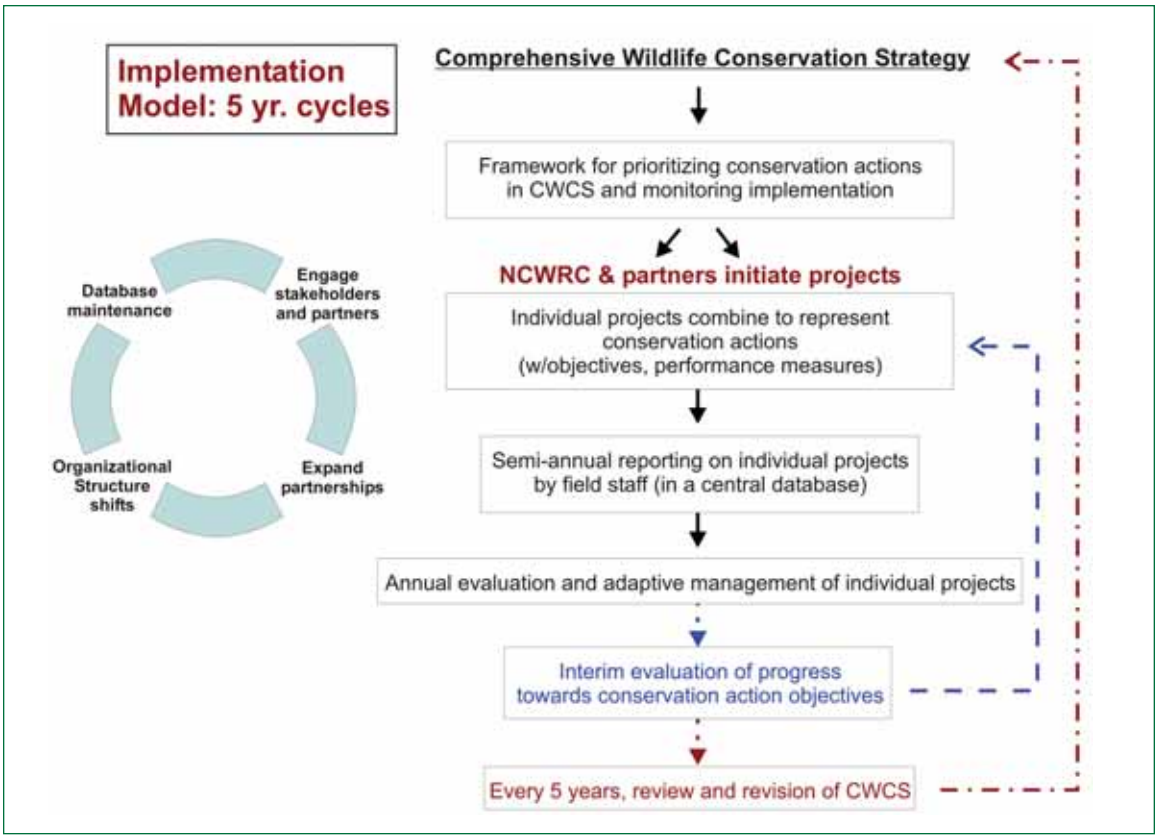


Figure 8.1. North Carolina's Wildlife Action Plan implementation model.

Monitoring of Conservation Actions and Adaptive Management

In order to effectively review and revise a document of this depth and breadth, we must first establish protocol and procedures for evaluating how well the conservation actions we have proposed are working to further the goals and objectives of the Plan. As an agency, the Commission is used to setting project level objectives and indicators of success; scaling those indicators up to address conservation action objectives will be a matter of organizing and classifying projects into the framework identified in Chapter 6 (Tables 6.2 – 6.6). In that chapter, we linked priority conservation actions to objectives and indicators that will facilitate monitoring and performance measurement of those conservation actions. Following, we describe how the outcomes of the conservation actions will be monitored and how adaptive management will be employed.

An effective, comprehensive approach to measuring success will need to take advantage of existing relevant monitoring and reporting (e.g., Federal Assistance documentation) and the expertise of other agencies and organizations (e.g., US Geological Survey). It will also require the development of new monitoring protocols to address measurement needs unmet by existing efforts. Coordination should be attempted on as broad a scale as feasible to make the monitoring process as useful as possible across multiple scales for multiple purposes. Design considerations might include extrapolating monitoring results at a smaller scale to a larger scale, using indicator species or communities, defining effectiveness as threat abatement when feasible, measuring habitat changes instead of animal responses, and other strategies to address success but manage difficulty and cost. (See Chapter 7 for a discussion on status and trends monitoring).

IAFWA guidance emphasizes the importance of a good cost accounting system to keep track of investments (time and money) at the individual project level, as well as the importance of commitment to evaluation and adaptation by project managers (2003). Another aspect of successful monitoring involves the recognition that, in order to be effective, evaluation must occur at different

levels – and that at each level there are unique time scales, relationships and evaluation questions. Successful implementation of the Plan will eventually require monitoring strategies across several scales, from a single project, to conservation actions applied over many projects, to broad programmatic evaluations. The Forest Service makes distinctions between the types of monitoring and evaluation they conduct (USFS 2002). Applied to the Plan, they include:

- *Implementation monitoring* – Determines if the activities and recommendations proposed in the Plan are being implemented through individual projects according to initial direction, requirements, and standards.
- *Effectiveness monitoring* – Determines if activities and recommendations are achieving, or moving towards, the desired goals or objectives.
- *Validation monitoring* – Determines if the initial activities and recommendations are valid, or are there better ways to meet the goals and objectives of the Plan.

We are committed to developing a centralized database to serve as the reporting mechanism for Plan implementation and the basis of our monitoring structure. This database will be maintained by the Commission to provide a meaningful tool for future review and revision procedures. Using this database, we will be able to query for information on, for example, how many acres of prescribed burning, linear feet of stream shoreline restoration, or new life history studies were conducted over a particular time period. At the project level, the step-down framework proposed in Chapter 6 will be a useful guide to reporting on specific targets across various planning activities (e.g., a shorebird project might employ a survey and a research component, thus performance measures and targets, identified in the database, would be set to reach stated objectives for each of those activities).

Note: While it is generally straightforward to gather and store implementation monitoring data, effectiveness data will be more difficult and costly to collect. Consider the example of fencing cattle out of a stream with the objective of reducing siltation in riffles and the goal of increasing population size of rare mussels. It is relatively easy to quantify the linear feet of stream protected by fencing (implementation monitoring). It is more difficult and costly to determine if fencing the stream has rehabilitated the riffle habitat (effectiveness monitoring), which requires measuring changes in silt coverage in the riffle over time. It is much more difficult and costly to determine if there better ways of increasing rare mussels in the riffle (validation monitoring). It is our long term goal to develop effectiveness and validation monitoring that is strategic and cost effective, through metrics we are able to track over time.

Making use of the Forest Service distinctions, we propose that evaluation must occur at the following levels, using diverse types of evaluation questions and employing different levels of leadership (Table 8.1) (*all of which must be considered in the proposed centralized database*).

Table 8.1. Evaluating the effectiveness of conservation actions in North Carolina's Plan.

Work Level	Time Scale	Type of Monitoring[1]	Types of Evaluation Questions	Conducted By	Methodology
Individual project	Semi-annual reporting Annual evaluation	I, E	• Did the project occur? • Did it stay within budget? Did it use funds correctly? • Are budgeting proportions accurate? • Who did the work? What was the quality of the work? • Were the hours required reasonable and expected? • Did it have the desired outputs? • How many targets or objectives were met? • Are the performance indicators useful metrics of progress/success? • Was there collaboration among agencies/private entities/NGOs? To what extent? How many? • Were volunteers encouraged/solicited to participate and at what level/to what extent? • Are there any unintended consequences of implementing the project? Unexpected side-effects? • What (if any) was public opinion of the project?	Program supervisors, and staff	Cost accounting system tracking time and money by project; central project tracking database used to track project accomplishments.
Adaptive management of project	Annual	I, E	• Based on evaluation, how should future projects be changed or retained?	Program supervisors and staff	
Wildlife Action Plan conservation actions (on par with program-level strategies)	Interim (every few years)	E, V	• What is the status of the desired outcomes associated with each activity, as measured by performance indicators? Are the performance indicators valid measures? • Are the individual projects meeting the conservation actions called for in the Plan? If not, why not?	Program supervisors, Steering Committee	Central project tracking database used to track project accomplishments.
Adaptive management of conservation actions	Interim (every few years)	E, V	• Based on evaluation, how should future program-level activities and projects be changed or retained?	Program supervisors, Steering Committee	
Wildlife Action Plan Goals	Every five years	E, V	• Are the conservation actions meeting the state's goals of the North Carolina Wildlife Action Plan?	Program supervisors, Steering Committee	Central project tracking database used to track project accomplishments.

Maintenance

Maintenance of the Plan will require the continuation of all the activities that went into the initial development of the document (e.g., communication and coordination with partners, database updates, organizational structure shifts), as well as the management of new activities (e.g., project evaluation/monitoring/adaptive management procedures, a funding allocation mechanism). Maintenance activities will be primarily coordinated by Commission staff, but will require regular communication with external stakeholders. If maintained properly, future revision of the Plan should be a straightforward and streamlined process.

Project Evaluation, Monitoring, and Adaptive Management

As reported above (see Figure 8.1 and Table 8.1) semi-annual reporting on projects, and annual evaluation of project accomplishments by program supervisors will be the tools to assess adaptive management needs on a project-by-project basis. Interim assessments of the individual projects'

[1] I = Implementation, E = Effectiveness, V= Validation

performance at meeting program-level strategies that are on par with the conservation actions called for in the Plan will be conducted by program supervisors and Commission administration. Program supervisors will work with staff and external partners to review the results of individual projects and make adaptive management changes as need be. Annual project updates will be sent to partners to keep them abreast of project progression and highlights.

Organizational Structure Shifts

Organizational structure shifts are inevitable considering imminent retirements, contract term expirations and staff changes. Through all of these changes, it is critical that connection and dedication to the Plan be maintained, even strengthened. Strong leadership from the Commission administration is vital.

- An agency-wide position will be created to assume the duties of the current Plan Coordinator and to oversee the implementation of the Plan and future revision procedures. A position at this level will promote institutional memory and reduce fragmentation within the project. This position should be filled by someone highly skilled in project coordination, planning, and communications, with strong multi-tasking skills.
- Current committee structures and roles will be reviewed and needed revisions made to maximize their efficiency and effectiveness (see Chapter 2 for committee descriptions).
- The role of the Nongame Wildlife Advisory Committee as a support mechanism for Plan implementation will be formalized and strengthened. This body represents a key link to external partners and to the Scientific Councils who are responsible for recommending additions or deletions to protected species lists in North Carolina; they are a key body to explore and offer solutions to the Commission on challenging issues like match generation and funding streams.

Communication and Coordination

Communication and coordination are vital aspects of Plan implementation. Again, an agency-wide position will be the most efficient way to manage Plan-related communications in the future. The following communications must be maintained throughout Plan implementation:

- Email updates to formal committees, partners, and stakeholders on implementation progression, project successes and adaptive management changes (might query stakeholders to determine the most effective way(s) to provide implementation updates).
- Web site updates and improvements.
- Small-scale meetings and communications to initiate implementation projects among partners.
- Annual “State of the Plan” meetings with partners and stakeholders to report on accomplishments, invite project coordination, and maintain enthusiasm for the Plan.
- Individual phone and email communications.
- Maintenance and management of formal committee structures.

Cooperative partnerships formed to meet shared needs and priorities will become increasingly important throughout Plan implementation, especially under current match requirements. The Commission will continue to actively search for partners to assist in addressing unmet priorities.

Database development and updates

A database manager will be responsible for developing, managing and maintaining Plan-related databases (e.g., priority species database). As previously mentioned, a centralized project management database will be developed in order to facilitate tracking and reporting on project accomplishments by Commission staff and partners. In this reporting system, individual project targets will be linked to conservation actions, objectives, performance measures, and broader Plan goals to show accountability for meeting with success. (*A prototype model has been developed, but the model will require substantial feedback and testing by technical staff who will be reporting in the database*).

State Wildlife Grants Fund Allocation

As the state fish and wildlife management agency, the Commission is charged to coordinate the development, implementation, and future revision of our state Plan, along with the allocation of funding. Having the staff and expertise to carry out projects, coordinate goals and objectives, and measure success is a critical component of realizing our Plan, so at current funding levels, the Commission is using much of the State Wildlife Grants funds to grow and support staff operations and projects. Until funding increases substantially, this will not change. Yet with a challenging match requirement for project implementation (currently 50:50 federal to state match), partnerships are absolutely essential to realizing implementation of our Plan.

The Commission has a long history of being involved in successful partnerships across the state:

- Since 1993 we have coordinated the state Partners in Flight program.
- Our Colonial Waterbird Cooperative Agreement has 11 different agency signatories and has been a model for other states since 1989.
- We rely on the assistance of hundreds of volunteers across the state to complete numerous conservation projects, including sea turtle nesting and stranding monitoring, peregrine falcon monitoring, bog turtle surveys and habitat management, and songbird monitoring.
- We hold Memorandums of Understanding related to conservation practices with corporations (e.g., International Paper), other agencies (e.g., the US Fish & Wildlife Service), and private entities (e.g., The Nature Conservancy).
- We support collaborative research with colleges and universities (past research projects have include work on northern flying squirrel, bog turtle, woodrats, and freshwater mussels).
- We participate in interstate efforts such as the Robust Redhorse Conservation Committee and the Pigeon River Restoration Project.

We strongly encourage our partners and stakeholders to stay engaged in the Plan implementation process. As funding increases, the services and support that we can provide to partners and external stakeholders will also increase (e.g., assistance with surveys and inventories, technical guidance, research and management), as will our ability to provide additional external funding to meet targeted needs identified in the Plan that cannot be met in-house. In time (if funding allows) we hope to work towards open competitive grants. We see our standing Nongame Wildlife Advisory Committee as a critical link to external partnerships and we intend to continue to use the assistance of that committee to facilitate long-term project planning with partners.

Review and Revision

As outlined in the Implementation model graphic (Fig. 8.1), revision of the actual Plan document will occur at five-year intervals, coinciding with the existing Federal Aid reporting cycle. Interim reporting, project evaluations, and reviews will largely determine the nature and direction of the five-year revision. However, the state will be especially vigilant of necessary changes and revisions in the short-term (the next revision may need to happen quicker than subsequent revisions because the Plan is 'untried' as of yet).

Future revision of the Plan is critical to its continued use as a planning document. We have ensured that review will occur by defining a timeframe over which revision will take place. Any number of issues may be cause to revise the document:

- New information gained through surveys, research, and monitoring will warrant future reevaluation of our species priorities.
- Reprioritization of activities following accomplished tasks will be also necessary.
- Flaws in how the Plan serves to guide implementation activities must be identified and eliminated.

- New or improved approaches to internal supporting processes (e.g., species prioritization, threat assessment) that are worth the investment of revision should be executed before an unwieldy process becomes tradition.
- Expansion of the Plan to primarily include species groups (e.g., game species, insects) that were secondarily addressed in the first iteration will make it a more truly comprehensive document.

There will be a need for fairly frequent review by the existing committees in the short term to answer the big question: 'How is the Plan working as a planning resource and guidance document'?

Evaluating the successful implementation of the Plan will take several forms (also see ideas above in the "Monitoring of Conservation Actions and Adaptive Management" section):

1. We must answer the question: "Are the stated goals of the Plan being fulfilled?" The project tracking database (mentioned previously) will be a direct way to track progress towards our stated goals.
2. Surveys of Commission biologists, partners, and stakeholders will help us gauge how well the Plan is functioning as a planning resource. Important queries will include:
   - How helpful was the Plan to your annual project planning?
   - Were the projects that you ended up pursuing emphasized/prioritized in the Plan?
   - Did you involve partners in your projects?
   - How easy/difficult was it for you to identify match opportunities for those projects?
   - Did potential partners contact you as a result of the Plan?
   - What are the strengths, weaknesses of the Plan?
3. Annual accomplishment measures[3] that correlate to implementation progress might include quantification of:
   - Acres of key habitat protected or improved through various means (e.g., acquisition, conservation easements, restoration)
   - Biological assessments of priority species
   - Research or surveys to fill data gaps
   - Monitoring program advances
   - Information management advances (e.g., database improvements, upgrades, etc)
   - Funding of conservation projects
   - Outreach to partners and the public
   - Partnership coordination (e.g., Memorandums of Understanding, match agreements, etc).

   "Success" criteria might thus include the following:
   - A net increase in the acreage of key habitats protected through acquisition, easements, or restoration.
   - A net increase in scientific knowledge of priority species and key habitats.
   - Successful funding of the highest priority conservation project(s).
   - Successful completion of the highest priority conservation project(s).
   - An increase in partner and public involvement in achieving protection of fish and wildlife resources in North Carolina.

[1]These measures should be components of the proposed central reporting database.

- The removal of threats to priority species and key habitats through avoidance, minimization and mitigation measures.
- The long-term reduction in the number of species on the priority species list, as threats are adequately addressed.

In addition to these measurable criteria, the success of the Plan (and the implementation of conservation actions) will be monitored in qualitative methods. An improvement in the coordination of similar monitoring projects conducted by disparate entities would be one such qualitative measure (enhancing the efficiency of each project). Another qualitative measure of success may be the increased involvement of the Commission in other statewide or regional conservation initiatives (e.g., Coastal Habitat Protection Plan implementation, One NC Naturally Initiative). By utilizing both quantitative and qualitative success criteria, the Commission will be responsive to the diverse nature, scope and scale of the proposed priority conservation actions.

A more broad-based review will be necessary on a longer-term basis, involving all of the stakeholder groups we have engaged thus far, and any that we may engage in the future. The Nongame Wildlife Advisory Committee is one such group who will be providing critical feedback and review of the Plan. They currently serve as an informal External Partners Committee, though representation by partners who are not currently represented on the Nongame Wildlife Advisory Committee (e.g., The Nature Conservancy) will also be critical to maintain.

Supporting materials to guide a review may include analysis of other state Plan efforts with recommendations given to strengthen particular aspects of North Carolina's Plan (e.g., separate reviews regarding threats analyses, species prioritization processes) and review of the Guiding Principles document to identify how many principles were attained during the first iteration and determine how North Carolina can work to attain more of them in the future.

When a revision is to occur, the Steering and Technical Committees will assemble teams that put the revisions together. It will be critical to identify criteria to guide the five-year review, then review the major elements of the Plan with those criteria, identify areas needing revision and the nature of the revision(s). Revisions will be peer reviewed and then major revisions will come to the Steering Committee, who will approve putting the revisions into the Plan. External views are especially important during a big revision, to give the Commission a "reality-check" and an outside view; this will involve partners (represented by the Nongame Wildlife Advisory Committee and others).

Reevaluation of our set of priority species should also occur on the five-year review cycle, as it takes considerable time to assess changes related to implementation of conservation activities and to amass new information useful in making management decisions. During revision of the species prioritization process, taxa committees should be reinstated, chaired by Technical Committee members to maximize the efficiency of each committee; representation by all current Scientific Council members should be ensured.

Conclusion

Many lessons have been learned from our efforts to develop this first iteration of the Plan. Over the next cycle of Plan implementation (and with each subsequent revision) we shall review and evaluate the Plan, and the processes that support it, for function and utility. The true value of the Plan will be conditional upon our experiences prioritizing our actions, building partnerships, and implementing the conservation recommendations proposed in this document and the ease with which we move forward with long-term planning. Monitoring, maintenance, review and revision are the tools that will allow us to continually improve and expand our vision for fish and wildlife conservation in North Carolina.

References

IAFWA Teaming With Wildlife Committee. 2003. Resources for development of state Comprehensive Wildlife Conservation Plans.

U.S. Forest Service (USFS). 2002. Revised land and resource management plan for the Croatan National Forest. U.S. Department of Agriculture, Forest Service, National Forests in North Carolina, Asheville, NC.

ACKNOWLEDGEMENTS

As with any large, multi-year project, the preparation of our Plan involved the input and participation of a wide variety of individuals, including staff within multiple divisions of the Commission, as well as from other state and federal agencies, conservation organizations, private industry, and academia. We extend our warmest thanks to everyone who has contributed their knowledge, time, and energy in the development of the Plan; your dedication has improved the final product immeasurably.

This first iteration of our Comprehensive Wildlife Conservation Plan is only the most visible result of our multi-year planning efforts. Of even greater value are the inter-agency and organizational networks and communication bridges that were formed and strengthened through this effort. The ultimate test of our Plan will be measured through the success of its implementation and the strengthening of collaborative efforts and partnerships.

The following people were directly involved in the development of the Wildlife Action Plan[1]:

Steering Committee:

Bob Curry, NCWRC
Brad Gunn, NCWRC
David Cobb, NCWRC
Fred Harris, NCWRC
Scott Van Horn, NCWRC
Shannon Deaton, NCWRC
Tom Henson, NCWRC
Wib Owen, NCWRC
Ken Bridle, NWAC representative

Wildlife Action Plan Coordinator

Salinda Daley, NCWRC

Internal Technical Committee:

Angie Rodgers, NCWRC
Chris McGrath, NCWRC
David Allen, NCWRC
Jeff Marcus, NCWRC
Jeff Simmons, NCWRC
Mark Johns, NCWRC
Nolan Banish, NCWRC
Rob Nichols, NCWRC
Ryan Heise, NCWRC
Sarah Cross, NCWRC
Scott Anderson, NCWRC
Steve Fraley, NCWRC

[1]See the Key to Acronyms and Abbreviations for a complete list of all acronyms and abbreviations used herein.

Additional input, feedback, and assistance in developing the Plan was provided by:

Alexa McKerrow, NCGAP
Alvin Braswell, NCMNS
Amy Bleckinger, NCWRC
Andy Wood, NC Audubon
Ann Berry Somers, UNC-Greensboro
Anna Huckabee Smith, NCWRC
Anne Deaton, NCDMF
Art Bogan, NCMNS
Barbie Byrd, NOAA - Fisheries
Barry New, NCDFR
Becca Madsen, Duke University
Bob Barwick, NCWRC
Bob Slocum, NC Forestry Association
Brady Beck, NCWRC
Brent Martin, Land Trust for the Little Tennessee
Brian McRae, NCWRC
Bryan Hulka, Weyerhaeuser Company
Bryn Tracy, NCDWQ
Chad Thomas, NCWRC
Chris Elkins, Coastal Conservation Association
Chris Goudreau, NCWRC
David Lee, (formerly) NCMNS
David Lenat, private consultant
David Vogel, NCSWCD
David Webster, UNC-Wilmington
David Yow, NCWRC
Dennis Desmond, Land Trust for the Little Tennessee
DJ Gerken, SELC
Don Hayes, NCWRC
Doreen Miller, USFS
Doug Besler, NCWRC
Doug Howell, NCWRC
Douglas Ruley, SELC
Evin Stanford, NCWRC
Fred Annand, TNC
Fritz Rohde, NCDMF
Gene Vaughn, Duke Power
Ginger Williams, NCWRC
Ginny Harrison, NCWRC
Glen Catts, Hoffman Forest, NCSU
Gordon Warburton, NCWRC
Harlan Hall, NCWRC
Harry LeGrand, NCNHP
Jeff Bean, NCMNS
Jenna Begier, NCWRC
Jim Borawa, NCWRC
Jodie Owen, NCWRC
Joe Fuller, NCWRC
John Alderman, private consultant
John Connors, NCMNS
John Cooper, NCMNS
John Gerwin, NCMNS
John Sealy, (formerly) Appalachian State University
John Townson, Camp Lejeune Marine Corps Base
JohnAnn Shearer, USFWS
Judy Ratcliffe, NCNHP
Kate Pipkin, NCWRC
Ken Bridle, Piedmont Land Conservancy
Kevin Dockendorf, NCWRC
Kevin O'Kane, Weyerhaeuser Company
Klugh Jordan, SELC
Lauren Battle, Duke University
Linda Pearsall, NCNHP
Logan Williams, NCDOT
Lori Williams, NCWRC
Mallory Martin, NCWRC
Marek Smith, Mecklenburg County Park and Recreation Department
Margaret Martin, NCWRC
Margit Bucher, TNC
Mark Danaher, International Paper
Mark Dubowski, NCWRC
Mark Fowlkes, NCWRC
Mark Jones, NCWRC
Mark Megalos, NCDFR
Mary Kay Clark, (formerly) NCMNS
Matina Kalcounis-Ruppell, UNC-Greensboro
Matthew Godfrey, NCWRC
Michael Baranski, Catawba College
Mike Seamster, NCWRC
Nick Haddad, NCSU
Perry Sumner, NCWRC
Pete Benjamin, USFWS
Pete Bromley, private consultant
Pete Kornegay, NCWRC
Peter Weigl, Wake Forest University
Russell Wong, NCWRC
Ryan Meyers, NCWRC
Sam Pearsall, TNC
Sandy Florence, USFS
Sarah McRae, NCNHP
Scott Chappell, NCDMF
Scott Osborne, NCWRC
Scott Pohlman, NCNHP
Sheryl Bryan, USFS
Steve Hall, NCNHP
Steve Williams, NCGAP
Sue Cameron, NCWRC
Ted Simons, NCSU
Terry Sharpe, NCWRC
Tisha Gennings, Duke University
Tom Henry, SELC
Tommy Hughes, NCWRC
Trish MacPherson, NCDWQ
Vickie Cumbee, NCWRC
Walker Golder, NC Audubon
Wayne Starnes, NCMNS
William McLarney, Little Tennessee Watershed Association
Wilson Laney, USFWS
Win Taylor, NCWRC
Zora Rhodes, NCWRC

We would also like to extend a thanks to participants of our 2004 Stakeholder Meeting (see Appendix C for a listing of participants), to all members of the Commission's Nongame Wildlife Advisory Committee, and to the International Association of Fish and Wildlife Agencies and the US Fish & Wildlife Service for their guidance and support through the Plan development process.

GLOSSARY

adaptive management – a process for adjusting management and research decisions to better achieve management objectives, recognizing that knowledge about natural resource systems is uncertain.

anadromous – a fish or fish species that migrates up rivers from the sea to breed in fresh water.

anthropogenic – relating to, or resulting from the influences of human beings on nature.

benthic – relating to, or of the bottom surfaces of bodies of water.

biodiversity – the variability among living organisms on the earth, including the variability within and between species and within and between ecosystems.

by-catch – the portion of a fishing catch that is discarded as unwanted or commercially unusable.

ecoregion – an area defined by environmental conditions and natural features; a region defined by its ecology.

endemic (endemism) – native to a particular locality, region, country, etc.

exotic species (also commonly called *alien*, *non-indigenous*, or *non-native*) – a species occurring outside of its native range.

extinction – the state of a species no longer existing throughout its entire range.

extirpate (extirpation) – to bring a species to extinction within part of its range.

hydrology – the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

introduced species – a species whose existence in a given area is due to human action or activity; this activity has led to its dispersal across natural geographic barriers, and/or has produced conditions favorable to its growth and spread.

invasive/injurious species – a species occurring outside of its native range and whose introduction does or is likely to cause harm or threaten the survival of native species.

objective – a concise statement of intended achievement; something toward which effort is directed.

optimum sustainable population – (as defined by the Marine Mammal Protection Act) the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the optimum carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element; a population size which falls within a range from the carrying capacity of the ecosystem to the population level that results in maximum net productivity.

pelagic – referring to species that spend the majority of their lives on or in the open ocean, beyond the near-shore coastal zone, >3 miles offshore.

potential biological removal – the maximum number of animals, not including natural mortalities, that may be removed from that stock, while allowing the stock to reach or maintain its optimum sustainable population.

riparian – pertaining to a river and the corridor adjoining it (i.e., the banks, floodplain); of, on, or relating to the banks of a natural course of water.

telemetry – the science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources to receiving stations for recording and analysis.

[1]See the Key to Acronyms and Abbreviations for a complete list of all acronyms and abbreviations used herein.

KEY TO ABBREVIATIONS AND ACRONYMS

AEC	Areas of Environmental Concern
APGI	Alcoa Power Generating Incorporated
ASMFC	Atlantic States Marine Fisheries Commission
BBS	Breeding Bird Survey
BHIC	Bald Head Island Conservancy
BMP	Best Management Practice
BRPP	Blue Ridge Paper Products
CAMA	Coastal Areas Management Act
CCARI	Central Carolina Amphibian and Reptile Initiative
CES	County Extension Service
CHPP	Coastal Habitat Protection Plan
Commission	North Carolina Wildlife Resources Commission (also see NCWRC)
CRC	Coastal Resources Commission
CTNC	Conservation Trust for North Carolina
CURE	Cooperative Upland habitat Restoration and Enhancement Program
DCE	Division of Conservation Education (in NCWRC)
DDT	Dichloro diphenyl trichloroethane
DIF	Division of Inland Fisheries (in NCWRC)
DMAP	Deer Management Assistance Program
DO	Dissolved oxygen
DoD	United States Department of Defense
DWM	Division of Wildlife Management (in NCWRC)
EELE	Environmental Education Learning Experience
EEP	Ecosystem Enhancement Program
EMC	Environmental Management Commission
ESA	Endangered Species Act
FDP	Forest Development Program
FERC	Federal Energy Regulatory Commission
FIA	Forest Inventory and Analysis
FMP	Fisheries Management Plan
GIS	Geographic Information Systems
HMS	Highly migratory species
HQW	High quality waters
HUC	Hydrologic unit code
IAFWA	International Association of Fish and Wildlife Agencies
IBA	Important Bird Areas
INRMP	Integrated Natural Resource Management Plan (DoD)
LRMP	Land and Resource Management Plan (USFS)
LTWA	Little Tennessee Watershed Association
MAFMC	Mid-Atlantic Fisheries Management Council
MAPS	Monitoring Avian Productivity and Survivorship
MFC	Marine Fisheries Commission

MMPA	Marine Mammal Protection Act
NABCI	North American Bird Conservation Initiative
NABCP	North American Bat Conservation Partnership
NAWMP	North American Waterfowl Management Plan
NBII	National Biological Information Infrastructure
NC GAP	North Carolina Gap Analysis Project
NCDENR	North Carolina Department of Environment and Natural Resources
NCDCM	North Carolina Division of Coastal Management
NCDFR	North Carolina Division of Forest Resources
NCDMF	North Carolina Division of Marine Fisheries
NCDOT	North Carolina Department of Transportation
NCDPR	North Carolina Division of Parks and Recreation
NCDWQ	North Carolina Division of Water Quality
NCMNS	North Carolina Museum of Natural Sciences
NCNHP	North Carolina Natural Heritage Program
NCOBCF	North Carolina Onslow Bight Conservation Forum
NCPARC	North Carolina Partners in Amphibian and Reptile Conservation
NCPIF	North Carolina Partners in Flight
NCSCP	North Carolina Sandhills Conservation Partnership
NCSU	North Carolina State University
NCWF	North Carolina Wildlife Federation
NCWRC	North Carolina Wildlife Resources Commission (otherwise called Commission)
NERR	National Estuarine Research Reserve
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service (in NOAA); currently abbreviated as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service, formerly abbreviated as NMFS
NPDES	National Pollution Discharge Elimination System
NPS	National Parks Service
NRCS	Natural Resources Conservation Service
NRI	National Resources Inventory, conducted by NRCS
NWAC	Nongame Wildlife Advisory Committee
NWR	National Wildlife Refuge (USFWS)
OPR	Office of Protected Resources (in NOAA Fisheries)
ORW	Outstanding Resource Waters
PARC	Partners in Amphibian and Reptile Conservation
PIF	Partners in Flight
Plan	Wildlife Action Plan
PNA	Primary Nursery Area
PUV	Present use value
RC & D	Resource Conservation and Development Councils
RRCC	Robust Redhorse Conservation Committee

SA	One of three primary surface water classifications for coastal waters established by the EMC; shellfishing waters
SAE	Southern Appalachian Ecoregion
SAFMC	South Atlantic Fisheries Management Council
SAIN	Southern Appalachian Information Node
SAMBI	South Atlantic Migratory Bird Initiative
SAV	Submerged aquatic vegetation
SCDNR	South Carolina Department of Natural Resources
SCDPRT	South Carolina Department of Parks, Recreation, and Tourism
SCWF	South Carolina Wildlife Federation
SNHA	Significant Natural Heritage Area
SREL	Savannah River Ecology Laboratory
TIMO	Timber Investment Management Organization
TNC	The Nature Conservancy
TNDEC	Tennessee Department of Environment and Conservation
TRT	Take Reduction Team
TSI	Timber stand improvement
TVA	Tennessee Valley Authority
UNC	University of North Carolina
UNC-W	University of North Carolina at Wilmington
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Department of Agriculture, Forest Service
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
USMC	United States Marine Corps
UT-K	University of Tennessee at Knoxville
VAD	Voluntary Agricultural District
VOA	Voice of America
WAIT	Wildlife and Industry Together
WCU	Western Carolina University
WDCA	Wildlife Damage Control Agent

APPENDIX A.

IAFWA GUIDING PRINCIPLES

Guiding Principles for States to Consider in Developing Comprehensive Wildlife Conservation Plans/Wildlife Action Plans and Wildlife Conservation Strategies (Plans-Strategies) for the State Wildlife Grant and Wildlife Conservation and Restoration Programs

Final: September 27, 2002

The International Association of Fish and Wildlife Agencies recommends the following guiding principles for the States, the US Fish & Wildlife Service, and their conservation partners to consider and apply while developing Comprehensive Wildlife Conservation Plans to meet their obligations under the State Wildlife Grant (SWG) and the Wildlife Conservation Strategies under the Wildlife Conservation and Restoration (WCRP) programs.

These Guiding Principles identify goals, objectives, and actions to strive for over time. Few if any will be fully realized in any State under what is hopefully just the first round of conservation program development under SWG and WCRP. Some things must occur from the outset, because they are legally required and/or because they are essential to success. Clearly, broad-scale public participation is an example of one such area. Among the diverse stakeholders in this effort are: private, local, State, and Federal agencies and governments, NGOs, etc.

The Plan-Strategy provides an opportunity for the State wildlife agency to provide effective and visionary leadership in conservation. The Plan-Strategy can identify the measures that will be used, the results achieved, and the threats and needs that remain with regard to wildlife and wildlife habitat. It is also an opportunity to address broader issues and programs, including environmental and wildlife-related education, outdoor recreation, and wildlife-related law enforcement. These other areas can constrain, or enhance, wildlife conservation efforts, and funding and public support for wildlife conservation can be increased, or at least stretched, by involving partners that share those interests.

A. Planning Process and Partnerships

1. Involve multiple staff levels within each agency, and broad public-private partnerships, to develop and implement the Plan-Strategy.
2. Involve partners that have the authorities necessary to ensure that the Plan-Strategy addresses the full range of issues at hand.
3. Build capacity for cooperative engagement among all partners in the effort, and make sure that it is productive, so trust and confidence grow, and organizational and interpersonal relationships become strengths of the Plan-Strategy.
4. Share responsibility and credit for planning and implementation among all partners, who collectively share responsibility for success of the Plan-Strategy.
5. Focus on efficiency and effectiveness, so the value added in planning and implementation is commensurate to the funds invested.
6. Ensure that the planning processes and the resultant Plans-Strategies are dynamic — so they can be improved and updated efficiently as new information is gained.
7. Communicate effectively with stakeholders, other partners, and the public, early and often.
8. The planning processes, and the decisions made during planning, should be obvious to those who read and use the Plan-Strategy, and repeatable — document the processes and the decisions so the next planning cycle can build on this one.

B. Focus and Scope

1. Base the Plan-Strategy in the principles of "best science," "best management practices," and "adaptive management," with measurable goals, objectives, strategies, approaches, and activities that are complete, realistic, feasible, logical, and achievable. Describe these processes and practices sufficiently that partners understand what they entail and how they should function.
2. Address the broad range of wildlife and associated habitats, with appropriate priority placed on those species of greatest conservation need and taking into account the relative level of funding available for conservation of those species.
3. Integrate and address wildlife-related issues statewide, across jurisdictions and interests, and coordinate with parallel efforts in other States and countries.
4. Combine landscape/ecosystem/habitat-based approaches and smaller-scale approaches (e.g., focal, keystone, and/or indicator species; guilds; species of special concern) for planning and implementation.
5. Make the Plan-Strategy an effective, long-lasting blueprint for conservation that provides a broad vision and priorities, so a broad array of organizations, including other government agencies and NGOs, can help realize the vision. The Plan-Strategy should have sufficient flexibility to respond to the full spectrum of conditions and circumstances likely to be encountered within the planning area.

C. Format and Content

1. Make the Plan-Strategy readable, understandable, and useful, with well-defined issues, short and long-term goals and objectives, strategies, and realistic measures of performance that enable State agencies and their partners to demonstrate accountability.
2. Make full and effective use of relevant existing information; in particular, integrate appropriate elements of other plans and initiatives (such as Partners-in-Flight and the many regional and other plans), databases, GIS layers, records, reports, other information sources, and management information systems that overlap or complement these Plans-Strategies.
3. Identify knowledge gaps, as well as areas of knowledge, to help focus future efforts to improve understanding and planning, but do not allow a lack of information to inappropriately limit necessary short-term application of the best available science and good judgment in decision-making.
4. Make the Plan-Strategy spatially explicit, to the extent feasible and appropriate, with a full complement of GIS and other maps, figures, and other graphics, as well as appropriate text to provide sufficient detail and consistency in describing species and habitat conditions, conservation needs, conservation recommendations, and other issues/actions, so it can be used effectively by all partners.
5. Use "threats analyses," "risk and stressor assessments," and other techniques to help set priorities for goals, objectives, strategies, and activities.
6. In addition to wildlife, address factors that can have substantial impact on wildlife conservation, such as management of invasive species, wildlife-related and conservation-related education, law enforcement, and outdoor recreation.
7. Include a comprehensive glossary, so partners and the public have a shared and common understanding of key terms used in the Plan-Strategy.
8. Develop an updatable information system to monitor Plan-Strategy implementation and the status and trends of wildlife and habitat.
9. Consider wildlife conservation-related education and wildlife-associated recreation as tools that can help accomplishing conservation goals.

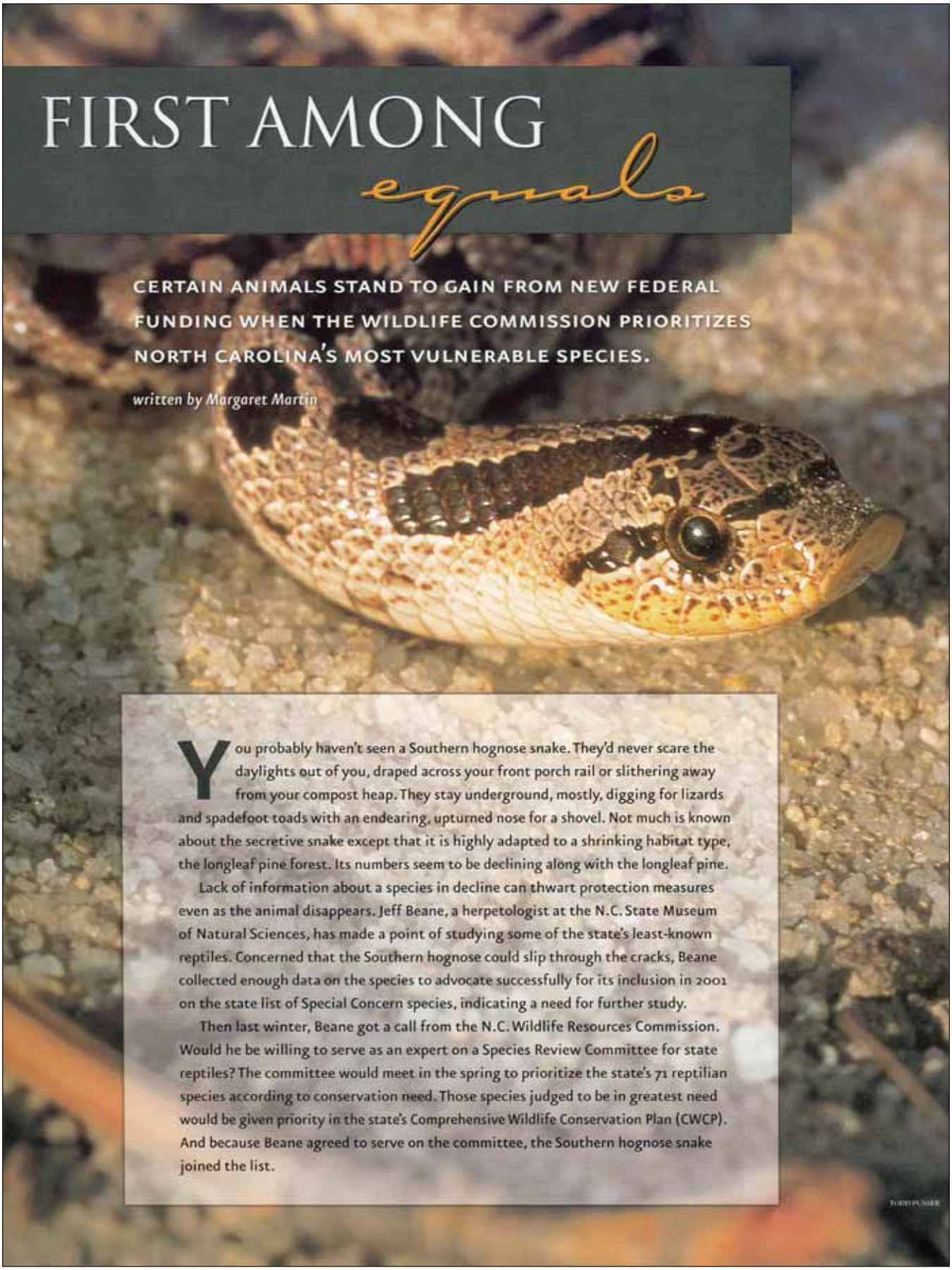
D. Completion, Outcomes, and Availability

1. Provide annual written progress updates on the planning effort and progress to IAFWA's CARA Implementation Committee each September, in addition to annual performance reports that must be submitted to the US Fish & Wildlife Service pursuant to Federal Aid guidelines.
2. Ensure that the Plan-Strategy clearly and definitively meets State obligations to Congress under the WCRP and SWG legislation, and to the US Fish & Wildlife Service with regard to Federal Aid administration.
3. Provide sufficient documentation in or with the Plan-Strategy to facilitate public understanding of the decisions that are made, how and why they were made.
4. Make the Plan-Strategy a driving force in guiding activities under diverse wildlife and habitat conservation initiatives, and usable for helping to inform land-use decision-making.
5. Make the Plan-Strategy readily available to the public in variety of media
6. Provide a mechanism for reporting accomplishments and tracking progress so local partners are aware of both.
7. Ensure that the Plan-Strategy can be implemented, i.e. that it is administratively and politically feasible, and that there are sufficient resources (funding and staff) among the partners to accomplish significant gains at a large scale, and within an appropriate time frame, to preserve our Nation's wildlife heritage.

APPENDIX B.
MEDIA EXAMPLES

The following documents are examples of some of the media coverage generated about the Wildlife Action Plan and the State Wildlife Grants Program in North Carolina.

- **FIRST AMONG equals** – Article in *Wildlife in North Carolina* magazine, February 2004.
- **Federal Grants Directly Benefit North Carolina's Wildlife** – Commission press release that generated more than 12 articles in the news media across North Carolina, May 2004.
- **N.C. Develops Wildlife Plan** – Write-up in North Carolina Sea Grant *Coastwatch* magazine, High Season (July) 2004.
- **More Federal Dollars Wanted For Wildlife Diversity** – 'Back porch' note in *Wildlife in North Carolina* magazine, August 2004.



FIRST AMONG *equals*

CERTAIN ANIMALS STAND TO GAIN FROM NEW FEDERAL FUNDING WHEN THE WILDLIFE COMMISSION PRIORITIZES NORTH CAROLINA'S MOST VULNERABLE SPECIES.

written by Margaret Martin

You probably haven't seen a Southern hognose snake. They'd never scare the daylights out of you, draped across your front porch rail or slithering away from your compost heap. They stay underground, mostly, digging for lizards and spadefoot toads with an endearing, upturned nose for a shovel. Not much is known about the secretive snake except that it is highly adapted to a shrinking habitat type, the longleaf pine forest. Its numbers seem to be declining along with the longleaf pine.

Lack of information about a species in decline can thwart protection measures even as the animal disappears. Jeff Beane, a herpetologist at the N.C. State Museum of Natural Sciences, has made a point of studying some of the state's least-known reptiles. Concerned that the Southern hognose could slip through the cracks, Beane collected enough data on the species to advocate successfully for its inclusion in 2001 on the state list of Special Concern species, indicating a need for further study.

Then last winter, Beane got a call from the N.C. Wildlife Resources Commission. Would he be willing to serve as an expert on a Species Review Committee for state reptiles? The committee would meet in the spring to prioritize the state's 71 reptilian species according to conservation need. Those species judged to be in greatest need would be given priority in the state's Comprehensive Wildlife Conservation Plan (CWCP). And because Beane agreed to serve on the committee, the Southern hognose snake joined the list.

What possible difference could CWCP status make to a Southern hognose snake pursuing toads along a sand ridge? Maybe all the difference, said Salinda Daley, the nongame biologist in charge of crafting the plan. The federal government wants to provide a safety net of sorts for the snake and more than 300 other species that received priority status because of documented population declines, degradation of known habitat or lack of data about their condition. When completed, the plan will outline habitat restoration and protection measures to preserve entire communities that support the priority species.

To reach that point, though, Daley has had to grapple with vague guidelines, a stable of stakeholders, multiple databases and a dense stew of field data and biologists' best judgments. The final document will guide funding, and therefore affect policy, for conservation strategies that could make or break the survival of some species into the next century.

Federal funds for nongame research are parceled out annually to the states through State Wildlife Grants. The legislation that created this funding source is widely regarded as a watered-down version of the Conservation and Reinvestment Act (CARA), a bill that passed the U.S. House of Representatives in 2001 but stalled in the Senate. CARA would have had a funding base similar to that of federal sport fish and game funds—that is, a percentage of revenues derived from a steady source. The current level of funding may not be as much money as conservationists had hoped for—North Carolina has received about $3 million since the program began in 2002—but it has already supported beneficial research.

"This [funding] is something we've needed for a long, long time," said Fred Harris, chief of the commission's Division of Inland Fisheries, who believes the traditional federal funding sources fed a value system that placed game above nongame concerns. "Now we can look at communities of wildlife and the interdependence of species, game and nongame alike."

Unlike game specialists, nongame biologists have hundreds of species to deal with. In the past, the factor that determined which species received study was often the need of the funding source. For example, agencies such as the Army Corps of Engineers or the Department of Transportation would fund a survey of at-risk species that happened to be in the path of a project. The CWCP should help nongame research respond more to needs that arise from the natural world. Although the scope of the plan is limited to vertebrates and a few macroinvertebrates—crayfish, snails and mussels—planners reason that the end result will benefit whole communities of organisms.

The filtering process built into the CWCP is designed to encourage the sometimes fractured conservation community to invest in a single plan that could achieve habitat restoration in key areas while there's still time. In October, Daley gathered together staff from six groups that produce environmental data relevant to the plan. Harris encouraged the assembled conservationists to find ways to forge their multiple visions into a single plan with statewide legitimacy. "I'm convinced that this is the direction we need to go in," he said. "We will have the information to predictably influence [natural] communities. That's the level we need to be working at, and that's more than one agency can accomplish. This [planning process] is good in that we're forced into partnerships with our diverse interests. We must make a sensible, comprehensive plan—a plan that will influence what wildlife communities will look like for decades."

There are many more groups within the state that will add to the plan before it is submitted to the feds in 2005. Daley is also laboring with neighboring states on conservation strategies that straddle political boundaries.

For the Southern hognose snake, a concerted effort and federal money could one day change its landscape of fast-disappearing pine thickets into sustainable swaths of longleaf pine forests. Healthy populations of Southern hognose, Pine Barrens treefrogs, red-cockaded woodpeckers and Eastern tiger salamanders would thrive in a natural community that was in trouble in 2004. That's the plan. ☒

***Species of concern to state conservationists** are the starting point of the Comprehensive Wildlife Conservation Plan, which will qualify the state for federal funds for species research and habitat restoration in North Carolina. The plan will be reviewed periodically after its completion in 2005.*

LINKING SPECIES RESEARCH TO HABITAT CONSERVATION

1 NORTHERN FLYING SQUIRREL

Only nine populations of the Carolina northern flying squirrel are known to inhabit the high-elevation forests of the southern Appalachians.

2 PEREGRINE FALCON

Habitat protection is key to the recovery of peregrine falcons, which nest in cliff-sides and rocky outcroppings.

3 BOG TURTLE

Fragile mountain bogs in western North Carolina are home to the bog turtle, one of the smallest turtles in the world.

4 ROBUST REDHORSE

A handful of very rare robust redhorses in the Pee Dee River system are receiving scrutiny from Wayne Starnes and other fish biologists.

The state's conservation plan should ultimately benefit habitats that support priority species. State Wildlife Grants will encourage conservation of habitats where clusters of priority species occur. Red indicates urban areas; color variations represent 68 habitat types. Numbered sites indicate current research on priority species.

12 ◆ February 2004 WINC

5 GREENSBORO BURROWING CRAYFISH

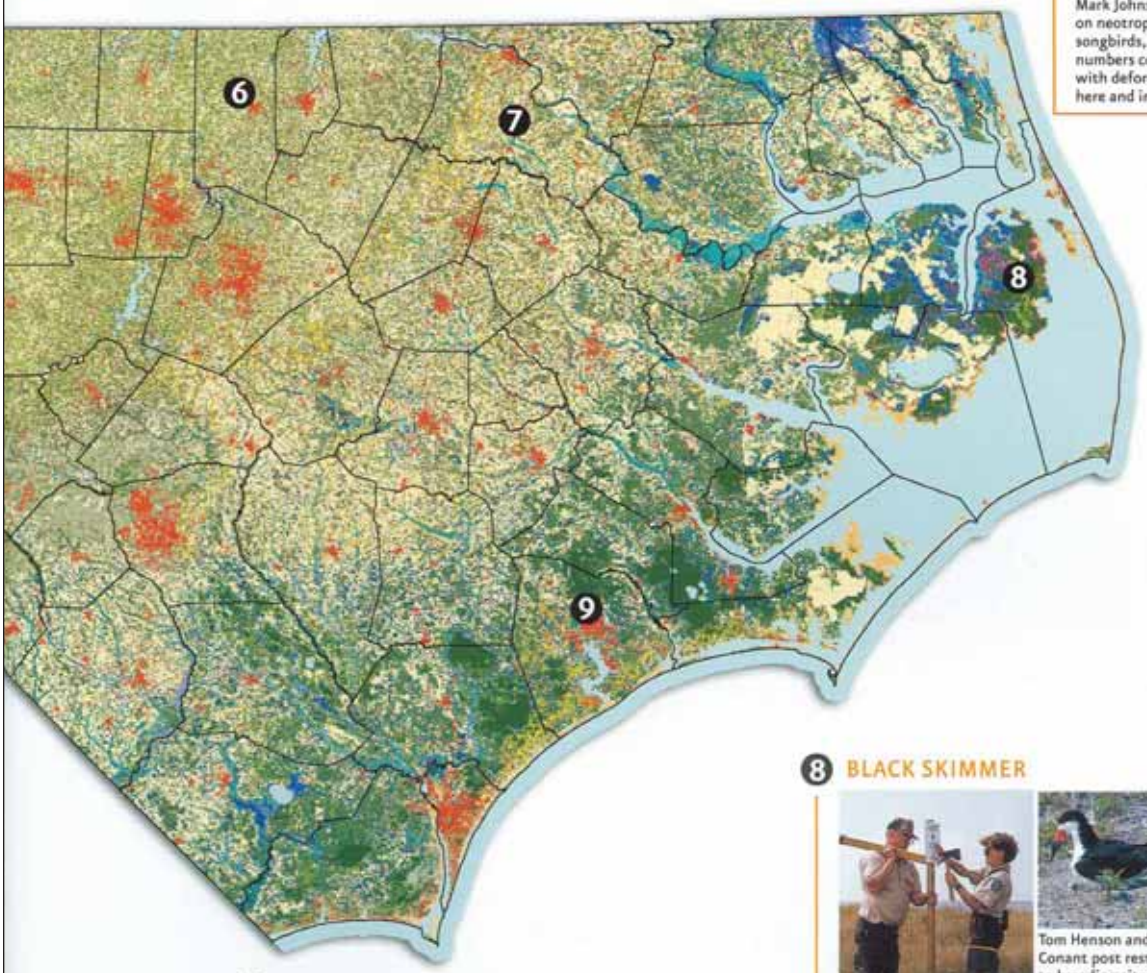
Surveys by Chris McGrath and other zoologists are expanding the known range of the Greensboro burrowing crayfish.

6 ATLANTIC PIGTOE

Biologists have much to learn about most of the state's freshwater mussel species, including this Atlantic pigtoe from the Tar River.

7 CERULEAN WARBLER

Mark Johns keeps an eye on neotropical migratory songbirds, whose declining numbers correlate directly with deforestation both here and in the tropics.



8 BLACK SKIMMER

Tom Henson and Therese Conant post restricted access to breeding sites, in response to a decrease in the survival of young black skimmers and other colonial waterbirds.

9 GOPHER FROG

The Carolina gopher frog breeds in temporary ponds of the longleaf pine forest. Alvin Braswell links a 15-year slide in the state's populations to habitat degradation.

FILE PHOTOS: N.C. WILDLIFE RESOURCES COMMISSION AND N.C. MUSEUM OF NATURAL SCIENCES; PEREGRINE FALCON: KEN WILSON; CERULEAN WARBLER: ARTHUR MORRIS - BIRDS AS ART
GRAPHIC BY VICTORIA CUMBEE

Source: N.C. Gap Analysis Project, NCSU

February 2004 WINC ◆ 13

Press Releases/What's New

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

Federal Grants Directly Benefit North Carolina's Wildlife

RALEIGH, N.C. (May 20) – Salamanders, songbirds, mussels, turtles and other wildlife in North Carolina are getting strong support from the state's congressional delegation in the budget for the 2005 fiscal year.

Commission biologists seine for tangerine darters in the upper Pigeon River.

Led by Rep. Robin Hayes (R), four N.C. representatives—Hayes, Cass Ballenger (R), Bob Etheridge (D) and David Price (D)—signed a letter sent to the Interior Appropriations Committee urging a $100 million budget for the State Wildlife Grants (SWG) program that supports the work of state wildlife agencies, such as the N.C. Wildlife Resources Commission.

"As a longtime environmental advocate, I have fought for legislation that protects public lands and endangered species and keeps our air and water clean," said Price. "These [wildlife grant] programs are particularly important for the environmental preservation efforts in rapidly developing communities across our state."

Black skimmer on nest

Media: Hi-res versions of these images may be downloaded here. **Please credit the NC Wildlife Resources Commission.**

Sen. John Edwards (D) signed a similar letter for the senate's budget leadership.

The SWG program provides funds to states for the research, management and conservation of wildlife "with the greatest conservation need, but not covered under other grant programs," according to the U.S. Fish and Wildlife Service, which administers the SWG program.

All states receive funds for sport fish and game management through the service's Sport Fish Restoration program and Wildlife Restoration program. Funds for these programs are derived from taxes on hunting and fishing equipment sales. For fiscal year 2003-2004 North Carolina received $7.3 million dollars from these programs.

The service also provides funds for endangered-species research and management. Most of North Carolina's fish and wildlife, however, fall outside the definitions of either a sport or endangered species. The SWG program, subject to annual appropriations, supports the conservation of these animals.

"SWG enables the faunal diversity and aquatic nongame program to set its own priorities," said Tom Henson, the Commission's faunal diversity coordinator. "In the past, we had to spend most federal money for work on endangered species. That meant we didn't have the opportunity to survey and research more common species, like basking turtles."

Congress first authorized the SWG program in fiscal year 2001. Since then, North Carolina's allocation has ranged from $1.2 to $1.5 million per year. Ongoing SWG projects include a crayfish inventory, reptile surveys, black skimmer and common tern nesting research, native fish reintroduction and the preparation of a conservation plan for North Carolina. The Comprehensive Wildlife Conservation Plan is a detailed document that will prioritize species' needs and guide SWG spending in years to come.

See more information on the conservation plan here.

The SWG program has boosted the research, survey and management of North Carolina's nongame species. Previously, the Commission relied on its Nongame and Endangered Wildlife Fund—voluntary contributions from North Carolinians through a line item on state tax returns, wildlife resources license plates and donations—as the backbone for this work. Now the fund provides the federally required matching dollars for SWG grant projects, essentially stretching each dollar from the fund into four dollars for planning projects and two dollars for implementation projects.

The Commission's Faunal Diversity and Aquatic Nongame Program, established in 1983, works to coordinate species and habitat-protection efforts for wildlife that are not hunted, fished or trapped. The program strives to prevent more than 1,000 native nongame mammals, reptiles, birds, amphibians, mollusks and crustaceans from becoming endangered and to recover those already endangered.

The Nongame and Endangered Wildlife Fund is the primary source of state funds for the program and provides nearly all the state matching dollars for SWG grants. Since 1984, taxpayers have given $6,933,382 dollars for wildlife conservation through voluntary contributions via state tax returns, wildlife resources license plates and donations.

See more information on the Commission's Nongame and Endangered Wildlife Program.

Return to News/Press Releases

N.C. Develops Wildlife Plan

What is being done about the robust redhorse or mole salamander — two North Carolina species of special concern?

The State Wildlife Grants (SWG) program, created by Congress in 2001 as a branch of the Conservation Trust Fund, provides federal funding to each state and territory to support cost-effective conservation with the goal of preventing wildlife from endangerment.

The grants call for statewide Comprehensive Wildlife Conservation Plans — due by October 2005.

North Carolina holds a $1.7 million share of funding — out of $80 million proposed for the 2005 budget — to be utilized by the N.C. Wildlife Resources Commission (WRC). Efforts must focus on the "species in greatest need of conservation." Generally these are nongame species not supported by recreational fees and taxes.

Species review committees guided by WRC and composed of North Carolina wildlife experts helped to compile a list of more than 300 species.

The comprehensive wildlife plan is slated for completion by July 2005. Stakeholders will review the plan and provide input.

Funds from SWG have supported a variety of projects in North Carolina, including research on beach nesting birds. To find out more about the wildlife plan, visit WRC's Web site at *www.wildlife.state.nc.us*. Click on the link to Wildlife Species and Conservation and navigate to the N.C. Comprehensive Wildlife Conservation Plan page.

— L.L.

back porch

NEWS and NOTES

Edited by Greg Jenkins

More Federal Dollars Wanted for Wildlife Diversity

Salamanders, songbirds, mussels, turtles and other wildlife in North Carolina are getting strong support from the state's congressional delegation this year. Four North Carolina representatives signed a letter urging a $100 million appropriation for the State Wildlife Grants (SWG) program, which supports the work of agencies such as the N.C. Wildlife Resources Commission (see "First Among Equals," February 2004).

State Wildlife Grants from the federal government fund research on nongame creatures such as the black skimmer.

The grant program funds the research, management and conservation of wildlife "with the greatest conservation need, but not covered under other grant programs," according to the U.S. Fish and Wildlife Service, which administers the SWG program.

All states receive funds for sport fish and game management through the service's Sport Fish Restoration program and Wildlife Restoration program. Funds for these programs are derived from taxes on hunting and fishing equipment sales. In fiscal year 2004, North Carolina received a total of $7.3 million from both programs.

The service also provides funds for endangered species research and management. But most of North Carolina's fish and wildlife are not sport or endangered species. The SWG program supports the conservation of these animals. The grants benefit the commission's Faunal Diversity and Aquatic Nongame Program, which works to prevent more than 1,000 native nongame animals from becoming endangered and to help those already endangered.

"State Wildlife Grants enable the faunal diversity and aquatic nongame program to set its own priorities," said Tom Henson, the Wildlife Commission's faunal diversity coordinator. "In the past, we had to spend most federal money for work on endangered species. That meant we didn't have the opportunity to survey and research more common species, like basking turtles."

Congress authorized the program in 2001. Since then, North Carolina has received $1.2 to $1.5 million per year. Ongoing projects include a crayfish inventory, reptile surveys, black skimmer and common tern nesting research, native fish reintroduction and the preparation of a conservation plan for North Carolina. A Comprehensive Wildlife Conservation Plan will prioritize nongame species' needs and guide spending of State Wildlife Grants in years to come.

AT HOME WITH WILDLIFE

The Pool Is Open

I heard a fellow once say that it was so hot, his outdoor thermometer climbed down the pole and crawled under the porch.

The dog days of summer create one big sauna here in North Carolina. If you aren't headed to the pool for some cool relief, then you are probably headed for the beach. Wildlife is no different, taking every opportunity to cool off in a bird bath or water hole. Birds use these backyard water attractions for drinking as well as bathing, which keeps parasites down.

But before running out and plunking down cash for a bird bath, you may already have one. A bird bath can be something as simple as a clay tray in which a potted plant once sat, or that oval piece of plastic your kids used to sled down snow-covered hills last winter. You can even take a large log, chisel out a 3-inch-deep depression, and fill it with water for a rustic bird bath.

Regardless of what you find, make sure it has a rough surface so birds can light on the rim without slipping off. Automatic misters or drippers provide a moving-water element birds can't resist. A homemade alternative is a plastic 2-liter bottle hung over a bath. Simply punch a pinhole and fill with water.

To attract more birds, place the bird bath in an open area. With little or no expense, you can have a water device to keep your backyard bird population quenched and drenched.

—Chris Powell

APPENDIX C.

EXECUTIVE SUMMARY OF STAKEHOLDER INPUT MEETING

Executive Summary of the

NC Wildlife Action Plan

Stakeholder Input Meeting

2 March 2004

Sponsored by the NC Wildlife Resources Commission

Compiled by:
Salinda Daley
Wildlife Action Plan Coordinator
NC Wildlife Resources Commission

Participant Input for the Wildlife Action Plan

The NC Wildlife Resources Commission (Commission) held a meeting on March 2, 2004 to educate stakeholders about the State Wildlife Grants Program and the Wildlife Action Plan (Plan), gain a better understanding of the conservation concerns of stakeholders, and learn how stakeholder groups would like to be involved in the Plan development and implementation process. Watershed Education for Communities and Local Officials (WECO), a Cooperative Extension program at NCSU, was asked to help facilitate stakeholder involvement. Fifty-two stakeholders attended, as well as 17 Commission staff, and 4 WECO facilitators (73 people in total). The meeting began with a Commission presentation to give participants background information about the State Wildlife Grants Program, the Plan requirement, and progress to-date towards developing North Carolina's Plan. An open discussion period followed as time allowed before lunch. After lunch, participants were split into four groups. Each group answered the same 3 questions. The questions were:

1. How should the Commission coordinate with stakeholders and involve the public in developing, implementing, and revising the Wildlife Action Plan?
2. What do you see as the most significant fish and wildlife conservation issues in North Carolina?
3. How do you propose that these issues be addressed?

The data from these four groups was compiled by the WECO facilitators and written up in a 17 page report. The results of the report are summarized below.

Contents:

Questions 1: How should the Commission coordinate with stakeholders and involve the public in developing, implementing, and revising the Wildlife Action Plan? *Major themes of discussion are listed below.*

During the development of the Wildlife Action Plan:

- Develop a mechanism to build and facilitate stakeholder participation (website, emails, newsletters, etc.)
- Make use of existing plans and information that stakeholder groups can provide
- Develop an internal prioritization mechanism for funding
- Develop a system for measuring progress and success towards goals
- Solicit structured input – need guidelines & clear objectives
- Acknowledge all the issues, what the Commission can do, what is beyond Commission jurisdiction, and who should be involved in the solution

During implementation & revision of the Wildlife Action Plan:

- Work directly with landowners—they are key to future fish and wildlife conservation
- Involve local planning commissions, local governments
- Engage the urban public to increase the visibility of projects
- Coordinate with the Department of Transportation
- Stress the economic and recreational benefit of wildlife
- Develop a public education campaign – get the public involved in hands-on work
- Use stakeholder groups to engage constituents
- Develop a Public Relations plan – tailor and market your message to different groups
- Track the implementation process in a medium that engages the public (video, PSA, public television)
- Identify and diversify sources for match funding; initiate discussions with others outside the agency about match opportunities
- Put out requests for proposals/grant applications; develop a mechanism to prioritize and administer funds externally

How will the Commission use this input?

Feedback related to ways that the Commission can engage and involve stakeholders during the development of the Wildlife Action Plan helped to confirm plans that we were already considering, or that we intend to pursue in the near future.

- The newly created Wildlife Action Plan web site will serve as the main source of information exchange between the Commission and stakeholders. Within the "Comments" section of the web site, we have listed existing conservation plans/resources that we will reference within the final document, and we invite visitors to add to the list.
- The development of systems to prioritize project funding and to measure progress and success towards conservation goals are critical components of the Plan development process. Division of Inland Fisheries and Division of Wildlife Management staff have initiated discussions on both topics and are working to develop such systems.
- Commission staff involved in the development of Plan text will continue to engage their professional contacts to solicit feedback and information. Widespread input on sections of the Plan will be sought via the website, in a structured format that will make feedback and comments easy to track and manage.

Participant suggestions related to ways of engaging stakeholders in the long-term are, to a large degree, goals that we must strive for over time and as opportunities arise. These are issues that are important not only to the Wildlife Action Plan and the State Wildlife Grants Program, but to the overall mission of the Commission, and to other natural resource agencies and organizations.

- The Commission is continually striving to improve opportunities to engage segments of the greater public, especially private landowners and the urban public. A key responsibility of our Piedmont Faunal Diversity Biologist is to pursue ways of engaging the urban public and involving them in projects. These sorts of opportunities will be highlighted within the Plan.
- The Commission, especially the Division of Inland Fisheries, already coordinates heavily with the DOT. With the newly created Ecosystem Enhancement Program, coordination for mitigation planning will increase.
- The entire Division of Conservation Education is dedicated to improving education and outreach opportunities for the public in North Carolina. The suggestions and feedback collected at the meeting related to public education will be used to help direct future planning activities as they relate to on-the-ground projects and educational needs and opportunities.
- Match opportunities are increasingly critical to pursue as other funding sources, such as the nongame tax check-off, continue to decline. The Commission welcomes discussions about match opportunities and overlapping project interests with any individuals who wish to pursue these discussions. We plan to continue to engage stakeholder groups through email, the website, newsletters, and to identify cooperative opportunities wherever we can.

Question 2: What do you see as the most significant fish and wildlife conservation issues in North Carolina? *Individual responses were grouped into categories and then tallied (in parentheses) to give an indication of the issues that were seen as most significant by participants.*

- **Habitat loss issues (54)**
  - Fragmentation (13)
  - (Mis)management (6)
  - Fire suppression (4)
  - Decline/reduction in quality (23)
  - Roads (8)
- P**ublic knowledge or perception of wildlife/need for education (22)**
- **Water quality/pollution (21)**
  - Water quality (12)
  - Sedimentation (5)
  - Contaminants (4)
- **Development and urbanization (20)**
- **Loss of biodiversity/species declines (11)**
- **Invasive and exotic species (10)**
- **Water resource issues (10**)
  - Dams (4)
  - Other migration barriers (2)
  - Water management/ground water depletion (4)
- **Policy/politics (10)**
- **Human population growth (7)**
- **Lack of data/knowledge gaps (7)**
- **Agriculture and forestry practices (6)**
- **Conflict between economic growth and conservation (5)**
- **Current fisheries regulations (3)**
- L**ack of funding (3)**

How will the Commission use this input?

Participant feedback related to Question 2 was a solid validation of the issues that we plan to address within the text (Threats, Statewide Conservation Strategies, and/or within individual ecoregional sections; see Outline section of the web site), and a reassurance that the concerns of our agency staff are in sync with you, our conservation partners. In some cases, participant feedback has given us a new perspective from which to look at or address certain issues (e.g., the conflict between economics and conservation). Many of these issues are, of course, also well-documented within existing conservation planning documents. The Wildlife Action Plan will be strengthened by the documentation of widespread concern for such issues among conservation stakeholders in North Carolina.

Question 3: How do you propose that these issues be addressed? *Solutions proposed by participants are linked to the issues they relate to in the table below.*

Issue	Proposed Solutions
Habitat issues	• Monitor loss of amphibian breeding habitat; • Restore early successional habitat; • Protect existing habitat; • Maintain & connect large blocks of habitat; • Pursue land acquisition/easements; • Restore riparian buffers and wetlands; • Initiate incentives for private landowners; • Promote fire management
Public knowledge or perception of wildlife/need for education	• Initiate urban/backyard wildlife monitoring programs; • Pursue private landowner cooperation and buy-in; • Create opportunities for people to participate in conservation projects; • Make unknown or cryptic groups more visible to the public (e.g., snails); • Promote fire management; • Engage county commissioners
Water quality/pollution	• Wetlands and riparian buffer protection; • Educate people about "downstream" effects; • Establish cost/benefits of water quality problems; • Establish incentives for riparian buffers; • Designate stream water quality parameters & monitor over the long-term
Development and urbanization	• Promote green development; • Mitigate sprawl; • Mandate incorporation of low impact development, urban revitalization, limits to sprawl
Loss of biodiversity/species declines	• Initiate/continue species specific inventories, monitoring, research; • Identify & protect critical habitats
Invasive/exotic species	• Fund position to deal exclusively with exotics and invasive species; • Pursue rigorous control of exotics and invasive species
Water resource issues	• Restore natural stream flow; • Flow management
Policy/politics	• Improve inter-agency cooperation; • Work to reduce stakeholder conflicts; • Mandate incorporation of low impact development, urban revitalization, limits to sprawl; • More stringent land use & watershed planning/regulations; • Encourage DOT to plan for infrastructure and wildlife; • Pursue policy to improve tax benefits & incentives for habitat protection; • Influence transportation policies of DOT
Human population growth	• (No specific solutions proposed)
Lack of data about species/habitats	• Identify data/knowledge gaps and work to fill them; • Develop and manage a centralized database
Agriculture and forestry practices	• Pursue policy to improve tax benefits & incentives for habitat protection; • Pursue private landowner cooperation and buy-in;
Economics	• Emphasize the economic importance of wildlife
Fisheries regulations	• Economic impact of recreational fishing versus commercial fishing is 10:1- use this to justify habitat protection
Lack of funding	• Make politicians aware of problems and conservation funding gap

How will the Commission use this input?

The Commission has direct involvement in most of the proposed solutions above. The agency is responsible for conducting species inventories and monitoring, managing and protecting habitat, identifying critical knowledge gaps and data needs, as well as public education and outreach, and landowner programming. Many of these activities are carried out in concert with partnering agencies and organizations with whom we share data, combine resources, and manage land. So, as with Question 1, suggestions about ways of addressing critical conservation issues in the state are goals that we all must strive for over time and as opportunities arise.

Some proposed solutions (e.g., improved water quality monitoring, more stringent land use regulations, changes to fisheries regulations) are beyond the purview of the Commission. We rely on groups such as the Division of Water Quality, local planning commissions, and the Division of Marine Fisheries to address such issues. This emphasizes the importance of cooperation and coordination among agencies to affect statewide conservation solutions, a point that will be highlighted repeatedly within the Wildlife Action Plan.

The Commission recognizes the growing need to engage and educate the general public, private landowners across the state, and to the majority of the population residing in urban centers. We plan to highlight specific ways of engage these groups within the Plan, and to pursue opportunities suggested by participants wherever possible.

Participant List

Name	Agency/Organization
Alexa McKerrow	NC GAP
Alvin Braswell	NC Museum of Natural Sciences
Angie Rodgers	NCWRC
Ann Berry Somers	UNC-Greensboro
Anne Deaton	NC Division of Marine Fisheries
Bethany Olmstead	Piedmont Land Conservancy
Bill Mandulak	Coastal Conservation Association
Bob Davis	NC Herpetological Society
Brad Gunn	NCWRC
Carl Dixon	National Wild Turkey Federation
Chris Elkins	Coastal Conservation Association
Chris McGrath	NCWRC
Chris Moorman	NC State University
Christy Perrin	Watershed Education for Communities and Local Officials
Chuck Peoples	Tar River Land Conservancy
Connie Tysinger	NC Bowhunters Association
Curtis Smalling	Audubon NC
Dave Davenport	NC Museum of Natural Sciences
David Cobb	NCWRC
David McNaught	Environmental Defense
Dennis Herman	Project Bog Turtle
Dick Lancia	NC State University
Emily Ander	Triangle Land Conservancy
Fred Harris	NCWRC
Grady McCallie	NC Conservation Network
Greg Cope	NC State University
Greg Messinger	Piedmont Land Conservancy

Participant List *(continued)*

Name	Agency/Organization
Henry Hammond	Nongame Wildlife Advisory Committee
Holly Allen	NCWRC
Jack Thigpen	NC SeaGrant
Jeff Beane	NC Museum of Natural Sciences
Jeff Esely	Mecklenburg County Division of Natural Resources
Jeff Marcus	NCWRC
Jeff Masten	Triangle Land Conservancy
Jennifer Braswell	UNC-Greensboro (grad student)
Jodie Best	NCWRC
Joe McDonald	NC Wildlife Federation
John Alderman	Independent contractor
John Connors	Wake Audubon
John Hagan	NC Wildlife Habitat Foundation
JohnAnn Shearer	US Fish & Wildlife Service
Josh Rose	Ellerbe Creek Watershed Association
Kat Oury	Watershed Education for Communities and Local Officials
Kate Pipkin	NCWRC
Kelli Johnson	SciWorks Science Center
Ken Bridle	Nongame Wildlife Advisory Committee
Leland Heath	Clean Water Management Trust Fund
Margit Bucher	The Nature Conservancy
Mark Johns	NCWRC
MaryKay Clark	NC Museum of Natural Sciences
Matina Kalcounis-Rueppell	UNC-Greensboro
Megan Wargo	Piedmont Land Conservancy
Michael Holmes	Watershed Education for Communities and Local Officials
Nolan Banish	NCWRC
Patrick Beggs	Watershed Education for Communities and Local Officials
Richard Rodgers	DENR
Rick Yates	Progress Energy
Rusty Painter	Conservation Trust of NC
Salinda Daley	NCWRC
Sarah Cross	NCWRC
Sarah Mabey	NCSU post doc with Ted Simons
Scott Anderson	NCWRC
Scott Van Horn	NCWRC
Shannon Deaton	NCWRC
Sudie Daves	Mecklenburg Co Division of Natural Resources
Tom Craven	Triangle Land Conservancy
Tom Duckwall	T.G. Pearson Audubon Society (Deep River Project)
Tom Henson	NCWRC
Tom Kwak	NC State University
Wade Teague	Quail Unlimited
Walker Golder	Audubon NC
Wayne Van Devender	Appalachian State University

APPENDIX D.
ADDITIONAL SPECIES EXPLANATIONS

The following groups were not included in the prioritization process described in Chapter 2 for reasons of jurisdictional limitations, a lack of information, and/or practicality within the time-frame for completion of the first iteration of the Wildlife Action Plan (hereafter Plan):

- Marine mammals & fish
- Pelagic birds
- Insects and arachnids
- Terrestrial gastropods

However, while severe limitations do exist in terms of data availability, overall knowledge, practicality of conservation actions, and/or jurisdictional or regulatory authority, we did not wish to simply ignore these species groups, all of which exist in, or off the coast of, North Carolina. The limitations associated with these groups point to the critical nature of partnerships and cooperative efforts among agencies and organizations to work towards improving our overall understanding of these groups.

Pelagic bird and marine species and habitat priorities were developed through review of existing publications and incorporated directly into the Plan in Chapter 5C (Marine Systems). The other groups could not be so easily organized in a common framework, as they are found across a myriad of habitats in the state. So below we have done our best, using resources currently available to us, to identify the following information for insects, arachnids, and terrestrial gastropods:

- Conservation priorities (species and/or habitats)
- Key agencies and organizations involved in the conservation of the group
- Conservation issues and needs
- Key references and additional information sources.

During future iterations of the Plan, this information should be better incorporated directly into the text where applicable.

Insects and Arachnids

Hall (1999a) presents a very good overview of general conservation issues involving insects and other invertebrates in his inventory of Lepidoptera of the Albemarle-Pamlico region of North Carolina. The following passage is from his work:

> "Conservation of insects and other invertebrates is a new, and, to some people, somewhat shocking concept. Nonetheless, preservation of native insects and other invertebrates is becoming an increasingly important concern for managers of state parks and other nature preserves. Ecosystem-oriented conservation—where the contribution of all species in maintaining ecological processes is considered—is coming to the forefront, replacing the previous focus on just a few conspicuous species, mostly vertebrates and plants. The public is also developing an appreciation for at least some groups of invertebrates. This is indicated, for example, in the growing number of butterfly counts conducted each year. There may be eventually as much demand for checklists of butterflies, dragonflies, tiger beetles, or other invertebrates as already exists for birds, other vertebrates, and wildflowers."

Insects and other arthropods are the most diverse group of any organisms, plant or animal. Over 1000 species of Lepidoptera—the best studied order of insects in North Carolina—have been recorded in the state (North Carolina Natural Heritage Program database) and at least another 1000 are expected to be eventually discovered. Equally as large, if not larger, numbers can be expected for several other insect orders. Beetles, in particular, are believed to outnumber all other taxonomic groups in terms of species.

The ecological significance of insects is great - insects play a key role in ecological processes such as primary consumption, decomposition and pollination. The majority of our plant species included on the state or federal endangered and threatened lists are dependent on insects for pollination. In some cases, specific species of insect pollinators may do most of the work and their loss, consequently, may contribute to the endangerment of the plant. *Lysimachia asperulifolia* may be one such example in North Carolina (Franklin 2001). The current low levels of seed set may indicate that a major, specialized pollinator has been lost. Insects are a primary food source for many vertebrate species groups. Game species that are largely or partly dependent on insects for food include turkey, bobwhite, ruffed grouse, and even black bear. Endangered species that rely primarily on insects include the red-cockaded woodpecker, Virginia big-eared bat, gray bat, and Indiana bat. Insects can also present considerable pest management challenges, especially introduced exotics such as the gypsy moth and Hemlock wooly adelgid. Conversely, the use of insects as biological controls may offer the best chance of combating these exotics.

However, our understanding of this group of species is far lower than almost any other animal group in the state. In recent years the North Carolina Natural Heritage Program (NC NHP) has undertaken a series of insect inventories in the coastal plain of North Carolina in order to bring understanding of the distribution, abundance, and habitat affinities for at least a few important groups of invertebrates up to the level already achieved for vascular plants and vertebrates. These surveys have uncovered not only species never before documented in North Carolina, but even species completely new to science (e.g., Apameini, New Genus 4, Species 1, Hall 1999b).

Status and Priority Species[1]

Insects and other non-crustacean arthropods are not protected by state law, nor are other groups of invertebrates except for mollusks. Yet several insects are themselves are among the most endangered of our species, primarily due to the loss of particular types of habitats. Federally-listed species in these taxa are protected under the provisions of the Endangered Species Act. In North Carolina, these include the following three insects and arachnids, all listed as Endangered Species:

- St. Francis satyr (*Neonympha mitchellii francisci*)
- American burying beetle (*Nicrophorus americanus*) (believed to be extirpated in North Carolina)
- Spruce-fir moss spider (*Microhexura montivaga*)

In addition to the American burying beetle, at least three other species are believed to have been extirpated from the state: regal fritillary (*Speyeria idalia*); grizzled skipper (*Pyrgus wyandot)*; and southern dusted skipper (*Atrytonopsis loammi*), all of which have been looked for repeatedly at sites where they were formerly known to occur. The same may also be true for the Cofaqui giant skipper (*Megathymus cofaqui*), which had previously been recorded only at a single site in North Carolina. Several other species are also known only from historic records but no real effort has been made to look for them

US Fish and Wildlife Service status surveys have been conducted on three species in collaboration with NC NHP. NC NHP recommended that the eastern Arogos skipper (*Atrytone arogos arogos*) be listed as Threatened (Hall et al.1999a), and that an undescribed species of dusted skipper (*Atrytonopsis* sp. 1) be listed as Endangered, once its taxonomic status has been resolved (Hall 2003). A status survey for the Venus flytrap moth (*Hemipachnobia subporphyrea*) is in progress, but preliminary results also indicate that this species will also be recommended for listing as Endangered (Hall and Sullivan 2000, Hall and Sullivan 2004).

Including the three species for which status surveys have been conducted, 23 species of insects and spiders occurring in North Carolina have been designated by the US Fish and Wildlife Service as Federal Species of Concern (which has no legal status). An additional 209 species of insects and spiders have been identified as Significantly Rare by the NC NHP (Table D1). This designation also carries no legal status but is used to drive conservation decisions in the state through both governmental and private initiatives.

[1]The majority of the information in this section pertains to terrestrial species.

Table D1. Rare insect and arachnid species tracked by the North Carolina Natural Heritage Program (LeGrand et al. 2004).

Group	# of Species Tracked	# of Tracked Species with Federal Protection Status
Arachnids[2]	11	1 Endangered (E); 1 Federal Species of Concern (FSC)
Mayflies[3]	16	1 FSC
Stoneflies[3]	7	0
Caddisflies[3]	14	0
Dragonflies and damselflies	37	8 FSC
Flies	1	0
Moths	70	4 FSC
Butterflies	38	1 E; 8 FSC
Grasshoppers and katydids	15	0
Beetles[3]	5	1 E (extirpated in NC); 1 Federal Species of Concern
True bugs	1	0

Including the federally listed or designated species, several species are known from only a single population in the state:

- Saint Francis' satyr (*Neonympha mitchellii francisci*) (endemic to North Carolina)
- Eastern Arogos skipper (*Atrytone arogos arogos*)
- Rare skipper (*Problema bulenta*)
- Undescribed dusted skipper (*Atrytonopsis* sp. 1) (endemic to North Carolina)

Several others are known to occur only in North Carolina and their loss here would mean total extinction of the species.

- Venus flytrap moth (*Hemipachnobia subporphyrea*)
- Carolina agrotis (*Agrotis carolina* [a newly described species formerly known as A. n. sp. nr. buchholzi])
- Sullivan's meropleon (*Meropleon diversicolor sullivani*)
- *Melanoplus decorus* (a flightless grasshopper)

Additional species that have their best known populations in North Carolina would also be strongly jeopardized if they were lost here:

- Edmund's snaketail dragonfly (*Ophiogomphus edumudo*)
- Fraser fir looper (*Macaria fraserata*)
- Appalachian crescent (*Phyciodes batesii maconensis*)
- Spruce-fir moss spider (*Microhexura montivaga*)

Still others are represented by only a handful of populations that are highly disjunct from the rest of their range. While loss of these populations might not jeopardize the entire species, they are of strong scientific interest and their loss would certainly diminish the state's natural heritage.

[2] The arachnid list is selective of cave and other montane species and is not intended to be a complete list of the rare arachnids in the state.

[3] Critically imperiled aquatic species in North Carolina (S1 or S1S2 species as ranked by NC NHP) in these groups are listed at the end of this section.

Examples include:

- *Stethophyma celatum* (a grasshopper)
- Duke's skipper (*Euphyes dukesi*)
- Bell's sandragon (*Progomphus bellei*)
- *Papaipema eryngii* (a moth)
- Berry's skipper (*Euphyes berryi*)
- Aaron's skipper (*Poanes aaroni aaroni*)
- *Spartiniphaga carterae* (a moth)
- Grisatra underwing moth (*Catocala grisatra*)
- Sundew moth (*Hemipachnobia monochromatea*)
- *Lemmeria digitalis* (a moth)

Finally, there are a large number of species that are still too poorly known to estimate their conservation significance, including several that have yet to be scientifically described. Examples (all moths) include:

- Apameini, New Genus 4, Species 1
- Apameini, New Genus 2, Species 3
- *Macrochilo* n. sp. 1 nr. *absorptalis*
- Apantesis n. sp. 1 nr. carlotta
- Noctuidae, New Genus nr. *Oligia*
- *Pangrapta* n. sp. 2
- *Cyclophora* n. sp.

Critically imperiled aquatic insects in North Carolina (S1 or S1S2 species as ranked by NC NHP, 2004) include species in the caddisfly, stonefly, mayfly, and beetle families[4]:

Mayflies

- *Baetisca becki* (a mayfly)
- *Baetisca obesa* (a mayfly)
- *Baetopus trishae* (a mayfly)
- Benfield's bearded small minnow mayfly (*Barbaetis benfieldi*)
- Cahaba sand-filtering mayfly (*Homoeoneuria cahabensis*)
- Spiculose serratellan mayfly (*Serratella spiculosa*)
- *Tortopus puella* (a mayfly)

Stoneflies

- Williams' rare winter stonefly (*Megaleuctra williamsae*)
- *Zapada chila* (a stonefly)

Caddisflies

- *Ceraclea cancellata* (a caddisfly)
- *Diplectrona metaqui* (a diplectronan caddisfly)
- Mount Mitchell caddisfly (*Manophylax altus*)
- *Rhyacophila vibox* (a rhyacophilan caddisfly)

Beetles

- Gammon's stenelmis riffle beetle (*Stenelmis gammoni*)

[4]Maps created and maintained by Eric Fleek, North Carolina Division of Water Quality (NC DWQ) identify distribution patterns of mayfly, stonfly, and caddisfly species based on NC DWQ sampling, though some are in need of update (David Lenat, pers. comm.).

Key Organizations

Only two state agencies are actively involved in conducting insect surveys and applying this information to conservation.

The **NC Division of Water Quality, Biological Assessment Unit** conducts aquatic invertebrate sampling as part of widespread monitoring of biological integrity in North Carolina waters. The Biological Assessment Unit uses stream insects (i.e., caddisflies, mayflies, stoneflies, beetles) for monitoring water quality; they conduct stream surveys across the state on a regular basis. The Unit does not attempt to determine the conservation concern for any of these species, nor does it seek protection for insects per se. Nonetheless, at least some stream reaches identified as High Quality Water or Outstanding Resource Waters through this process receive a significant amount of protection.

The **NC Natural Heritage Program** (NC NHP) is the only state agency involved in directly determining the conservation status of individual insect species and other invertebrates and using this information to help guide ecosystem conservation. NC NHP itself conducts surveys for a few selected groups including moths, butterflies, grasshoppers, and dragonflies (the results of several of these surveys are available as NC NHP reports). They also collaborate with the Biological Assessment Unit of the Division of Water Quality in making use of their survey data to identify rare species of aquatic insects. They work in partnership with USFWS to conduct status surveys on several species of rare insects (e.g., in addition to the ones listed above, NC NHP conducted surveys on the Saint Francis' Satyr that led to its being listed as Endangered). They use occurrence records for rare species of insects, along with similar records for other taxonomic groups, to assess ecosystem integrity and conservation priority of individual natural areas. NC NHP uses information provided by habitat-specialist insects, along with other animals, to assess landscape integrity at a regional level. Examples of this use can be found in the Conservation Assessment of the Southeast Coastal Plain of North Carolina (Hall and Schafale 1999) and in the Assessment of Terrestrial Habitat Quality and Landscape Integrity in the Albemarle-Pamlico Estuarine Study Area (Hall 2004; revision in progress). NC NHP staff have authored many other critical reports regarding insect conservation in North Carolina (Hall and Sullivan 2000, Hall 1999a, Hall 2003, Hall et al. 1999a, Hall et al. 1999b).

Hall's "Rules of Thumb"

While recognizing that insects and other invertebrates may never be studied as fully as other species groups by preserve managers, Hall (1999a) makes the point that some attention must be given towards their proper management if an ecosystem-based approach is the desired outcome. He presents five rules of thumb, generalizations that may be a first-step towards more comprehensive management of natural areas and ecological preserves in North Carolina. The following passages are taken directly from his work:

"The first of these rules follows a general principle of ecosystem conservation by Aldo Leopold (1953):

> *If the biota, in the course of aeons, 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.*

Rule of Thumb 1. Management actions that significantly alter some aspect of an ecosystem are likely to have major effects on insects and other invertebrates. The responses of these species to the management actions may be very different than those of plants or vertebrates, the usual intended beneficiaries of the action. In the worst case, a large number of the unknown but important "cogs and wheels" of the ecosystem may be lost as a result of the action.

Keeping this in mind, additional rules of thumb will be described below that can help reduce the likelihood of a dire outcome.

Role of state parks and nature preserves in the conservation of insects and invertebrates

Nature preserves, including most state parks, are usually established where high quality examples of native ecosystems exist, as indicated by vegetative communities or the presence of rare species of plants or vertebrates. Although few preserves have yet been created specifically with insects or other invertebrates in mind, areas of high quality native habitats usually contain significant faunas of invertebrates as well. There are, in fact, several reasons why invertebrates frequently turn out to be among the rarest species in a given preserve:

- Invertebrates often have highly specific habitat requirements, much more so than is typical for vertebrates. Many insects, for instance, feed only on a particular host plant. Habitat requirements for these species include those for its host plant as well as additional ones of their own.
- Invertebrate populations often undergo extreme fluctuations in numbers, resulting from vagaries in weather or cyclical changes in abundance of their predators or parasites. They are much more prone to local extirpation than either vertebrates or plants. As discussed below, they often survive only where there are enough well-dispersed habitat patches to support a metapopulation.
- Despite their vulnerability to local extirpation, some species can survive in long-lasting, relict populations, as long as natural ecosystem processes are continuous through time. For example, a population of the brown elfin (*Incisalia augustinus*) found on the summit of Occoneechee Mountain, a State Natural Area along the Eno River, may have existed there since the end of the Ice Age approximately 10,000 years ago, just as have several rare plants with similar montane or boreal distributions (no other populations of this species are known from fifty miles around). Their presence on this monadnock is indicative not only of the high quality of the habitats that currently exist, but on the continuity of those habitats and the ecological processes maintaining them throughout that immense span of time. This ability to maintain relict populations is shared with many rare plant species but is less typical for vertebrates.

For all these reasons, the presence of healthy populations of rare or habitat specialist species of insects and other invertebrates is invariably an indication of a high degree of native ecosystem integrity. Conversely,

Rule of Thumb 2. Where high quality natural areas exist and have maintained their quality through time, a significant fauna of insects and other invertebrates—containing both rare species and a high proportion of habitat specialists—should be expected.

Role of the larger landscape in the conservation of insects and other invertebrates

Although some species of invertebrates, like some plants, can maintain small relict populations over large spans of time, most invertebrates require a distribution of habitats spread out over an entire landscape. This is especially the case for species prone to local extirpation and that depend on a metapopulation structure for survival within a region. A metapopulation is composed of a number of sub-populations, each of which may be relatively unstable, some increasing in a given year, others declining to the point of extirpation. As long as movement is possible between the sub-populations, declining populations can be "rescued" by immigration from increasing populations elsewhere within the metapopulation. A metapopulation can therefore be much more stable than its parts, at least as long as not all sub-populations are affected by the same set of events. Metapopulations are most stable, consequently, when they are spread out over a significant area of the landscape.

Conservation biologists are just beginning to realize how important metapopulations are for animals in general (for vertebrate examples, see McCullough 1996). Due to the greater fluctuations their subpopulations experience within a given year or season, invertebrates are often dependent on metapopulation structures. This is especially true of species associated with ecosystems maintained by frequent disturbances, such as fire, storms, or floods. Whereas vertebrates (and many plants) often have escape mechanisms for coping with unpredictable ecological disruptions, invertebrates typically do not. The only way many insects species survive in habitats maintained by frequent fire, for instance, is through recolonization of recently burned areas from unburned patches of habitat (Hall and Schweitzer 1993).

Habitat fragmentation – Replacement of natural landscapes with a mosaic of small patches of native habitats in a matrix of lands converted to human uses—affects all species by reducing the overall amount of available habitat, involving outright losses as well as more subtle reductions due to edge effects. The most severe effects, however, may be on species critically dependent on metapopulation structures.

By definition, habitat fragmentation is a process that increases the distances between suitable habitat patches and therefore increases the difficulties or outright danger to individuals dispersing from one habitat block to another. Since the very existence of a metapopulation depends on dispersal between suitable patches of habitat, any factor that reduces the changes of successful dispersal may doom the whole metapopulation to eventual extirpation, not just individual sub-populations as normally occurs within intact landscapes. Habitat specialists, particularly those dependent on naturally rare types of habitat or on disturbance-maintained habitats, are at greatest risk.

Rule of Thumb 3. Insects and other invertebrates should be considered at particular risk from fragmentation of native habitats. Even though invertebrate populations can be particularly high within a given sub-population during a given season, this should not be taken as a sign that, as small species, they only need a limited amount of space to maintain themselves. Their long term survival within a region may depend on as much landscape as is required to support a population (or metapopulation) of black bears, red-cockaded woodpeckers, or other species of vertebrates.

Several insects are believed, in fact, to have become critically endangered through loss of metapopulation structure, even though habitats within portions of the range of the metapopulation still appear to be high in quality. Examples in the North Carolina Coastal Plain include the Arogos skipper (*Atrytone arogos*), St Francis' satyr (*Neonympha mitchelli francsici*), and Venus flytrap moth (*Hemipachnobia subporphyrea*)[5].

Implications for management of insects and other invertebrates within state parks and nature preserves

Preserves can to some degree be regarded as islands of habitat. They are often chosen for conservation as something special in areas where the rest of the landscape has been significantly altered. All too frequently, preserves contain the only remnants of native ecosystems for miles around.

While these preserves are intended to remain "natural," active management is often needed to accomplish this goal, although management, almost by definition, involves some form of artificial disturbance. This disturbance may replace a natural form, such as wildfires, or it may be entirely new, such as spraying an entire preserve with a pesticide to control an exotic pest such as the gypsy moth.

Based on the three rules of thumb given previously, it should be clear that special precautions need to be considered in preserve management if crucial "cogs and wheels" of the ecosystem are to be retained. Given the importance of metapopulation structure to many invertebrates, particularly those most tightly associated with native habitats, preserve managers should always ask where will recolonization come from if species are lost from a given area of habitat.

Rule of Thumb 4. Wherever possible, management activities should be restricted to only a portion of a given habitat type. Other areas of the same habitat should be set aside as refuge areas (although potentially subject to treatment at a later time).

Rule of Thumb 5. In cases where a management action affects an entire preserve, as in treatment for gypsy moths, decisions about the scope, intensity, and alternative treatments should be based according to the proximity of refuge areas beyond the boundary of the preserve. Where other, untreated blocks of habitat are located close by, a wider range of management options can be considered. Even in the worst case, where species are extirpated from the preserve, recolonization from outside can still be expected. Where external refuges are located far away, however, management decisions should be based on the worst possible case: irrecoverable losses of species from the preserve."

[1]The NC NHP has conducted or is in the process of conducting status surveys for all three of these species.

Conservation Issues and Needs

Habitat loss: The greatest threat to insects comes from habitat loss, thus conservation efforts aimed at protecting native ecosystems offers the best hope for the majority of endangered insect species. However, even on lands that have been protected to maintain their natural features, management practices need to take the specific requirements of insects into account.

Consideration of insects in site management: If ecosystem-level conservation planning is to be successful, managers must include invertebrates in site management considerations. Consider Hall's rules of thumb from above (Hall 1999a).

Management practices: Insects and other invertebrates may respond to certain management practices very differently than plants or vertebrates; gauging the success of management by the effects on those species may miss significant damage being done inadvertently to insects and other non-target species. This is particularly true for prescribed burning. NC NHP has developed a set of guidelines for conducting burns in ways that minimize impacts to rare insect populations (Hall and Schwietzer 1993, Hall 1999a). Non-target impacts—particularly to rare species—also need to be carefully assessed any time pesticides (or biological control agents) are applied to natural areas.

Collection: Some species—particularly butterflies—are sought after by collectors, and over-collection can be a threat in some situations. One species, *Megathymus cofaqui*, may, in fact, have been extirpated from the state due to overcollection. Insect collecting is not regulated under state law, although permits are required in some cases for collecting on public lands (e.g., state parks, game lands, national forests).

Species control: Use of species-specific insecticides should be encouraged when possible in order to minimize non-target impacts. Key natural areas must be protected during large-scale applications of insecticides with broad non-target impacts. This is especially important in areas where native habitats are restricted in distribution (e.g., maritime and longleaf pine forests) (Hall et al. 1999b).

Outdoor lighting: Moths and other night-flying insects are particularly impacted by outdoor lighting; they become disoriented by artificial lights and can perish due to dehydration, starvation, or predators who key in on these areas. Where possible, low voltage, shielded fixtures should be used. Lighting of any kind should be avoided around habitats likely to support rare nocturnal insects (Hall 1999a). Further lighting recommendation can be found in publications of the International Dark Sky Association (www.darksky.org).

Web-based Resources

- US Fish & Wildlife Service, NC Ecological Services Office, North Carolina's Threatened and Endangered Species web site: http://nc-es.fws.gov/es/es.html
  - Recovery plan for St. Francis satyr can be found at: http://ecos.fws.gov/docs/recovery_plans/1996/960423.pdf
  - Recovery plan for Spruce-fir moss spider can be found at: http://ecos.fws.gov/docs/recovery_plans/1998/980911b.pdf
- Notes on the butterflies of North Carolina web site: (http://www.ncsparks.net/butterfly/nbnc.html) – *Contains extensive natural history information on all North Carolina butterflies, including flight phenograms, and county atlases.*
- Opler, Paul A., Harry Pavulaan, and Ray E. Stanford (coordinators). Butterflies of North America. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/bflyusa.htm (Version 12, Dec 2003). *This site provides state by state accounts of butterfly species, including information on habitat, range, conservation, management need, Global rank, and references.*
- USGS National Water Quality Assessment Program. Invertebrate community data from North Carolina can be downloaded from the NAWQA Data Warehouse at http://water.usgs.gov/nawqa/data.
- International Dark Sky Association. www.darksky.org

References

Franklin, M. A. 2001. Factors affecting seed production in natural populations of *Lysimachia asperulifolia* Poir. (Primulacea), a rare, self-incompatible plant species. Masters Thesis, N.C. State University. Raleigh, NC.

Hall, S. P. 1999a. Inventory of lepidoptera of the Albemarle-Pamlico peninsular region of North Carolina, including Pettigrew, Goose Creek, and Jockey's Ridge State Parks and Nag's Head Woods Ecological Preserve. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S.P. 1999b. Inventory of the moths and butterflies of the lower Roanoke River floodplain. Report to the N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S.P. 2003. Status survey for *Atrytonopsis* new species 1 in North Carolina. Report to the US Fish & Wildlife Service, Raleigh Field Office, Raleigh, NC.

Hall, S.P. 2004. Assessment of terrestrial habitat quality and landscape integrity in the Albemarle-Pamlico Estuarine Study Area, using a Habitat/Indicator-Group analysis. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S. P., and D. F. Schweitzer. 1993. A survey of the moths, butterflies, and grasshoppers of four Nature Conservancy preserves in Southeastern North Carolina. Report to the Nature Conservancy. The Nature Conservancy, Durham, NC.

Hall, S.P. and M.P. Schafale. 1999. Conservation assessment of the Southeast Coastal Plain of North Carolina, using site-oriented and landscape-oriented analyses. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S.P. and Sullivan, J.B. 2000. A rangewide status survey of the Venus flytrap moth *Hemipachnobia subporphyrea* (Lepidoptera: Noctuidae). Report to the US Fish & Wildlife Service, Region 6 Endangered Species Field Office, Asheville, NC.

Hall, S.P. and Sullivan, J.B. 2004. Status survey for *Hemipachnobia subporphyrea*, based on larval presence and feeding sign. Interim Report to the US Fish & Wildlife Service, Raleigh Field Office, Raleigh, NC.

Hall, S.P., Baker, W. H., Gatrelle, R.R, Minno, M.C., Schweitzer, D.F., Sullivan, J.B., Calhoun, J.V., Minno, M., Slotten, J.R. 1999a. A rangewide status survey of the eastern Arogos skipper *Atrytone a. arogos* (Lepidoptera: Hesperiidae). Report to the US Fish & Wildlife Service, Region 6 Endangered Species Field Office, Asheville, NC.

Hall, S. P., J. B. Sullivan, and D. F. Schweitzer. 1999b. Assessment of risk to non-target macro-moths after Bacillus thuringiensis var. kurstaki application to Asian gypsy moth in the Cape Fear region of North Carolina. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV.

Hall, S.P., Sullivan, J.B. and Schweitzer, D.F. 1999c. Eradication of The Asian-strain of The Gypsy Moth from the Cape Fear Region of North Carolina: Assessment of Risk to Nontarget Macro-Lepidoptera. U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV.

LeGrand, H. E., S. E. McRae, S. P. Hall, and J. T. Finnegan. 2004. Natural Heritage Program list of the rare animal species of North Carolina. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

McCullough, D. R. 1996. Metapopulations and wildlife conservation. Island Press, Washington, DC.

Terrestrial Gastropods

Terrestrial gastropods are protected under state law in North Carolina. However, due to extremely limited data and a scarcity of biologists who work on the taxa, little is known about the 200+ species of native terrestrial gastropods known to exist in the state or the 30+ introduced species of land snail or slugs. The North Carolina Natural Heritage (NC NHP) program collects data on 37 rare terrestrial gastropod species; their status' break down as follows:

Federally threatened:

- Noonday globe snail (*Patera clarki nantahala*)

State endangered:

- Fragile glyph (*Glyphyalinia clingmani*)

State threatened:

- Waccamaw ambersnail (*Catinella waccamawensis*)
- Big-tooth covert (*Fumonelix jonesiana*)
- Engraved covert (*Fumonelix orestes)*
- Clingman covert (*Fumonelix wheatleyi clingmanicus*)
- Smoky Mountain covert (*Inflectarius ferrissi*)
- Sculpted supercoil (*Paravitrea ternaria*)
- Roan supercoil (*Paravitrea varidens*)
- Cape Fear threetooth (*Triodopsis soelneri*)

Species of concern:

- Queen crater (*Appalachina chilhoweensis*)
- Sawtooth disc (*Discus bryanti*)
- Dark glyph (*Glyphyalania junaluskana*)
- Pink glyph (*Glyphyalinia pentadelphia*)
- Honey glyph (*Glyphyalinia vanattai*)
- Blue-footed lancetooth (*Haplotrema kendeighi*)
- Spiral coil (*Helicodiscus bonamicus*)
- Fringed coil (*Helicodiscus fimbriatus*)
- Velvet covert (*Inflectarius subpalliatus*)
- Black mantleslug (*Pallifera hemphilli*)
- High Mountain supercoil (*Paravitrea andrewsae*)
- Mirey Ridge supercoil (*Paravitrea clappi*)
- Ramp cove supercoil (*Paravitrea lacteodens*)
- Lamellate supercoil (*Paravitrea lamellidens*)
- Glossy supercoil (*Paravitrea placentula*)
- Open supercoil (*Paravitrea umbilicaris*)
- Dwarf proud globe (*Patera clarki*)
- Great Smoky slitmouth (*Stenotrema depilatum*)
- Dwarf threetooth (*Triodopsis fulciden*)
- Bidentate dome (*Ventridens coelaxis*)
- Appalachian gloss (*Zonitoides patuloides*)

Significantly rare (a NC NHP designation that does not carry any legal protection):

- Talus coil (*Helicodiscus triodus*)
- Dwarf globelet (*Inflectarius downieanus*)
- Budded threetooth (*Triodopsis tennesseensis*)
- A valvatid snail (*Valvata sincera*)
- Sculptured dome (*Ventridens collisella*)
- Hollow dome (*Ventridens lasmodon*)

Key Organizations

Collections on land snails can be found at a number of museums around the country. Review of those collections will be critical to better verifying species identifications and distributions for records pertaining to North Carolina (Art Bogan, pers. comm.).

- Field Museum of Natural History, Chicago, IL. The collections of L. Hubricht are available on the web.
- Academy of Natural Sciences, Philadelphia, PA. The collections of H. A. Pilsbry are housed here, which form the basis for the monograph of land snails of North America (see key references).
- Florida Museum of Natural History, Gainsville, FL. John Slapcinsky is conducting work on the zonitidae of western North Carolina; computerized collections.
- Carnegie Museum of Natural History, Pittsburgh, PA. Tim Pearce has a very large land snail collection which should be reviewed for North Carolina records.
- Ohio State Museum of Zoology. Tom Watters' has a computerized collection of land snails that may contain information on western North Carolina species.

Art Bogan, Curator of Aquatic Invertebrates at the North Carolina Museum of Natural Sciences, has compiled a list of land snails of North Carolina (by county) based on the Field Museum collections, though this work is very preliminary. Amy VanDevender, another North Carolina-based researcher, has begun work collecting land snails from the western part of the state (Art Bogan, pers. comm.)

Conservation Issues and Needs

The most pressing conservation issues regarding the land snails relates to the paucity of data and knowledge of this group of animals. The needs are thus the most basic: surveys, inventories, and review of existing collections. Basic systematics of most land snail fauna are very poorly known. Most of the species in family Zonitidae have never been dissected and the anatomy described, much less phylogenetic and DNA work done. Little to nothing is known about their ecology, egg laying behavior, or reproductive biology.

Specific needs include:

- A thorough state-wide survey to confirm species distributions beyond county boundaries
- Review of existing collections to verify North Carolina species records
- Basic systematics work on most fauna, especially family Zonitidae

Additional Resources

Burch, J. B. 1962. How to know the eastern land snails. Wm. C. Brown Co., Publishers, Dubuque, IA.

Hubricht, L. The distributions of the native land mollusks of the eastern United States. 1985. Fieldiana, Zoology, New Series no. 24.

Pilsbry, H. A. Land mollusca of North America (North of Mexico). 1938-1948. 4 parts. (http://www.acnatsci.org/library/scipubs/Malacology.html)

Volume 1, Part 1. 1939. Families Helicidae, Helicellidae, Helminthoglyptidae, Camaenidae.

Volume 1, Part 2. 1940. Families Polygyridae and Sagdidae.

Volume 2, Part 1. 1946. Families Bulimulidae, Urocoptidae, Cerionidae, Achatinidae, Oleacinidae, Haplotrematidae, Testacellidae, Zonitidae; and supplement to family Camaenidae, subfamily Ammonitellinae.

Volume 2, Part 2. 1948. Families Helminthoglyptidae, Limacidae, Endodontidae, Arionidae, Philomycidae, Succineidae, Strobilopsidae, Pupillidae, Valloniidae, Cionellidae, Carychiidae, Veronicellidae, Truncatellidae, Pomatiopsidae, Helicinidae.

APPENDIX E.
DESCRIPTIONS OF ORIGINAL SPECIES PRIORITIZATION CRITERIA

1. State protection status (Endangered, Threatened, or Special Concern)
2. NC Natural Heritage Program state rank (S1-S5)
3. Degree of exploitation/harvest (*How heavily is this species taken, for example, as game, or for the pet trade, or as bait or feed?*)

   High (H) – Heavily exploited/harvested

   Medium (M) – Harvested, but not at especially high levels

   Low (L) – Not harvested, or harvested on a very selective basis

4. Past or current Commission funding

   If the species has received Commission funding, indicate with an "x".

5. Past or current external funding

   If the species has received funding from an external source (e.g., Museum of Natural Sciences, NC Natural Heritage Program), indicate with an "x".

6. Feasibility measure (*How likely is it that conservation activities in North Carolina can make a difference for this species?*)

   High (H) – It is very likely that research, management, and/or conservation actions could have a positive impact on the species

   Medium (M) – It is somewhat likely

   Low (L) – It is not at all likely

   *This criterion was developed as a rough measure of our ability to be effective in research, management, and/or conservation actions initiated for a particular species/habitat— **this is a subjective measure, your perception**. For example, there may be an animal that exists in such low numbers that you do not feel any activities initiated in North Carolina could really help to conserve that species (you would give it a Low feasibility measure).*

7. Knowledge of the species' population status

   High (H) – We know the status throughout the species' range within the state

   Medium (M) – We know the status in select areas, but are not certain of the status throughout the state range

   Low (L) – We know little to none about the population status in the state

   This criterion is a measure of your perception of how well we understand a species' population status within the state.

8. Population Status (if known)

   Increasing (I) – The population is increasing

   Stable (S) – The population is stable

   Declining (D) – The population is declining

9. Knowledge of species' distribution in the state

   High (H) – We know the species' distribution across the state

   Medium (M) – We know some places where the species can be found, but do not know its distribution statewide

   Low (L) – We know little to none about where this species is located throughout the state

10. Knowledge of limiting factors affecting the species

    High (H) – We know a great deal about the limiting factors

    Medium (M) – We know some of the factors, but do not fully understand the reasons for population changes

    Low (L) – We know little to none about limiting factors affecting the species

APPENDIX F.

LAND COVER DATA CROSSWALK

Table F1. Crosswalk between Wildlife Action Plan habitat labels and North Carolina Gap Analysis Program 1992 land cover types.

Wildlife Action Plan Habitat Label (and additional labels to account for all GAP types)	Region	GAP Mapcode	GAP Map Unit Name	Comments
Beach/dune	CP	372	Interdune Herbaceous Wetlands	May not map well due to scale of regional maps
	CP	375	Hypersaline Coastal Salt Flats	
	CP	371	Maritime Grasslands	
	CP	378	Ocean Beaches	
Estuarine communities	CP	3	Tidal Marsh	Tidal marshes all along salinity gradient, mostly salt
Maritime forest/shrub	CP	17	Maritime Forests and Hammocks	
	CP	121	Maritime Pinelands	
	CP	124	Maritime Scrubs and Tidal Shrublands	
	CP	126	Interdune Wooded Depression Swamp	
Tidal swamp forest and wetlands	CP	75	Tidal Swamp Forest	Does not contain tidal emergent wetlands, class 3
Lake communities		8	Open water	
Small wetland communities	CP	380 (in part)	Coastal Plain Depression Ponds, Seepage Bogs	Concern over mapping sensitive locations, difficult to ID using aerial photography
Wet pine savanna	CP	67	Wet Longleaf or Slash Pine Savanna	
	CP	97	Mesic Longleaf Pine	
Pocosin	CP	87	Pocosin Woodlands and Shrublands	
	CP	15	Seepage and Streamhead Swamps	
Nonalluvial mineral wetlands	CP	158	Coastal Plain Nonriverine Wet Flat Forests	
	CP	78	Pond-Cypress-Gum Swamps, Savannas and Lakeshores	
	CP	41	Peatland Atlantic White-Cedar Forest	
Floodplain forest	CP	49	Coastal Plain Oak Bottomland Forest	
	CP	50	Coastal Plain Mixed Bottomland Forests	
	CP	30	Cypress-Gum Floodplain Forests	
	CP	173	Coastal Plain Riverbank Shrubs	
	P; M	384	P/M Mixed Bottomland Hardwood Forests	
	P	385	P Oak Bottomland Forest and Swamp Forest	
	P, M	267	Riverbank Shrublands	
	P, M	269	Floodplain Wet Shrublands	
	M	517	Hemlock Floodplain Forest	
Dry longleaf pine	CP	42	Xeric Longleaf Pine	
Mesic forest	CP	63	Coastal Plain Mesic Hardwood Forests	
	CP	138	Coastal Plain Dry to Dry-Mesic Oak Forests	
	P	230	Piedmont Mesic Forest	
	P	520	Mesic Hardwood Forest	
Oak forest (& mixed hardwoods/pine)	CP	46	Xeric Oak-Pine Forests	
	P;M	228	P/M Dry-Mesic Oak and Hardwood Forests	
	P	232	Xeric Pine-Hardwood Woodlands and Forests	

Table F1 (*continued*). Crosswalk between Wildlife Action Plan habitat labels and North Carolina Gap Analysis Program 1992 land cover types.

Wildlife Action Plan Habitat Label (and additional labels to account for all GAP types)	Region	GAP Mapcode	GAP Map Unit Name	Comments
Oak forest (& mixed hardwoods/pine) *continued*	CP; P	382	Dry Mesic Oak Pine Forests	
	M	518	Dry Mesic Oak Forest	
	M	519	Dry Mesic Mixed Forest	
	M	525	Appalachian Oak Forest	
	M	529	Appalachian Xeric Mixed Forest	
	M	530	Appalachian Xeric Deciduous Forest	
	P	226	Piedmont Xeric Woodlands	
Dry coniferous woodlands	P	222	Piedmont Dry-Mesic Pine Forests	
	P	220	Piedmont Xeric Pine Forests	
	M	527	Appalachian Hemlock	
	M	528	Appalachian Xeric Pine Forest	
	CP; P	21	Plantation (Coniferous Cultivated Natural/Plantation)	
Early successional	M	523	Grassy Bald	
	M	524	Shrub Bald	
	CP; P; M	205	Agricultural Pasture/Hay and Natural Herbaceous	
	CP	51	Deciduous Cultivated Plantation	
	CP; P	20	Coniferous Regeneration	Depends on current successional stage
	CP; P	36	Successional Deciduous Forests	
	CP; P	383	Coastal Plain Mixed Successional Forest	
Low elev. cliff/rock outcrop	P; M	No code	Not mapped	Essentially point locations, no way to locate
High elev. rock outcrops	M	535	Talus/Outcrops/Cliffs	Scale of maps prohibits accurate identification
Bogs and associated wetlands	M	534	Appalachian Wet Shrubland/Herbaceous; Appalachian Bog, Fens, and Seeps	Locations not mapped over concern about sensitive species; difficult to ID using aerial photography
	M	533	Appalachian Swamp Forest; also Forested Bog, Seepage Swamp	
	P; M	239	Piedmont/Mountain Emergent Vegetation	
Cove forest	M	526	Appalachian Cove Forest	
Northern hardwoods	M	522	Northern Hardwood Forest	
Spruce-fir forest	M	521	Spruce/Fir Forest	
Urban	CP; P; M	202	Residential Urban	
	CP; P; M	203	Urban Low-Intensity Developed	
	CP; P; M	204	Urban High-Intensity Developed and Transportation Corridors	
Open water	CP; P; M	8	Open Water	
	P;M	238	P/M Submerged Aquatic Vegetation	
Exposed sand	CP	60	Exposed Sand	
Agricultural crops	CP; P; M	180	Agricultural Crop Fields	
Barren areas	CP; P; M	213	Barren; Quarries, Strip Mines, and Gravel Pits	
		214	Barren; Bare Rock and Sand	
Caves	M	No code	Not mapped	Point locations, no coverage
Riverine aquatic communities	CP; P; M	No code		Mapped using other coverages

APPENDIX G.

HABITAT ASSOCIATION MATRIX (Terrestrial Species)

Table G1. Priority bird distributions by habitat type.

			Southern Blue Ridge Ecoregion												Piedmont Ecoregion									Mid-Atlantic Coastal Plain Ecoregion																
	Scientific Name	Common Name	Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
1	*Accipiter cooperii*	Cooper's Hawk		X	X	X	X								X	X	X							X	X													
2	*Accipiter striatus*	Sharp-shinned Hawk	X	X	X	X	X								X	X																						
3	*Aegolius acadicus*	Northern Saw-whet Owl	X	X																																		
4	*Aimophila aestivalis*	Bachman's Sparrow																X						X		X						X						
5	*Ammodramus caudacutus*	Saltmarsh Sharp-tailed Sparrow																																X		X	
6	*Ammodramus henslowii*	Henslow's Sparrow																X								X				X		X					
7	*Ammodramus nelsoni*	Nelson's Sharp-tailed Sparrow																																X		X	
8	*Ammodramus savannarum*	Grasshopper Sparrow						X										X								X											
9	*Anhinga anhinga*	Anhinga																									X	X	X					X			
10	*Asio flammeus*	Short-eared Owl																								X								X		X	
11	*Botaurus lentiginosus*	American Bittern																																X		X	
12	*Calidris alba*	Sanderling																																		X	X
13	*Calidris canutus*	Red Knot																																		X	X
14	*Caprimulgus carolinensis*	Chuck-will's-widow														X		X						X	X	X				X							
15	*Caprimulgus vociferus*	Whip-poor-will					X	X								X	X	X	X					X	X	X				X							
16	*Carduelis pinus*	Pine Siskin	X																																		
17	*Certhia americana*	Brown Creeper	X	X	X		X																														
18	*Chaetura pelagica*	Chimney Swift																									X										
19	*Charadrius melodus*	Piping Plover																																		X	X
20	*Charadrius wilsonia*	Wilson's Plover																																		X	X
21	*Chondestes grammacus*	Lark Sparrow																								X											
22	*Chordeiles minor*	Common Nighthawk						X										X						X		X											X
23	*Circus cyaneus*	Northern Harrier																								X								X		X	
24	*Cistothorus platensis*	Sedge Wren																								X								X		X	
25	*Coccyzus americanus*	Yellow-billed Cuckoo			X		X					X			X		X		X				X		X		X										
26	*Coccyzus erythropthalmus*	Black-billed Cuckoo		X	X		X																															
27	*Colaptes auratus*	Northern Flicker			X		X								X	X	X		X				X	X	X					X	X	X						
28	*Colinus virginianus*	Northern Bobwhite						X										X						X		X				X		X						
29	*Contopus virens*	Eastern Wood-pewee			X		X								X	X	X		X				X	X	X		X			X								
30	*Coragyps atratus*	Black Vulture																																			
31	*Coturnicops noveboracensis*	Yellow Rail																																X		X	
32	*Dendroica cerulea*	Cerulean Warbler			X		X																				X										
33	*Dendroica discolor*	Prairie Warbler				X		X										X								X				X	X	X					
34	*Dendroica magnolia*	Magnolia Warbler	X																																		
35	*Dendroica pensylvanica*	Chestnut-sided Warbler	X	X				X																													
36	*Dendroica virens waynei*	Wayne's Black-throated Green Warbler																									X				X			X			
37	*Dolichonyx oryzivorus*	Bobolink						X										X																			

Table G1. Priority bird distributions by habitat type.

			Southern Blue Ridge Ecoregion												Piedmont Ecoregion								Mid-Atlantic Coastal Plain Ecoregion																
	Scientific Name	Common Name	Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
38	*Egretta caerulea*	Little Blue Heron																											X					X		X	
39	*Egretta thula*	Snowy Egret																											X					X		X	
40	*Egretta tricolor*	Tricolored Heron																																		X	
41	*Elanoides forficatus*	Swallow-tailed Kite																									X							X			
42	*Empidonax alnorum*	Alder Flycatcher						X						X																				X			
43	*Empidonax traillii*	Willow Flycatcher						X						X				X																X			
44	*Eremophila alpestris*	Horned Lark						X																													
45	*Falco peregrinus*	Peregrine Falcon							X	X																										X	X
46	*Falco sparverius*	American Kestrel						X								X		X						X		X				X		X					
47	*Gallinula chloropus*	Common Moorhen																											X					X			
48	*Haematopus palliatus*	American Oystercatcher																																		X	X
49	*Haliaeetus leucocephalus*	Bald Eagle																	X		X						X		X					X		X	
50	*Helmitheros vermivorus*	Worm-eating Warbler			X	X	X								X		X		X				X	X			X				X		X				
51	*Himantopus mexicanus*	Black-necked Stilt																																X		X	
52	*Hylocichla mustelina*	Wood Thrush			X		X								X		X		X				X		X		X										
53	*Icterus spurius*	Orchard Oriole						X										X									X										
54	*Ictinia mississippiensis*	Mississippi Kite																									X										
55	*Ixobrychus exilis*	Least Bittern																											X					X		X	
56	*Lanius ludovicianus*	Loggerhead Shrike																X									X										
57	*Laterallus jamaicensis*	Black Rail																																X		X	
58	*Limnothlypis swainsonii*	Swainson's Warbler			X							X							X				X				X				X		X				
59	*Loxia curvirostra*	Red Crossbill	X			X																															
60	*Melanerpes erythrocephalus*	Red-headed Woodpecker				X	X								X	X	X		X		X		X	X	X		X		X	X	X	X					
61	*Mycteria americana*	Wood Stork																											X					X		X	
62	*Nyctanassa violacea*	Yellow-crowned Night-heron																	X		X	X					X		X				X	X		X	
63	*Oporornis formosus*	Kentucky Warbler					X					X			X				X				X				X						X				
64	*Passerculus sandwichensis*	Savannah Sparrow						X																													
65	*Passerina ciris*	Eastern Painted Bunting																									X								X		
66	*Pelecanus occidentalis*	Brown Pelican																																		X	X
67	*Pheucticus ludovicianus*	Rose-breasted Grosbeak		X			X																														
68	*Picoides borealis*	Red-cockaded Woodpecker																							X					X	X	X					
69	*Picoides villosus*	Hairy Woodpecker	X	X	X		X								X	X	X		X				X		X		X										
70	*Plegadis falcinellus*	Glossy Ibis																																X		X	
71	*Poecile atricapilla*	Black-capped Chickadee	X	X			X																														
72	*Pooecetes gramineus*	Vesper Sparrow						X																													
73	*Porzana carolina*	Sora																																X		X	
74	*Rallus elegans*	King Rail																																X		X	
75	*Rallus limicola*	Virginia Rail																																X		X	
76	*Rynchops niger*	Black Skimmer																																		X	X
77	*Scolopax minor*	American Woodcock						X											X	X																	
78	*Sitta pusilla*	Brown-headed Nuthatch				X										X								X						X		X				
79	*Sphyrapicus varius*	Yellow-bellied Sapsucker		X	X		X																														

	Scientific Name	Common Name	Southern Blue Ridge Ecoregion												Piedmont Ecoregion								Mid-Atlantic Coastal Plain Ecoregion																
			Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
80	*Spiza americana*	Dickcissel																X																			
81	*Spizella pusilla*	Field Sparrow						X										X								X											
82	*Sterna antillarum*	Least Tern																																		X	X
83	*Sterna caspia*	Caspian Tern																																		X	X
84	*Sterna hirundo*	Common Tern																																		X	X
85	*Sterna nilotica*	Gull-billed Tern																																		X	X
86	*Sturnella magna*	Eastern Meadowlark						X										X								X											
87	*Tyrannus tyrannus*	Eastern Kingbird						X										X								X											
88	*Tyto alba*	Barn Owl						X										X								X											
89	*Vermivora chrysoptera*	Golden-winged Warbler		X			X	X						X																							
90	*Vermivora pinus*	Blue-winged Warbler						X																													
91	*Wilsonia canadensis*	Canada Warbler	X	X			X																														
92	*Wilsonia citrina*	Hooded Warbler			X		X					X			X		X		X					X		X		X			X						

Table G2. Priority mammal distributions by habitat type.

	Scientific Name	Common Name	Southern Blue Ridge Ecoregion												Piedmont Ecoregion									Mid-Atlantic Coastal Plain Ecoregion																		
			Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
1	*Condylura cristata pop. 1*	Star-nosed Mole																								X	X				X		X		X				
2	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat									X								X								X							X					
3	*Corynorhinus townsendii virginianus*	Virginia Big-eared Bat									X																													
4	*Cryptotis parva*	Least Shrew																X								X								X		X		
5	*Glaucomys sabrinus*	Northern Flying Squirrel	X	X																																			
6	*Lasionycteris noctivagans*	Silver-haired Bat		X											X								X																
7	*Lasiurus cinereus*	Hoary Bat	no specific habitat associations known																																				
8	*Lasiurus intermedius*	Northern Yellow Bat																					X				X							X					
9	*Lasiurus seminolus*	Seminole Bat														X			X					X			X			X				X					
10	*Microtus chrotorrhinus*	Rock Vole	X					X	X																														
11	*Microtus pennsylvanicus*	Meadow Vole						X						X				X								X													
12	*Mustela frenata*	Long-tailed Weasel	X	X	X		X								X		X	X					X		X	X					X	X							
13	*Mustela nivalis*	Least Weasel					X	X																															
14	*Myotis austroriparius*	Southeastern Bat																	X								X							X					
15	*Myotis grisescens*	Gray Bat									X																												
16	*Myotis leibii*	Small-footed Bat								X	X																												
17	*Myotis septentrionalis*	Northern Long-eared Bat								X	X																												
18	*Myotis sodalis*	Indiana Bat									X	X																											
19	*Napaeozapus insignis*	Woodland Jumping Mouse		X	X																																		
20	*Neotoma floridana*	Eastern Woodrat								X																	X							X					
21	*Neotoma magister*	Allegheny Woodrat							X		X																												
22	*Parascalops breweri*	Hairy-tailed Mole		X			X																																
23	*Peromyscus gossypinus*	Cotton Mouse																					X				X				X								
24	*Peromyscus leucopus easti*	White-footed Mouse																																		X			X
25	*Peromyscus polionotus*	Old-field Mouse																X																					
26	*Scalopus aquaticus*	Eastern Mole		X	X		X								X		X	X					X		X	X													
27	*Sciurus niger*	Eastern Fox Squirrel					X																	X	X					X									
28	*Sorex cinereus*	Masked Shrew	X	X	X		X																																
29	*Sorex dispar*	Rock Shrew	X	X					X																														
30	*Sorex fumeus*	Smoky Shrew	X	X	X		X					X																											
31	*Sorex hoyi winnemana*	Southern Pygmy Shrew		X			X																				X											
32	*Sorex palustris*	Water Shrew		X									X																										
33	*Spilogale putorius*	Eastern Spotted Skunk								X																													
34	*Sylvilagus obscurus*	Appalachian Cottontail		X				X																														
35	*Sylvilagus palustris*	Marsh Rabbit																									X								X		X	
36	*Synaptomys cooperi helaletes*	Southern Bog Lemming																								X					X		X					
37	*Trichechus manatus*	Manatee																										X								X		
38	*Zapus hudsonius*	Meadow Jumping Mouse						X						X				X																				

Table G3. Priority amphibian distributions by habitat type.

			Southern Blue Ridge Ecoregion													Piedmont Ecoregion								Mid-Atlantic Coastal Plain Ecoregion																
	Scientific Name	Common Name	Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
1	*Ambystoma mabeei*	Mabee's Salamander																					X				X					X	X						
2	*Ambystoma maculatum*	Spotted Salamander		X	X		X					X		X	X		X		X				X		X		X					X						
3	*Ambystoma opacum*	Marbled Salamander			X		X					X		X	X		X		X				X		X		X					X						
4	*Ambystoma talpoideum*	Mole Salamander										X		X	X				X			X																
5	*Ambystoma tigrinum*	Eastern Tiger Salamander																				X								X		X	X						
6	*Aneides aeneus*	Green Salamander			X		X		X	X																													
7	*Bufo quercicus*	Oak Toad																												X	X	X	X			X			
8	*Cryptobranchus alleganiensis*	Hellbender											X																										
9	*Desmognathus aeneus*	Seepage Salamander			X		X					X																											
10	*Desmognathus auriculatus*	Southern Dusky Salamander																		X								X			X			X		X		
11	*Desmognathus marmoratus*	Shovel-nosed Salamander											X																										
12	*Desmognathus wrighti*	Pigmy Salamander	X	X	X																																		
13	*Eurycea guttolineata*	Three-lined Salamander										X	X	X					X	X							X	X										
14	*Eurycea junaluska*	Junaluska Salamander										X	X																										
15	*Eurycea longicauda*	Longtail Salamander								X		X	X																										
16	*Eurycea quadridigitata*	Dwarf Salamander																				X					X					X	X						
17	*Eurycea sp 1*	Sandhills Salamander																		X	X						X	X										
18	*Hemidactylium scutatum*	Four-toed Salamander					X					X		X	X		X		X			X	X		X		X					X						
19	*Hyla andersonii*	Pine Barrens Treefrog																												X	X	X	X						
20	*Hyla gratiosa*	Barking Treefrog													X							X	X							X		X	X						
21	*Hyla versicolor*	Northern Gray Treefrog													X		X		X			X																
22	*Necturus lewisi*	Neuse River Waterdog																			X																	
23	*Necturus maculosus*	Common Mudpuppy											X																										
24	*Plethodon aureolus*	Tellico Salamander		X	X		X																															
25	*Plethodon chattahoochee* Salamander	Chattahoochee Slimy		X	X		X																															
26	*Plethodon glutinosus sensustricto*	Northern Slimy Salamander	X	X	X		X					X			X		X		X				X		X		X			X		X						
27	*Plethodon longicrus*	Crevice Salamander			X		X			X																												
28	*Plethodon richmondi*	Southern Ravine Salamander		X	X		X																															
29	*Plethodon ventralis*	Southern Zigzag Salamander			X		X			X																												
30	*Plethodon wehrlei*	Wehrle's Salamander					X																															
31	*Plethodon welleri*	Weller's Salamander	X	X																																		
32	*Pseudacris brachyphona*	Mountain Chorus Frog					X					X																										
33	*Pseudacris brimleyi*	Brimley's Chorus Frog																					X									X	X					
34	*Pseudacris nigrita nigrita*	Striped Southern Chorus Frog																					X									X	X	X				
35	*Pseudacris ornata*	Ornate Chorus Frog																					X							X		X	X					
36	*Rana capito*	Carolina Gopher Frog																					X							X		X	X					
37	*Rana heckscheri*	River Frog																			X																	
38	*Scaphiopus holbrookii*	Eastern Spadefoot															X					X	X		X		X			X		X	X			X		
39	*Siren intermedia intermedia*	Eastern Lesser Siren																															X					
40	*Siren lacertina*	Greater Siren																			X																	
41	*Stereochilus marginatus*	Many-lined Salamander																			X										X							

Table G4. Priority reptile distributions by habitat type.

			Southern Blue Ridge Ecoregion													Piedmont Ecoregion								Mid-Atlantic Coastal Plain Ecoregion																			
	Scientific Name	Common Name	Spruce-fir Forest	Northern Hardwood Forest	Cove Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	High Elevation Rock Outcrops	Low Elevation Cliffs/Rock Outcrops	Caves and Mines	Floodplain Forest	Riverine Aquatic Communities	Bogs and Associated Wetlands	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Small Wetland Communities	Mesic Forest	Dry Coniferous Woodlands	Oak Forest (& Mixed Hardwood/Pine)	Early Successional	Floodplain Forest	Riverine Aquatic Communities	Lakes and Reservoirs	Dry Longleaf Pine	Pocosin	Wet Pine Savanna	Small Wetland Communities	Nonalluvial Mineral Wetlands	Tidal Swamp Forest and Wetlands	Maritime Forest/Shrub	Estuarine Communities	Beach and Dune
1	*Alligator mississippiensis*	American Alligator																		X	X										X										
2	*Apalone spinifera aspera*	Gulf Coast Spiny Softshell																	X	X										X	X										
3	*Apalone spinifera spinifera*	Eastern Spiny Softshell											X																													
4	*Caretta caretta*	Loggerhead Seaturtle																																					X	X	
5	*Cemophora coccinea copei*	Northern Scarletsnake															X								X					X							X				
6	*Chelonia mydas*	Green Seaturtle																																					X	X	
7	*Clemmys guttata*	Spotted Turtle													X				X			X	X					X						X							
8	*Clemmys muhlenbergii*	Bog Turtle										X		X					X																						
9	*Crotalus adamanteus*	Eastern Diamond-backed Rattlesnake	X				X																																		
10	*Crotalus horridus*	Timber Rattlesnake				X	X	X	X	X		X			X	X	X		X					X	X	X		X			X			X						
11	*Deirochelys reticularia*	Eastern Chicken Turtle																											X	X			X							
12	*Dermochelys coriacea*	Leatherback Seaturtle																																							X
13	*Elaphe guttata*	Corn Snake													X		X		X					X		X		X			X		X		X					
14	*Eretmochelys imbricata imbricata*	Atlantic Hawksbill Seaturtle																																				X		
15	*Eumeces anthracinus*	Coal Skink				X		X	X	X																														
16	*Eumeces laticeps*	Broad-headed Skink													X		X		X					X		X		X					X		X					
17	*Farancia abacura abacura*	Eastern Mudsnake																		X									X	X			X	X	X					
18	*Farancia erytrogramma erytrogramma*	Common Rainbow Snake																											X	X					X					
19	*Heterodon platirhinos*	Eastern Hog-nosed Snake			X							X							X						X	X				X		X		X						
20	*Heterodon simus*	Southern Hog-nosed Snake																													X					X				
21	*Kinosternon baurii*	Striped Mud Turtle																		X									X	X					X					
22	*Lampropeltis calligaster rhombomaculata*	Mole Kingsnake					X								X		X	X						X		X	X				X		X		X					
23	*Lampropeltis getula getula*	Eastern Kingsnake										X						X	X								X	X						X		X	X			
24	*Lampropeltis getula sticticeps*	Outer Banks Kingsnake																																		X	X			
25	*Lampropeltis triangulum elapsoides*	Scarlet Kingsnake															X														X		X		X					
26	*Lepidochelys kempii*	Kemp's Ridley Seaturtle																																				X	X	
27	*Malaclemys terrapin*	Diamond-backed Terrapin																																				X	X	
28	*Masticophis flagellum*	Eastern Coachwhip																									X				X				X		X		X	
29	*Micrurus fulvius*	Eastern Coral Snake																													X						X			
30	*Nerodia sipedon williamengelsi*	Carolina Watersnake																																				X		
31	*Opheodrys vernalis*	Smooth Greensnake						X																																
32	*Ophisaurus attenuatus longicaudus*	Eastern Slender Glass Lizard					X										X	X									X				X								
33	*Ophisaurus mimicus*	Mimic Glass Lizard																														X		X					
34	*Pituophis melanoleucus melanoleucus*	Northern Pinesnake					X																				X				X								
35	*Regina rigida*	Glossy Crayfish Snake																											X	X			X							
36	*Rhadinaea flavilata*	Pine Woods Littersnake																						X								X		X						
37	*Seminatrix pygaea*	Black Swamp Snake																											X				X							
38	*Sistrurus miliarius*	Pigmy Rattlesnake														X	X								X					X		X		X					
39	*Sternotherus minor*	Loggerhead Musk Turtle											X																												
40	*Tantilla coronata*	Southeastern Crowned Snake														X									X					X				X						
41	*Terrapene carolina*	Eastern Box Turtle					X	X				X			X		X	X	X					X		X	X	X												
42	*Thamnophis sauritus sauritus*	Common Ribbonsnake											X	X					X	X	X	X					X	X	X				X		X		X		
43	*Virginia valeriae valeriae*	Eastern Smooth Earthsnake			X		X								X		X							X		X								X					

APPENDIX H.

RIVER BASIN MATRIX (Aquatic Species)

Table H1. Priority fish distributions by river basin (H = Historical distribution, N = Nonnative in basin, ? = Uncertain distribution). *See page H4 for a key to the river basin names.*

	Scientific Name	Common Name	River Basins															
			H	LT	FB	W	New	S	B	C	Y-P	R	CF	N	T-P	L	WO	CH	P
1	*Acipenser brevirostrum*	Shortnose Sturgeon									X		X					X	
2	*Acipenser oxyrhynchus*	Atlantic Sturgeon									X	X	X	X	X		X	X	X
3	*Ambloplites cavifrons*	Roanoke Bass											X	X	X				
4	*Ameiurus brunneus*	Snail Bullhead						X	X	X	X	X	X	X		X			
5	*Carpiodes carpio*	River Carpsucker			X														
6	*Carpiodes cyprinus*	Quillback			X				X	X	X	X		X					
7	*Carpiodes velifer*	Highfin Carpsucker								X	X		X						
8	*Clinostomus funduloides sp.*	Little Tennessee Rosyside Dace	X	X															
9	*Cottus caeruleomentum*	Blue Ridge Sculpin										X							
10	*Cyprinella monacha*	Spotfin Chub		X															
11	*Cyprinella sp. (cf. zanema)*	Thinlip Chub									X		X			X			
12	*Elassoma boehlkei*	Carolina Pygmy Sunfish														X			
13	*Elassoma evergladei*	Everglades Pygmy Sunfish											X			X			
14	*Elassoma zonatum*	Banded Pygmy Sunfish										X	X	X	X	X			
15	*Enneacanthus chaetodon*	Blackbanded Sunfish										X	X	X	X	X	X	X	X
16	*Enneacanthus obesus*	Banded Sunfish										X	X	X	X	X	X	X	X
17	*Erimystax insignis*	Blotched Chub	X		X														
18	*Erimyzon sucetta*	Lake Chubsucker											X	X	X	X	X	X	X
19	*Etheostoma acuticeps*	Sharphead Darter			X														
20	*Etheostoma collis*	Carolina Darter								X	X	X	X	X	X				
21	*Etheostoma inscriptum*	Turquoise Darter						X											
22	*Etheostoma jessiae*	Blueside Darter			X?														
23	*Etheostoma kanawhae*	Kanawha Darter					X												
24	*Etheostoma mariae*	Pinewoods Darter														X			
25	*Etheostoma nigrum*	Johnny Darter										X		X	X				
26	*Etheostoma perlongum*	Waccamaw Darter														X			
27	*Etheostoma podostemone*	Riverweed Darter										X							
28	*Etheostoma vitreum*	Glassy Darter										X		X	X			X	
29	*Etheostoma vulneratum*	Wounded Darter		X	X														
30	*Exoglossum laurae*	Tonguetied Minnow					X												
31	*Exoglossum maxillangua*	Cutlips Minnow										X							
32	*Fundulus diaphanus*	Banded Killifish										X	X	X	X			X	
33	*Fundulus cf. diaphanus*	Lake Phelps Killifish																	X
34	*Fundulus lineolatus*	Lined Topminnow									X	X	X	X	X	X	X	X	
35	*Fundulus waccamensis*	Waccamaw Killifish														X			
36	*Heterandria formosa*	Least Killifish											X						
37	*Hybopsis rubifrons*	Rosyface Chub						X											
38	*Hypentelium roanokense*	Roanoke Hog Sucker										X							
39	*Ichthyomyzon greeleyi*	Mountain Brook Lamprey	X	X	X														
40	*Ictiobus bubalus*	Smallmouth Buffalo			X					N	N			N					
41	*Labidesthes sicculus*	Brook Silverside		X							N					N			
42	*Lampetra aepyptera*	Least Brook Lamprey												X	X				
43	*Lampetra appendix*	American Brook Lamprey			X														
44	*Lepomis marginatus*	Dollar Sunfish								X	X		X	X	X	X			
45	*Lepomis punctatus*	Spotted Sunfish											X			X			
46	*Lucania goodei*	Bluefin Killifish											X						

Table H1. Priority fish distributions by river basin (H = Historical distribution, N = Nonnative in basin, ? = Uncertain distribution) (*Continued*). *See page H4 for a key to the river basin names.*

	Scientific Name	Common Name	River Basins																
			H	LT	FB	W	New	S	B	C	Y-P	R	CF	N	T-P	L	WO	CH	P
47	*Luxilis chrysocephalus*	Striped Shiner			X														
48	*Lythrurus matutinus*	Pinewoods Shiner											X	X	X				
49	*Menidia extensa*	Waccamaw Silverside														X			
50	*Moxostoma collapsum*	Notchlip Redhorse							X	X	X	X	X	X	X				
51	*Moxostoma macrolepidotum*	Shorthead Redhorse								X	X	X	X	X	X			X	
52	*Moxostoma pappillosum*	V-lip Redhorse							X	X	X	X	X	X	X			X	
53	*Moxostoma robustum*	Robust Redhorse									X								
54	*Moxostoma* sp 1	Sicklefin Redhorse	X	X															
55	*Moxostoma* sp 2	Carolina Redhorse									X		X						
56	*Notropis amoenus*	Comely Shiner									N	X	X	X	X			X	
57	*Notropis bifrenatus*	Bridle Shiner												X					
58	*Notropis chalybaeus*	Ironcolor Shiner										X	X	X	X	X	X	X	X
59	*Notropis lutipinnis*	Yellowfin Shiner		N				X											
60	*Notropis maculatus*	Taillight Shiner									X		X			X			
61	*Notropis mekistocholas*	Cape Fear Shiner											X						
62	*Notropis photogenis*	Silver Shiner	X	X	X	X	X												
63	*Notropis rubellus*	Rosyface Shiner					X												
64	*Notropis volucellus*	Mimic Shiner		X	X		X							X	X				
65	*Noturus eleutherus*	Mountain Madtom			H														
66	*Noturus flavus*	Stonecat		X	X														
67	*Noturus furiosus*	Carolina Madtom												X	X				
68	*Noturus gilberti*	Orangefin Madtom										X							
69	*Noturus* n. sp.	Broadtail Madtom											X			X			
70	*Percina aurantiaca*	Tangerine Darter	X	X	X	X													
71	*Percina burtoni*	Blotchside Darter		X	X														
72	*Percina caprodes*	Logperch			X		X												
73	*Percina macrocephala*	Longhead Darter			X?														
74	*Percina nigrofasciata*	Blackbanded Darter						X											
75	*Percina oxyrhynchus*	Sharpnose Darter					X												
76	*Percina squamata*	Olive Darter	X	X	X														
77	*Petromyzon marinus*	Sea Lamprey											X	X				X	X
78	*Phenacobius teretulus*	Kanawha Minnow					X												
79	*Pimephales notatus*	Bluntnose Minnow	X		X	X	X												
80	*Poecilia latipinna*	Sailfin Molly											X			X			
81	*Scartomyzon ariommus*	Bigeye Jumprock										X							
82	*Semotilus lumbee*	Sandhills Chub									X		X			X			
83	*Thoburnia hamiltoni*	Rustyside Sucker										X							

Table H2. Priority mussel distributions by river basin (H = Historical distribution, N = Nonnative in basin, ? = Uncertain distribution). *See page H4 for a key to the river basin names.*

	Scientific Name	Common Name	River Basins															
			H	LT	FB	W	New	S	B	C	Y-P	R	CF	N	T-P	L	WO	CH	P
1	*Alasmidonta heterodon*	Dwarf Wedgemussel												X	X				
2	*Alasmidonta raveneliana*	Appalachian Elktoe		X	X														
3	*Alasmidonta robusta*	Carolina Elktoe								X?	X								
4	*Alasmidonta undulata*	Triangle Floater									X	X	X	X	X			X	
5	*Alasmidonta varicosa*	Brook Floater								X	X	X	X	X					
6	*Alasmidonta viridis*	Slippershell Mussel		X	X														
7	*Anodonta couperiana*	Barrel Floater											H						
8	*Anodonta implicata*	Alewife Floater									X	X						X	
9	*Cyclonaias tuberculata*	Purple Wartyback					X												
10	*Elliptio cistellaeformis*	Box spike								X	X		X	X	X	X			
11	*Elliptio congaraea*	Carolina Slabshell									X		X	X	X				
12	*Elliptio dilatata*	Spike	X	X			X												
13	*Elliptio folliculata*	Pod Lance									X		X			X			
14	*Elliptio icterina*	Variable Spike							X	X	X	X	X	X	X	X	X		
15	*Elliptio lanceolata*	Yellow Lance												X	X				
16	*Elliptio marsupiobesa*	Cape Fear Spike											X	X		X			
17	*Elliptio roanokensis*	Roanoke Slabshell									X	X	X	X	X				
18	*Elliptio steinstansana*	Tar River Spinymussel												X	X				
19	*Elliptio waccamawensis*	Waccamaw Spike														X			
20	*Fusconaia barnesiana*	Tennessee Pigtoe	X	X															
21	*Fusconaia masoni*	Atlantic Pigtoe									X	X	X	X	X				
22	*Fusconaia subrotunda*	Longsolid	X?	X?	X?														
23	*Lampsilis cariosa*	Yellow Lampmussel											X	X	X	X			
24	*Lampsilis fasciola*	Wavyrayed Lampmussel	X	X	X														
25	*Lampsilis fullerkati*	Waccamaw Fatmucket														X			
26	*Lampsilis radiata conspicua*	Carolina Fatmucket									X			X					
27	*Lampsilis radiata radiata*	Eastern Lampmussel									X		X	X	X	X		X	
28	*Lasmigona decorata*	Carolina Heelsplitter								X	X								
29	*Lasmigona holstonia*	Tennessee Heelsplitter		X	X?														
30	*Lasmigona subviridis*	Green Floater				X	X					X		X	X				
31	*Leptodea ochracea*	Tidewater Mucket										X			H	X		X	
32	*Ligumia nasuta*	Eastern Pondmussel									X	X	X		H			X	
33	*Pegias fabula*	Littlewing Pearlymussel	X	X															
34	*Pleurobema collina*	James Spinymussel										X							
35	*Pleurobema oviforme*	Tennessee Clubshell	X	X	X														
36	*Strophitus undulatus*	Creeper (Squawfoot)			X				X		X	X	X	X	X				
37	*Toxolasma pullus*	Savannah Lilliput									X		X						
38	*Villosa constricta*	Notched Rainbow								X	X	X	X	X	X			X	
39	*Villosa delumbris*	Eastern Creekshell								X	X		X			X			
40	*Villosa iris*	Rainbow	X	X															
41	*Villosa trabalis*	Cumberland Bean	X		X?														
42	*Villosa vanuxemensis*	Mountain Creekshell	X																
43	*Villosa vaughaniana*	Carolina Creekshell								X	X		X						

Table H3. Priority crayfish distributions by river basin. *See below for a key to the river basin names.*

	Scientific Name	Common Name	River Basins																
			H	LT	FB	W	New	S	B	C	Y-P	R	CF	N	T-P	L	WO	CH	P
1	*Cambarus acanthura*	Spinytail Crayfish	X																
2	*Cambarus catagius*	Greensboro Burrowing Cayfish									X		X						
3	*Cambarus chaugaensis*	Oconee Stream Crayfish						X											
4	*Cambarus davidi*	Carolina Ladle Crayfish											X	X					
5	*Cambarus georgiae*	Little Tennessee River Crayfish		X															
6	*Cambarus hiwaseensis*	Hiwassee Crayfish	X																
7	*Cambarus hystriocosus*	Sandhills Spiny Crayfish											X						
8	*Cambarus lenati*	Broad River Stream Crayfish							X										
9	*Cambarus nodosus*	Knotty Burrowing Crayfish	X																
10	*Cambarus parrishi*	Hiwassee Headwaters Crayfish	X																
11	*Cambarus reburrus*	French Broad River Crayfish		X	X			X											
12	*Cambarus spicatus*	Broad Rver Spiny Crayfish							X										
13	*Cambarus tuckasegee*	Tuckasegee Stream Crayfish		X															
14	*Orconectes carolinensis*	North Carolina Spiny Crayfish												X	X				
15	*Orconectes sp. cf. spinosus*	No common name until status finalized		X															
16	*Orconectes virginiensis*	Chowanoke Crayfish										X						X	
17	*Procambarus ancylus*	Edisto Crayfish											X			X			
18	*Procambarus blandingii*	Santee Crayfish														X			
19	*Procambarus braswelli*	Waccamaw Crayfish														X			
20	*Procambarus medialis*	Tar River Crayfish												X	X				
21	*Procambarus plumimanus*	Croatan Crayfish											X	X			X		

Table H4. Priority snail distributions by river basin. *See below for a key to the river basin names.*

	Scientific Name	Common Name	River Basins																
			H	LT	FB	W	New	S	B	C	Y-P	R	CF	N	T-P	L	WO	CH	P
1	*Amnicola sp.*	Waccamaw Snail														X			
2	*Cincinnatia sp.*	Waccamaw Siltsnail														X			
3	*Elimia interrupta*	Knotty Elimia	X																
4	*Ferrissia hendersoni*	Blackwater Ancylid	Unknown distribution in eastern basins																
5	*Helisoma eucosmium*	Greenfield Rams-horn											X						
6	*Leptoxis dilatata*	Seep Mudalia					X												
7	*Leptoxis virigata*	Smooth Mudalia	X																
8	*Planorbella magnifica*	Magnificent Rams-horn											X						
9	*Somatogyrus virginicus*	Panhandle Pebblesnail												X					
10	*Viviparus intertextus*	Rotund Mysterysnail											X			X			

Key to the River Basins

H – Hiwassee
LT – Little Tennessee
FB – French Broad
W – Watauga
New – New
S – Savannah
B – Broad
C – Catawba
YP – Yadkin-PeeDee
R – Roanoke
CF – Cape Fear
N – Neuse
T-P – Tar-Pamlico
L – Lumber (and lower PeeDee)
WO – White Oak
CH – Chowan
P – Pasquotank

APPENDIX I.

LIST OF SPECIES RECOVERY PLANS

Recovery plans for Endangered or Threatened species that may occur in, or were extirpated from, North Carolina. (Source: US Fish & Wildlife Service, Atlanta GA, 2004)

Status	Species	Lead FO[1]	Lead Reg[2]	Listing Date	Recovery Plan Date	Revised Plan Date
MAMMALS						
E	Carolina Northern Flying Squirrel	ASNC	4	85-07-01	90-09-24	
E	Eastern Cougar	ASNC	5	73-06-04	82-08-02	
E	Gray Bat	ASNC	3	76-04-28	82-07-08	
ECH	Indiana Bat	ASNC	3	67-03-11	83-10-14	R3 T draft
E (XN)	Red Wolf	ARNWR	4	67-03-11	82-07-12	90-10-26
ECH	Virginia Big-eared Bat	ASNC	5	79-11-30	84-05-08	
ECH	West Indian (Florida) Manatee	JAFL	4	67-03-11	80-04-15	10-30-01
BIRDS						
T	Bald Eagle (Proposed for delisting)	JAFL	3	67-03-11	84-08-03	89-04-19
ECH, TCH	Piping Plover	RANC,PCFL	5	85-12-11	88-03-31	
E	Red-cockaded Woodpecker	CLSC	4	70-10-13	79-08-24	T draft
E	Wood Stork	JAFL	4	84-02-28	86-09-09	97-01-27
REPTILES						
E,T	Green Sea Turtle	JAFL	4	70-10-13	84-09-19	91-10-29
ECH	Hawksbill Sea Turtle	JAFL	4	70-06-02	84-09-19	93-12-15
E	Kemp's (Atlantic) Ridley Sea Turtle	JAFL	2	70-12-02	84-09-19	92-08-21
ECH	Leatherback Sea Turtle	JAFL	4	70-06-02	84-09-19	92-04-06
T	Loggerhead Sea Turtle	JAFL	4	78-07-28	84-09-19	91-12-26
FISHES						
ECH	Cape Fear Shiner	RANC	4	87-09-25	88-10-07	
TCH	Spotfin Chub	ASNC	4	77-09-09	83-11-21	
TCH	Waccamaw Silverside	RANC	4	87-04-08	93-08-11	
MUSSELS						
EPCH	Appalachian Elktoe	ASNC	4	94-11-23	96-08-26	
ECH	Carolina Heelsplitter	ASNC	4	93-06-30	97-01-17	
E (XN)	Cumberland Bean Pearlymussel	ASNC	4	76-06-14	84-08-22	
E	Dwarf Wedge Mussel	ASNC	5	90-03-13	93-02-08	
E	James River Spinymussel	??	5	88-07-22	90-09-24	
E	Little-wing Pearlymussel	ASNC	4	88-11-14	89-09-22	
EPCH (XN)	Oyster Mussel	COTN	4	97-01-10	FINAL	
E	Tar (River) Spinymussel	ASNC	4	85-06-27	87-01-16	92-05-05

[1] FO = Field Office

[2] Reg = Region

Recovery plans for Endangered or Threatened species that may occur in, or were extirpated from, North Carolina. (*continued*) (Source: US Fish & Wildlife Service, Atlanta GA, 2004)

Status	Species	Lead FO[1]	Lead Reg[2]	Listing Date	Recovery Plan Date	Revised Plan Date
SNAILS						
T	Noonday Snail	ASNC	4	78-07-03	84-09-07	
INSECTS						
E	Saint Francis Satyr	RANC	4	95-01-26 final 94-04-18 emg	96-04-23	
ARACHNIDS						
ECH	Spruce-fir Moss Spider	ASNC	4	95-02-06	98-09-11	

Lead Field Office:

Alligator River NWR [ARNWR] (252/473-1131)
Asheville, NC [ASNC] (828/258-3939)
Clemson, SC [CLSC] (864/656-2432)
Cookeville, TN [COTN] (931/528-6481)
Jacksonville, FL [JAFL] (904/232-2580)
Panama City, FL [PCFL] (850/769-0552)
Raleigh, NC [RANC] (919/856-4520)

Key

E = Endangered
T = Threatened
CH = Critical habitat
PCH = Proposed critical habitat
XN = Experimental nonessential population designation
T draft = Technical draft
ncn = No common name

APPENDIX J.

FORESTRY SUMMIT AND WORKING LANDS SUMMIT RECOMMENDATIONS

2004 North Carolina Forestry Summit Report Issues and Action Items (NCDFR 2004)

Urbanization

- The Division of Forest Resources (NCDFR) will continue its Longleaf Pine Initiative, and begin developing a Shortleaf Pine Initiative. NCDFR will investigate other means to promote and invigorate efforts to enhance the growth of forest communities that warrant special attention.

Increased Risk of Wildfire

- Undertake initiatives to address the contributing role of working forests in an urbanizing area, through established Wildland/Urban Interface fire prevention programs and developing programs for urbanized forested watersheds.
- The NCDFR will continue an aggressive program to protect North Carolina's citizens, property, and forest resources from disastrous wildfire.

Natural Disasters

- Work to assure adequate cost share funds are available to continue forest regeneration.
- The use of 'timber bonds' or some form of affordable insurance policy could relieve the risk burden forest landowners currently face with having to invest for several decades in forest improvements and growth.

Forest Health

- Continue monitoring threats and promote research for affordable, effective, and ecologically sound control and eradication methods.
- Encourage all government agencies to evaluate the use and establishment of plant materials to insure that aggressive, non-native, or invasive plants are not being perpetuated.
- Aggressively monitor these forest health indicators and take action to alleviate poor conditions.

The Next Generation

- The NCDFR will increase information and education efforts focused on working forests with the message "Managed Forests = Healthy Forests" and a corresponding healthy economy. Additionally, NCDFR will continue its assessment of "under served" customers that have not been adequately addressed through traditional forest management or forest protection programs.

Focus Area 1: Necessity of Present Use-Value (PUV) Taxation & the Right to Practice Forestry

- Legislative enactment of a "right to farm and practice forestry" would eliminate the ability of local governments to enact prohibitive zoning, rules, ordinances, or other restrictions related to working forests and farms.
- Develop a white paper that provides benefit: cost information for local government to highlight the potential value of maintaining working lands versus the need for infrastructure to support commercial or residential development. This paper would:
  - Explain the intent and provisions of Forestry and Agriculture PUV programs.
  - Provide options for allowing wildlife and conservation lands to qualify for PUV in a manner that is consistent with, and complementary to, existing PUV programs.
  - Provide examples where shortcomings in the current PUV system create unintended punitive consequences on landowners.

Focus Area 2: Value of Professional Forestry Assistance and Forestry Associations

- Improve involvement of County Extension Agents, NRCS District Conservationists, and other agencies with forest management needs.
- Re-establish CES Area Forestry Specialists to support County Agents' forestry needs.
- Re-invigorate the development and continuity of county forestry associations.
- Strengthen relationships between consulting foresters, Division of Forest Resources, Soil & Water Conservation Districts, and CES Extension Agents.

Focus Area 3: Growth of the NC Forest Development Program (FDP) and Other Cost Share

NCDFR will explore issues of funding and administering cost-shared timber stand improvement (TSI), such as:

- Are changes needed in primary processor assessment fees?
- What additional appropriations are necessary to support TSI cost sharing?
- Is it possible to reduce the percentage of cost-shared amount and still remain as a viable financial incentive for landowners? This may allow existing funding to be used over more acres and landowners.
- Is a stand-alone cost share program needed for TSI work, instead of modifying FDP?

Focus Area 4: Sustainability of Forest Industry Markets and Wood/Fiber Product Research

- NCDFR will hire a Utilization & Marketing Forester (position was advertised in Nov. 2004).
- Enhance inter-agency cooperation with Dept of Agriculture & Consumer Services and Department of Commerce in promoting forestry-based goods and commerce.
- Educate policy-makers and the general public on:
  - The economic importance of forestry for North Carolina.
  - Opportunities for new economic gains from non-traditional forestry operations
- Provide forest industry with worker training and development through continued support of the Community College system.

Focus area 5: Working Lands Opportunities with Conservation Easements and Trust Funds

- North Carolina should fully fund its Trust Funds to insure land conservation efforts continue. These include the Farmland Preservation Trust Fund, Clean Water Management Trust Fund, Natural Heritage Trust Fund, Ecosystem Enhancement Program, and Parks & Recreation Trust Fund.
- Draft a letter, on behalf of this committee, for state elected officials and policy-makers explaining the value of creating, or expanding an existing, Trust Fund that would promote CE's on working forests and farms.
- NCDFR will develop a proposal for a State Forest Legacy trust fund that could provide additional funding for conservation easements or NCDFR fee-simple acquisition of ecologically significant working forestland in support of the NCDFR's long-term plans for expanding the Educational State Forest system and Forest Legacy Program.

North Carolina Plan for Working Lands Conservation - summary of issues and action steps (NC Association of Soil and Water Conservation Districts and NC Div. of Soil and Water Conservation, 2005)

Private Lands; Public Benefits

- The Association of Soil and Water Conservation Districts, together with partnering organizations and agencies, should prepare a report describing the public benefits of private working lands conservation.
- The Association of Soil and Water Conservation Districts, together with partnering organizations and agencies, including the One North Carolina Naturally initiative, should prepare and distribute a brochure for the above report.

Balancing State Policies and Priorities in Conservation

- Agencies and partnering groups must make more of a collaborative effort to articulate the working lands conservation message to the Governor, members of the General Assembly and agency heads.
- Private working lands conservation should be elevated as a priority in state conservation policy via legislation. Statutory direction should be provided by the General Assembly stating a preference that land shall remain in a privately owned working state where feasible in achieving conservation purposes.
- To complement existing legislation codifying the Million Acres Initiative for land preservation, the General Assembly should provide legislative direction to NCDENR to track and report conservation on privately owned *working lands* as a tool in accomplishing the state's goal for protecting land and natural resources, specifically directing that NCDENR cooperate with local governments and Soil and Water Conservation Districts, and to add support services (e.g., GIS), to provide an annual report on categories of conservation programs delivered in partnership with working landowners.
- Looking specifically at military properties and adjacent privately owned lands, military base closure or encroachment response plans should avoid relying on public purchase of adjacent lands, because such lands (e.g., agriculture and forest lands) should remain in private ownership and in a working state.
- The North Carolina General Assembly should develop new funding sources to grow overall conservation funding, adding emphasis to programs for working lands conservation.
- While growing overall conservation funding is an objective of this or any plan for conservation, it must be recognized that funding is finite. Success of this plan in advancing working lands conservation should not be limited to the event that new, additional funds are made available for all conservation purposes. That is, should new funds not be made available, North Carolina's General Assembly should re-examine its existing priorities, and should give greater emphasis to working lands conservation in allocating available resources among programs in conservation of working lands, public land acquisition, and regulation.
- The state's commitment to a greater emphasis on working lands conservation should be reflected in the state budget process and in budget decisions at the agency level and in the General Assembly.
- This plan should be used to shape state policy, as it is incorporated in legislation and in formulation of the overall state plan for land conservation under the One North Carolina Naturally initiative, to advance emphasis on working lands conservation.
- Agencies, boards and commissions administering conservation programs and related grant programs using public funds should be directed by the General Assembly to incorporate working lands conservation purpose and components into their programs as appropriate.

Local Leadership and Partnerships

- The NC Association of Soil and Water Conservation Districts should co-host a series of local (county-level) workshops with county commissions to discuss, in a public forum, local land conservation issues, and to develop a local strategy for land conservation.
- The One NC Naturally plan should include actions designed to facilitate local leadership on the working lands conservation issue, such as initiatives to build local leadership in forming a local strategy for conservation.
- The General Assembly should provide direction, via legislation, to state efforts to support local leadership in land conservation. This should include an overall statement of intent as to the facilitating role for state government, and specific direction to agencies as to how to promote and support local leadership through facilitation, planning, technical assistance, incentives and innovative funding mechanisms.
- The Association of Soil and Water Conservation Districts and the Association of County Commissioners should cooperate in development of coordinated association policy or enter into agreements dealing with issues of common interest on working lands conservation and related issues.
- The One NC Naturally plan should include state actions designed to facilitate local partnership-building on the working lands conservation issue, including providing grant opportunities, identifying appropriate organizations to help bring together at the local level, sponsorship and planning of local workshops and meetings, and identifying innovative ways to establish and support local partnerships through facilitation by state-level organizations (state associations, agencies, non-profit organizations, Councils of Government, etc.).
- The Association of Soil and Water Conservation Districts should work with land trusts and other "non-traditional" partners identified at the Summit on Working Lands Conservation to continue to build local networks and partnerships.
- The Association of Soil and Water Conservation Districts should actively involve Resource Conservation and Development Councils (RC&D) as partners at the local and multi-county RC&D area level in working lands conservation.
- Land trusts should inform Soil and Water Conservation Districts about their local capabilities and interests, develop shared objectives for working lands conservation, train local conservation district staff in stewardship and monitoring associated with various conservation easements, and undertake joint projects.

Existing Tools

- The General Assembly should direct agencies, trust funds, boards and commissions using public conservation funds to evaluate how their conservation programs can be made more landowner-driven, by incorporating greater landowner participation and developing objectives based on working lands conservation purpose and conservation planning.
- Execution of working lands conservation agreements (e.g., conservation easements) should be built upon conservation planning based on the land and landowner needs, and easement terms (periods) and conditions should be developed based on conservation and management options chosen by the landowner (not the other way around).
- The Conservation Partnership should reinforce its efforts to achieve comprehensive conservation planning by its members, by continuing to place priority (e.g., scoring, ranking) on systems-based approaches and comprehensive planning as appropriate in its services and technical training programs.
- The Conservation Partnership and other participating organizations should explore "place-based" approaches as a means to enhance comprehensive conservation planning (e.g., in watersheds) to supplement base conservation programs, and to combine conservation planning with services responding to other location-based needs.

- The NC Soil and Water Conservation Commission, working with NRCS, land trusts, watershed groups, and NCDENR, should develop a plan for accessing, collecting, compiling and distributing improved natural resource information on working lands for use by local leaders in working lands conservation program planning and setting of priorities.
- The NC Soil and Water Conservation Commission, working with NRCS and NCSU, should strengthen its process for creating and modifying technical standards and specifications for conservation practices and for new and innovative tools for working lands conservation, taking advantage of the Commission's statutory authority and rules for approving best management practices for water quality programs.
- NRCS, working in cooperation with the NC Soil and Water Conservation Commission, should adapt technical standards and specifications as necessary to support innovative tools for working lands conservation.
- The General Assembly should increase appropriations for technical assistance in the Agriculture Cost Share Program by $2 million.
- State agencies should determine how to expand opportunities to leverage funding from federal, local, other state, and private sources for technical assistance for working lands conservation, including in particular, federal Clean Water Act non-point source program (s.319), Farm Bill conservation programs, state revolving loan funds, and state trust fund grants.
- The Conservation Partnership should prepare a training needs assessment to identify the needed training and potential funding sources.
- The General Assembly should increase Agriculture Cost Share Program Financial Assistance funding by $3 million over 2001 funding levels to reflect cost share programs' critical support to working lands conservation.
- The General Assembly should establish funding for a forestry management practices cost share program for private forest landowners to supplement that for agriculture.
- The General Assembly should increase appropriations for technical assistance (see section 4.4) concomitant with increased appropriations for financial assistance for cost share programs.
- The Conservation Partnership and other participating organizations should explore “place-based” approaches as a means to focus additional comprehensive conservation planning and cost share participation (e.g., in watersheds) for a portion of increased appropriation, as a complement to base conservation programs.
- The General Assembly should explore how to expand the meaningfulness to private landowners of Voluntary Agriculture Districts (VADs) under North Carolina statutes, by offering added benefits and services to working landowners through VAD designation and related actions. This should include supporting an expanded NC Farmland Protection Program, supporting local agricultural economic development planning and implementation, targeting business planning and education programs and professional services in VADs, employing location-based marketing approaches, and connecting landowner incentives and local government revenue challenges associated with VADs.
- The General Assembly should pass legislation adding forested properties to VADs, creating Voluntary Agricultural and Forestry Districts, and offering additional incentives, benefits and services to attract working forest landowners and mangers.
- Where public funds are used in programs that acquire interest in private property by way of conservation easements on working lands, greater flexibility and working land purpose should be incorporated into these agreements to ensure that they are consistent with the working nature of the land, and the certainty of changes in the future.
- The General Assembly should consider extending state income tax credits to landowners participating in conservation programs applying agreements other than permanent conservation easements.

- North Carolina's Congressional Delegation should seek federal legislation expanding federal income tax credits for conservation to include additional non-permanent conservation easement options.
- The General Assembly should direct agencies, boards and commissions using public funds for conservation easements to increase options available to landowners to include their forested properties to help the state achieve its environmental goals while retaining landowners' opportunities for economic benefit.

New Tools

- The state association should seek additional appropriations from the General Assembly to support technical assistance positions in Soil and Water Conservation Districts under the Agriculture Cost Share Program, and for other related working lands conservation work.
- The state association and NCDENR should seek additional appropriations from the General Assembly to fund technical and professional support positions in the Division of Soil and Water Conservation, to provide scientific and technical tools, training and other support to Soil and Water Conservation Districts in areas of engineering, design, soil science, conservation planning, water quality, grant management, technical operation review, regional coordination and other needed services.
- The Soil and Water Conservation Commission should work with the Conservation Partnership to prepare a plan to deliver training and build added technical capacity in the local conservation infrastructure, and to produce a technical services infrastructure funding strategy taking advantage of appropriations, grants and partnership training.
- Soil and Water Conservation Districts, through the state association, should prepare an agreement with the NCDFR, USFS, and private forestry associations to help deliver technical and financial assistance and conservation planning to small plot, non-industrial forest landowners.
- The state association should establish partnerships with the North Carolina Farm Transition Network, land trusts and other organizations to help make available these professional services, and to couple these technical and professional services with delivery of traditional working lands conservation programs.
- The state association should continue working with non-traditional partners to help develop training for Soil and Water Conservation Districts in technical assistance for innovative land conservation tools.
- The Soil and Water Conservation Commission and General Assembly should work together to improve participation by the private sector and non-governmental organizations in working lands conservation programs, to fill critical gaps in technical capacity at local levels.
- North Carolina must maintain high standards and accountability for private sector technical specialists, such as under technical specialist designation by the NC Soil and Water Conservation Commission and certification by NRCS, to ensure that landowners receive good quality technical services at a fair price.
- One North Carolina Naturally maps, or other land conservation planning maps or databases, should include attribute data for all parcels describing what the parcel is to be protected for. Maps should refer to plans or other documents describing to what degree such purposes may be achieved through public/private partnerships, retaining the land in private ownership and in a working state.
- The General Assembly should consider incentives and benefits needed to implement innovative approaches to help sustain the working nature of lands identified as significant candidate properties for conservation agreements.
- The General Assembly should direct, via legislation, that land shall remain in private ownership and in a working state where feasible in achieving conservation purposes.

- Agencies with public holdings should consider innovative partnership approaches with private landowners (for example, establishing encroachment buffers around military bases, shared-use agreements, contracting land management services), where feasible, as an alternative to additional public lands purchase, so that adjacent lands may retain their private ownership and working character, and where local private/public partnerships can work together to determine how the land can best be managed to provide mutual benefit.
- The One North Carolina Naturally initiative should prepare maps of public holdings and portfolio parcels, and should overlay these areas with productive farmland, forestlands, and ranches in private holdings, to determine where public/private partnerships may be developed that provide mutual benefits while retaining land in private ownership and a working state.
- Soil and Water Conservation Districts, through the state association, should seek assistance from organizations such as the NC Farm Transition Network, NC Farm Bureau, American Farmland Trust, Conservation Fund and others to prepare recommendations to boards, commissions and agencies, and to the General Assembly, regarding two areas: a) the most effective range of options that should be provided to working landowners and managers from a business perspective; and b) the best application of conservation tools involving private working lands, based on an analysis of business planning and transition issues.
- Soil and Water Conservation Districts, through the state association, should become part of the NC Farm Transition Network, joining the network of business transition and viability professionals to combine conservation technical assistance with services to overcome business succession related barriers to participation in conservation, to assist farm and forest owners with the development of business succession and transition plans, and to integrate conservation measures together with those business succession plans.
- North Carolina should expand benefits delivered to private landowners and managers through Voluntary Agricultural Districts (VADs). Soil and Water Conservation Districts, through the state association, should cooperate with organizations such as the NC Association of County Commissioners, NC Farm Transition Network, NC Farm Bureau, American Farmland Trust, Conservation Fund and others to recommend to the General Assembly revisions to the NC VAD law to include additional incentives as may be successfully employed in other states, or as hold promise based on North Carolina's needs.
- The state association should consider and support findings and recommendations of Present Use Value Tax study group regarding tax incentives for conservation, specifically as they pertain to fairness in establishing incentives for working landowners' conservation efforts.
- The state association should cooperate with DENR to specifically evaluate how to provide regulatory benefits to working lands via water use allocation, water use efficiency rewards, and emergency water use requirements.
- The General Assembly should consider how to provide liability protection to working lands where public/private partnerships are established to enhance conservation on private lands in cooperation with management of adjacent public holdings.
- The state association should work with USDA and the NC Congressional delegation to help establish a larger state partnership role in procedures used and decisions made regarding the federal Conservation Security Program created under the 2002 Farm Bill, especially as the Conservation Security Program continues to take shape under this and the next Farm Bill.
- Soil and Water Conservation Districts, through the state association, should prepare resolution(s) for action in 2005 to place conservation districts in a leadership role in determining and facilitating proper management of private working lands participating in conservation programs. This should include development of expanded partnerships with land trusts and other interests, and any needed legislation.

Limited Resources and Beginning Farmers and Landowners

- The General Assembly should direct conservation agencies, boards, commissions and trusts using public funds to develop improved working lands conservation tools (including "working" farm and forest easements), designed to improve participation and meet landowner objectives, in particular those with limited available resources.
- The General Assembly should direct agencies, boards, commissions and trusts to avoid over-reliance on measures such as perpetual easements, and bargain sales or donations, that cannot (of themselves) sustain working landscapes, and that offer very little opportunity to limited resource and beginning working farmers, ranchers and foresters and their families.
- The One North Carolina Naturally plan should include provisions that facilitate technical information and contacts in support of services designed to reach limited resource and beginning farmers, ranchers and foresters.
- Soil and Water Conservation Districts, through the state association, and partnering with the Land Trust Assembly, Black Family Land Trust, Land Loss Prevention Project, Sandhills Family Heritage Association, Conservation Trust of North Carolina, tribal councils, Forest Landowners Association and other interests, should develop plans and partnerships for outreach and education to limited resource landowners, beginning farmers, tribal groups, and other landowners who may not have participated in traditional conservation programs, taking advantage of the special provision in cost share programs for these landowners, and working to develop other means of improved access to conservation programs.

Working Lands Conservation Funding

- The NC Association of Soil and Water Conservation Districts should prepare a multi-year financial needs assessment for conservation on working lands, and submit the assessment and related information to the Governor and General Assembly, for their consideration in developing bi-annual state budgets.
- The association should request the General Assembly to establish a dedicated funding source for working lands conservation, and to appropriate funds from this new source directly to responsible conservation agencies, commissions and programs.
- The General Assembly should establish a time-limited advisory group knowledgeable about working lands and land-based businesses to provide input and advice to that body in design and implementation of a new, dedicated funding source for working lands conservation.
- The state association should partner with other working lands conservation interests to identify funding source options for the General Assembly, and to establish a process for developing funding source(s) needed to support working lands conservation funding needs.
- The state association should partner with other working lands conservation interests to identify specific programs and services that will be included under any new funding source(s), and to catalogue what is to be accomplished with proposed programs and services for working lands conservation.

References

N.C. Division of Forest Resources (NCDFR). 2004 (DRAFT). 2004 North Carolina Forestry Summit Report. N.C. Department of Environment and Natural Resources, Division of Forest Resources, Raleigh, NC.

N.C. Association of Soil and Water Conservation Districts and N.C. Division of Soil and Water Conservation. 2005 (DRAFT). A North Carolina plan for working lands conservation: summary of principles and action steps. N.C. Department of Environment and Natural Resources, Division of Soil and Water Conservation, Raleigh, NC.

APPENDIX K.

NORTH CAROLINA GAP ANALYSIS PROJECT AND PRODUCTS

North Carolina Gap Analysis Program

The Gap Analysis Program (GAP) is a national program of the US Geological Survey (USGS) Biological Resources Division whose goal is to work with partners to develop data and conservation plans that serve to keep common species common. The North Carolina Gap Analysis Project (NC GAP) is the state level representative of the National Gap Analysis Program.

The datasets created by state GAP projects and central to their conservation assessments include:

- Detailed land cover including vegetation types
- Species distribution models – terrestrial vertebrates (birds, mammals, reptiles and amphibians) that are known to breed (5 of the last 10 years) and that are regularly occurring non-accidentals in North Carolina
- Stewardship analysis – assessing the amount and degree of protected lands in North Carolina

We were fortunate in that the NC GAP project was completed in time for us to include the results in our Plan. We used their data in the four ways described below.

1. **Habitat mapping** – We used 1992 NC GAP land cover data to create our habitat maps. First we identified major habitat types in the state (derived from NCNHP 2001 and Schafale and Weakley 1990). We then built a cross-walk between the NC GAP land cover data and those habitat types, where the mapped land cover type corresponded to one of the habitats (see Appendix F for the cross-walk). The data was then recoded to create the habitat maps referenced in the terrestrial habitat sections in Chapter 5A. See McKerrow et al. (in prep.) for NC GAP land cover mapping methods.
2. **Species distribution models** – One of the key datasets for GAP projects are predicted distribution models for terrestrial vertebrate species that occur regularly in the state during the breeding season. Distributions for the NC GAP project were developed by mapping the known ranges of the species, creating a habitat affinity database, and identifying additional spatial parameters that could used to model where the species is likely to use habitat within the state. These predicted distributions represent a model of the presence of suitable habitat. For this report, the NC GAP staff provided their data on the subset of our priority species that they modeled as a part of their efforts (Table K1 and Map Series K1-4).

Table K1. Priority species mapped by NC GAP.

Taxa group	# of priority species	# of priority species mapped by NC GAP
Birds	92	81
Mammals	38	33
Amphibians	41	38
Reptiles	43	41
Total	**214**	**193**

Those priority species that were not mapped by NC GAP are species that did not meet the GAP guidelines for inclusion (Table K2). This guideline was designed to exclude species that would be modeled poorly due to their unpredictable distribution.

Table K2. Priority species not mapped by NC GAP.

Group	Scientific name	Common name
Birds	*Ammodramus caudacutus*	Saltmarsh Sharp-tailed Sparrow
	Ammodramus nelsoni	Nelson's Sharp-tailed Sparrow
	Asio flammeus	Short-eared Owl
	Calidris alba	Sanderling
	Calidris canutus	Red Knot
	Cistothorus platensis	Sedge Wren
	Coturnicops noveboracensis	Yellow Rail
	Dendroica magnolia	Magnolia Warbler
	Elanoides forficatus	Swallow-tailed Kite
	Mycteria americana	Wood Stork
	Porzana carolina	Sora
Mammals	*Lasionycteris noctivagans*	Silver-haired Bat
	Lasiurus cinereus	Hoary Bat
	Lasiurus intermedius	Northern yellow Bat
	Myotis grisescens	Gray Bat
	Trichechus manatus	Manatee
Amphibians	*Eurycea sp 1*	Sandhills Salamander
	Pseudacris brachyphona	Mountain Chorus Frog
	Rana heckscheri	River Frog
Reptiles	*Eretmochelys imbricata imbricata*	Atlantic Hawksbill Seaturtle
	Opheodrys vernalis	Smooth Greensnake

Of the 193 priority species being mapped by NC GAP, 25 species did not have an exact match to the NC GAP list (Table K3). This was primarily caused by the subspecies epithet not being used by NC GAP. However, 12 of those species did not have any other subspecies present in North Carolina, and therefore, do not represent a mismatch of the species concept (see ** in Table K3). Of the remaining 13 species, 11 are multiple subspecies represented in the NC GAP data as a single full species. Two species (the shovel-nosed salamander and the crevice salamander) have been redefined taxonomically since NC GAP developed their database. For these 13 species true mismatches of the species concept exists between our priority species and NC GAP species, and as such, the predicted distribution maps will not be representative of our species concepts.

Table K3. Priority species mapped by NC GAP that do not match up exactly (** indicates species that don't have any other subspecies present in North Carolina).

Group	Scientific Name (as per priority list)	Common Name (as per priority list)	NC GAP-Listed Scientific Name	NC GAP-Listed Common Name
Birds	*Dendroica virens wayne*	Wayne's Black-throated Green Warbler	*Dendroica virens*	Black-throated Green Warbler
Mammals	*Corynorhinus townsendii virginianus***	Virginia Big-eared Bat	*Corynorhinus townsendii*	Townsend's Big-eared Bat
	Peromyscus leucopus easti	White-footed Mouse (coastal subsp.)	*Peromyscus leucopus*	White-footed Mouse
	*Sorex hoyi winnemana***	Southern Pygmy Shrew	*Sorex hoyi*	Pygmy Shrew
	Synaptomys cooperi helaletes	Southern Bog Lemming (coastal subsp.)	*Synaptomys cooperi*	Southern Bog Lemming
Amphibians	*Desmognathus marmoratus*	Shovel-nosed Salamander	*Desmognathus quadramaculatus*	Blackbelly Salamander
	Plethodon chattahoochee	Chattahoochee Slimy Salamander	*Plethodon glutinosus*	Slimy Salamander
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	*Plethodon glutinosus*	Slimy Salamander
	Plethodon longicrus	Crevice Salamander	*Plethodon yonahlossee*	Yonahlossee Salamander
	*Pseudacris nigrita nigrita***	Striped Southern Chorus Frog	*Pseudacris nigrita*	Southern Chorus Frog
	*Siren intermedia intermedia***	Eastern Lesser Siren	*Siren intermedia*	Lesser Siren
Reptiles	*Apalone spinifera aspera*	Gulf Coast Spiny Softshell	*Apalone spinifera*	Spiny Softshell
	Apalone spinifera spinifera	Eastern Spiny Softshell	*Apalone spinifera*	Spiny Softshell
	*Cemophora coccinea copei***	Northern Scarletsnake	*Cemophora coccinea*	Scarlet Snake
	*Farancia abacura abacura***	Eastern Mudsnake	*Farancia abacura*	Mud Snake
	*Farancia erytrogramma erytrogramma***	Common Rainbow Snake	*Farancia erytrogramma*	Rainbow Snake
	*Lampropeltis calligaster rhombomaculata***	Mole Kingsnake	*Lampropeltis calligaster*	Mole Kingsnake
	Lampropeltis getula getula	Eastern Kingsnake	*Lampropeltis getula*	Common Kingsnake
	Lampropeltis getula sticticeps	Outer Banks Kingsnake	*Lampropeltis getula*	Common Kingsnake
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	*Lampropeltis triangulum*	Milk Snake
	Nerodia sipedon williamengelsi	Carolina Watersnake	*Nerodia sipedon*	Northern Watersnake
	*Ophisaurus attenuatus longicaudus***	Eastern Slender Glass Lizard	*Ophisaurus attenuatus*	Slender Glass Lizard
	*Pituophis melanoleucus melanoleucus***	Northern Pinesnake	*Pituophis melanoleucus*	Pine Snake
	*Thamnophis sauritus sauritus***	Common Ribbonsnake	*Thamnophis sauritus*	Eastern Ribbon Snake
	*Virginia valeriae valeriae***	Eastern Smooth Earthsnake	*Virginia valeriae*	Smooth Earth Snake

The complete set of NC GAP vertebrate distribution models, as well as the full report including methods, will be included in the standard GAP distribution formats (McKerrow et al. in prep., www.gap.uidaho.edu).

3. **Species richness analyses** – For the priority species that were included in the NC GAP effort, a series of maps of species richness by taxa were developed specifically for inclusion in this report (Figures K1–4). The richness maps will underestimate richness in areas of overlap in the ranges of subspecies. The development of each of the individual species predicted distributions and the richness maps are described in McKerrow et al. (in prep.).

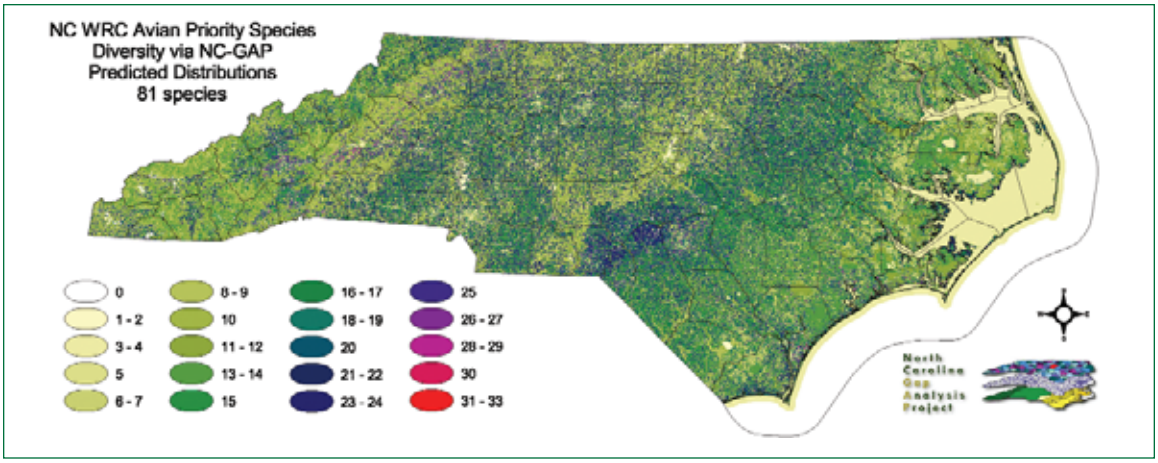


Figure K1. Avian priority species diversity according to NC GAP predicted distributions.

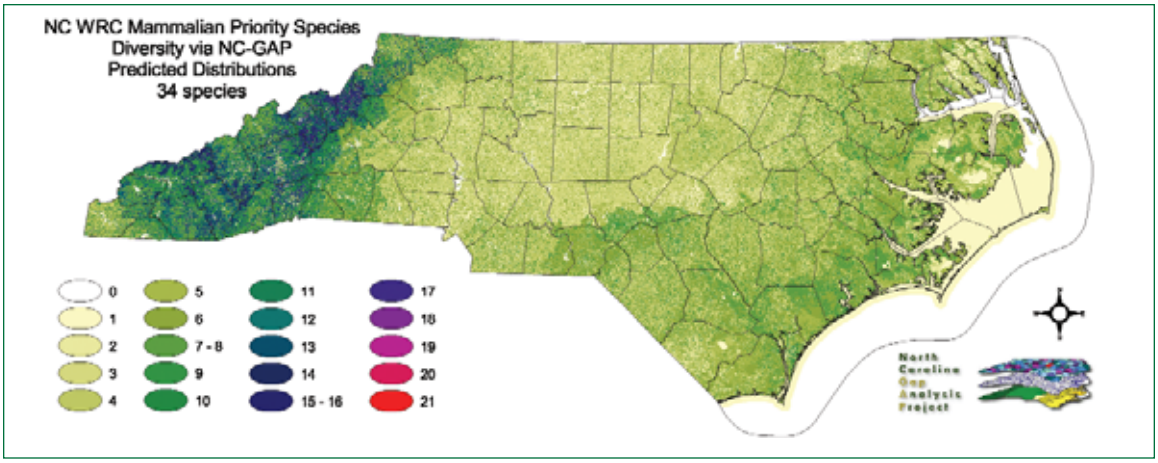


Figure K2. Mammalian priority species diversity according to NC GAP predicted distributions.

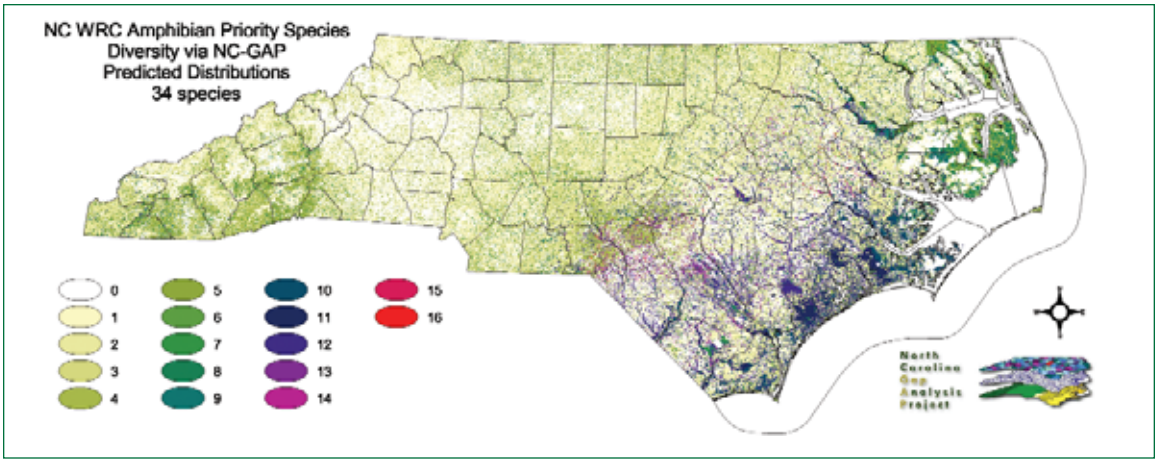


Figure K3. Amphibian priority species diversity according to NC GAP predicted distributions.

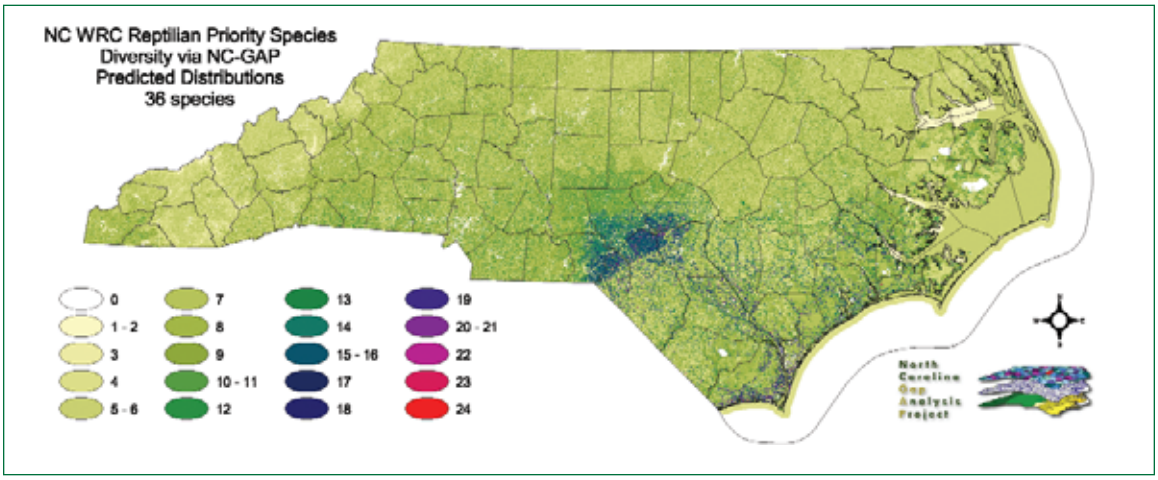


Figure K4. Reptilian priority species diversity according to NC GAP predicted distributions.

The figures above identify richness across the state for the subset of priority species modeled by NC GAP. For the 81 bird species, the Sandhills region of the upper coastal plain and the Blue Ridge Escarpment stand out as important areas (Figure K1). High elevations throughout the central Southern Blue Ridge region represent the hotspots for the mammalian species mapped (Figure K2). Amphibian diversity is very closely tied to Coastal Plain riverine and wetland systems, according to the NC GAP models (Figure K3). The pattern highlights the role of the Carolina bays and peatland pocosins in providing habitat islands in the southern outer Coastal Plain and the role of riparian wetlands in the northern outer Coastal Plain and in the Sandhills. Reptile species richness is closely tied to the Sandhills region of the upper Coastal Plain, as well as xeric pine woodlands (Figure K4).

These analyses point to the need for statewide conservation planning and management if the priority species identified in this Plan are to be maintained. The overlap in species use of Sandhills region habitats by birds, reptiles, and amphibians reinforces ongoing conservation efforts in that region, as does the importance of the wetlands of the outer Coastal Plain to the priority amphibian species. The concentration of priority mammals in the Southern Blue Ridge supports the need for a concerted inventory, research, and monitoring effort there. Even the highly fragmented Piedmont seems to be supporting a fair number of bird species, although the question of habitat quality in this landscape is difficult to assess. The potential for habitat conversion is greatest in the Coastal Plain and Piedmont regions. That fact makes the role of the Piedmont for those priority bird species worth exploring in greater detail.

4. **Stewardship "gaps"** – In order to assess the conservation status of a species within the state, NC GAP developed a statewide land management status dataset or stewardship map. They pulled together several disparate data sets that contain the boundaries of public lands and reviewed each parcel of land with respect to its ownership and management status. Using standard criteria described below, each parcel was then assigned a stewardship code between 1 and 4 to designate the level of protection afforded to biodiversity. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents no biodiversity protection or areas of unknown status. The characteristics used to determine status are as follows:

   - **Permanence** of protection from conversion of natural land cover to unnatural (human-induced barren, arrested succession, cultivated exotic-dominated).
   - **Amount** of the tract protected, with 5% allowance for intensive human use.
   - **Inclusiveness** of the protection, i.e., single feature such as wetland versus all biota and habitat.
   - **Type** of management program and degree that it is mandated or institutionalized.

The four status categories utilized can generally be defined as:

Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown.

A relatively small proportion of the state is under any sort of protection in order to maintain biodiversity (Figures K5 and K6). In fact, NC GAP found that approximately 10% of the state's area was under management, with the majority of that (7.6%; 969, 940 hectares) being federally managed. State management represented 2.2% of the state's area (277,064 hectares). A total of 37,413 hectares of non-governmental organization lands had been mapped through a variety of mapping projects and included in this dataset, but we know that is an underestimate for the state and that those lands will become increasingly important for natural resource management over time. The pattern of land ownership is highly skewed across the state with the vast majority of public lands being in the outer Coastal Plain and mid- to high-elevation mountains. See McKerrow et al. (in prep.) for methods.

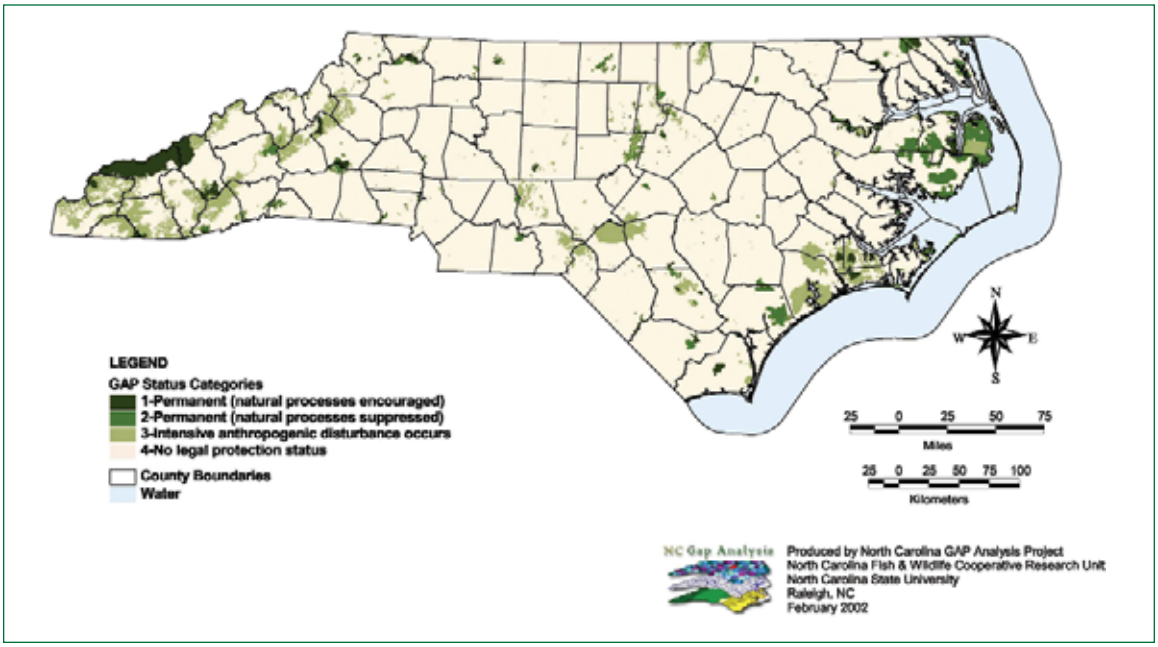


Figure K5. North Carolina stewardship map by GAP status.

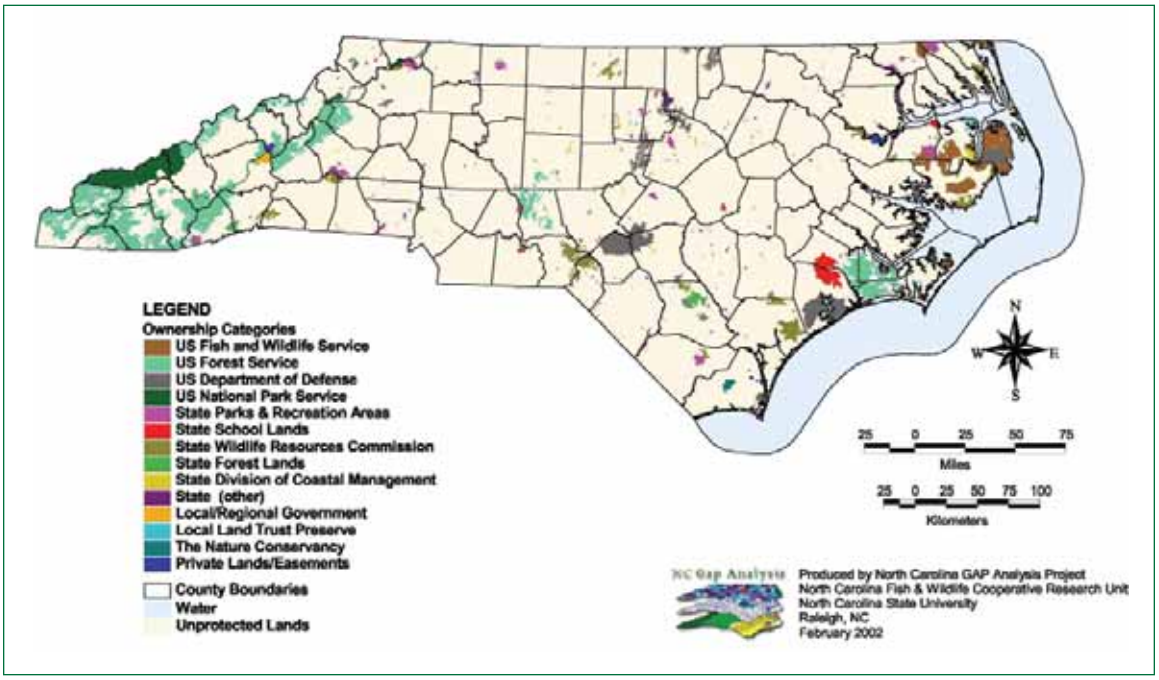


Figure K6. North Carolina stewardship map by ownership type.

The Gap Analysis Program defines species with a critical lack of long term protection as those species with less than 1% of their predicted distribution on GAP status 1 and 2 lands. Of the 193 priority species modeled by NC GAP, 24 have less than 1% of their predicted distribution on lands with long term protection of biodiversity one of their primary goals (Table K4).

Table K4. Number of priority species in categories of percent of predicted distribution on GAP Status 1 and 2 lands.

	0 – 1 %	1 – 10 %	10 – 20 %	20 – 50 %	> 50 %
# of Species	24	96	32	31	5

Sixteen of those 24 species are avian species, many of which are associated with grassland habitat (Table K5). This highlights the lack of grassland habitat in long term protection status.

Table K5. Priority species with <1.0 % of predicted distribution on GAP Status 1 and 2 lands.

NC-GAP Common Name	NC-GAP Scientific Nomenclature	NC State Status	Federal Status	% Predicted Distribution on GAP Status 1 & 2 Lands
Mississippi Kite	*Ictinia mississippiensis*	SR		1.0
American Kestrel	*Falco sparverius*			1.0
Northern Bobwhite	*Colinus virginianus*			0.6
Chimney Swift	*Chaetura pelagica*			0.5
Willow Flycatcher	*Empidonax traillii*			0.7
Horned Lark	*Eremophila alpestris*			0.4
Loggerhead Shrike	*Lanius ludovicianus*	SC		0.3
Prairie Warbler	*Dendroica discolor*			0.9
Dickcissel	*Spiza americana*			0.3
Bachman's Sparrow	*Aimophila aestivalis*	SC		0.6
Field Sparrow	*Spizella pusilla*			0.9
Lark Sparrow	*Chondestes grammacus*	SR		0.5
Grasshopper Sparrow	*Ammodramus savannarum*			0.4
Henslow's Sparrow	*Ammodramus henslowii*	SR		0.8
Eastern Meadowlark	*Sturnella magna*			0.5
Orchard Oriole	*Icterus spurius*			0.9
Oldfield Mouse	*Peromyscus polionotus*	SR		< 0.1
Bog Turtle	*Clemmys muhlenbergii*	T	T(S/A)[1]	0.7
Loggerhead Musk Turtle	*Sternotherus minor*	SC		< 0.1
Slender Glass Lizard	*Ophisaurus attenuatus*			0.6
Southern Hognose Snake	*Heterodon simus*	SR		1.0
Coachwhip	*Masticophis flagellum*	SR		0.7
Smooth Earth Snake	*Virginia valeriae*			0.9
Eastern Coral Snake	*Micrurus fulvius*	SR		0.9

Future Directions for the National Gap Analysis Program

State-based GAP products are currently available for 46 states. Of the remaining four states, a pilot project has been initiated in Alaska while full scale projects are underway in Hawaii, Ohio, and Alabama. In addition, Puerto Rico is nearing completion of GAP as well. These state-based projects have provided many states with their first vegetation maps, their first databases and distribution models for their vertebrate species, as well as their first stewardship data layer. The strengths of the state-based project model included capacity building, rapid technological advancements, and the advancement of GIS as a powerful tool for conservation. Its main weakness lies in a lack of consistency of products from state to state. Several factors contributed to interstate inconsistency including different budget cycles, available technology, as well as different standards set, in part, by state cooperators. Now that all of the state datasets are nearly complete, the National Gap Office is refocusing its efforts on regionalization by establishing several Regional Gap Projects. Regional Gap Projects seek to take the best efforts from the preceding state projects and develop seamless, high quality regional datasets that will not only provide a more timely product, but also one that can used to address regional concerns. This is a major advancement for not only traditional conservations agencies (US Fish & Wildlife Service, US Forest Service, National Parks Service, etc.), but also can serve as a common basis to support state Wildlife Action Plans for adjoining states. Partnerships will play an increasingly important role as agencies are asked to be more efficient with their conservation dollars. Currently, there are three ongoing Regional Gap Projects: Southwest, Eastern

[1]T (S/A) - Threatened by Similarity of Appearance.

States, and Northwest. For more information on the National Gap Analysis Program, existing data, regional projects, and other activities throughout the country, please visit their website (http://www.gap.uidaho.edu). For more information on the Southeastern Regional Project see below.

Gap Analysis in the Eastern United States

In the east the Gap Program will be working on a series of regional projects to develop the seamless datasets. The Southeast Gap Analysis Project is a regional project with the goal of developing datasets and tools for use in conservation planning. The primary objective is to create detailed land cover and animal modeling datasets that are consistent across the region. GAP has moved from a state-based model to a regional one in order to facilitate consistency in all of the data being produced. The current project extent intersects 14 states, with nine states being completely mapped (VA, NC, SC, GA, FL, AL, MS, TN, and KY) and four others (LA, IN, OH, and WV) having at least a portion of their states included (Figure K7). Soon we will be adding mid-Atlantic states to the project study area. For now the work we are describing is specific to the Southeast Gap Project.

Figure 7. Southeast portion of the Eastern States Gap Analysis Project Area.

Approach

Land Cover Mapping

Southeast GAP is currently working on a series of land cover mapping products, including:
1) General land cover map (21 map units) based on 2001 era imagery,
2) Detailed land cover map (140+ map units) based on 2001 era imagery,
3) Impervious surface estimates, and
4) Canopy closure estimates.

GAP is working in parallel with several agencies to complete the 2001 National Land Cover Dataset (NLCD) (Homer et al. 2002) for southeastern states, which include the general land cover map, impervious surface and canopy closure estimates. All groups involved in NLCD mapping are using the same approach with LandSat satellite images, decision tree classification methodology, and a standard classification scheme, all provided by US Geological Survey EROS Data Center. Detailed land cover map units (being mapped by Regional Gap Projects) will be based on Ecological Systems as described by NatureServe ecologists as well as other land use classes derived from the general land cover map.

Vertebrate Modeling

Six hundred and fourteen terrestrial vertebrate species will be included in the Southeast Regional Gap Project (Table K6). The majority of the species being modeled are those that use habitat during their breeding season, although wintering waterfowl and bats have also been included. The Southeast GAP approach to modeling the animal distributions requires several key datasets including:
1) Species specific range maps (Figure K8),
2) Habitat affinity database, and
3) Ancillary datasets (hydrology, elevation, road density, etc.).

Table K6. Number of species being modeled by Southeast GAP by taxa.

Taxa	Number of Species
Amphibians	133
Reptiles	124
Birds	258
Mammals	99
Total	**614**

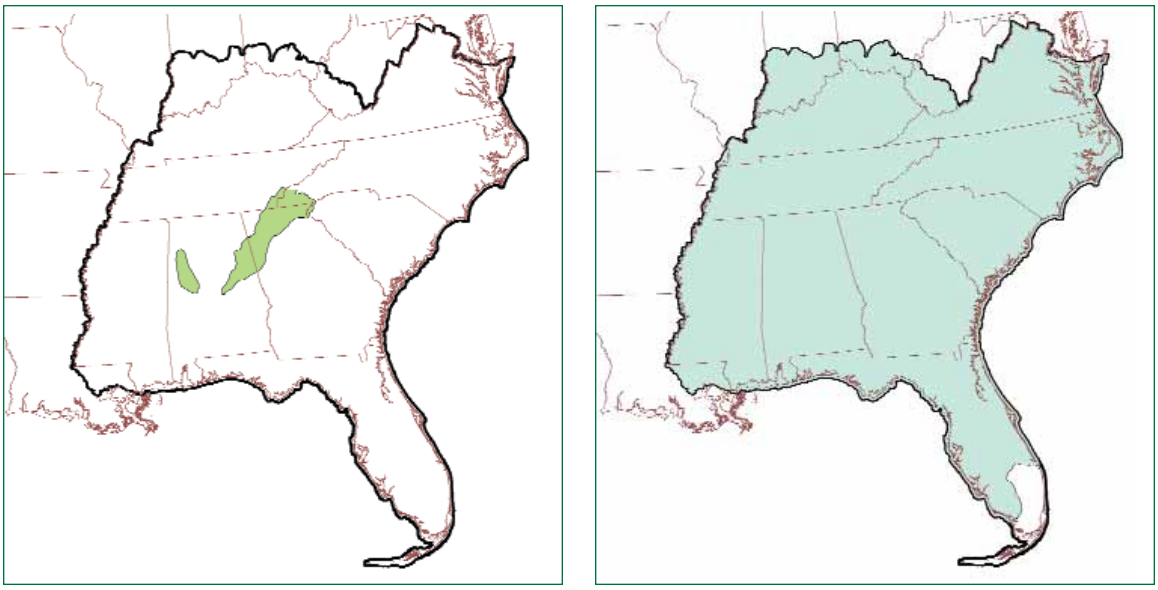


Figure K8. Sample range maps for seepage salamander (*Desmognathus aeneus*) (left) and northern parula (*Parula americana*) (right).

Analyses

In addition to the standard analysis of 'gaps' (lack of protection) for each of the land cover types and species, a variety of applications and agency specific analyses will use these datasets. For example, the priority species analyses in this state report will be available across the region upon completion of the project. Currently, Southeast GAP is working with the US Fish & Wildlife Service on use of GAP data in modeling Partner in Flight Priority bird species. For the vertebrate species endemic to the Southeast this data will provide a basis for range-wide analysis of protection for Southeastern endemic vertebrates.

Products and Timeline

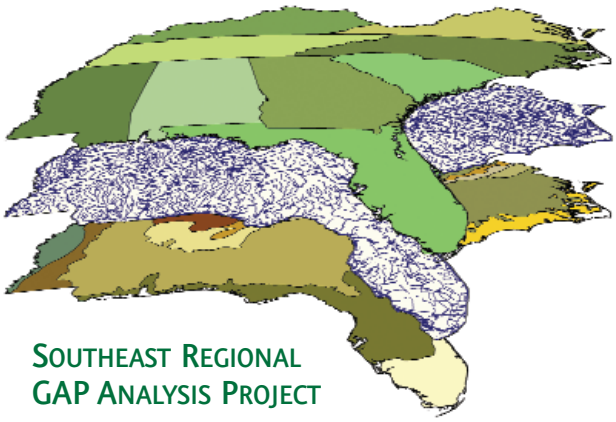
Component	Estimated completion date
Land Cover	
Impervious Surface Estimates (%)	June 2005
Canopy Closure Estimates (%)	June 2005
General Land Cover (21 cover classes)	June 2005
Detailed Vegetation (135+ vegetation types)	June 2006
Vertebrate Modeling	
Draft Species Range Maps (614)	Sept. 2004
Habitat Affinity Database	Dec. 2005
Ancillary Datasets Complete	June 2006
Species Distribution Maps (614)	June 2006
Biodiversity Analysis and Final Report	Sept. 2006

Project Contacts

Alexa McKerrow
Southeast GAP Coordinator – Land Cover
alexa_mckerrow@ncsu.edu
(919) 513-2853

Steve Williams
Southeast GAP Coordinator –
Vertebrate Modeling
steve_williams@ncsu.edu
(919) 513-7413

Biodiversity and Spatial Information Center
Department of Zoology
North Carolina State University
Raleigh, NC 27695-7617
Fax (919) 515-4454



References

Homer, C.G., C. Huang, L. Yang, and B. Wylie. 2002. Development of a circa 2000 landcover database for the United States. Proceedings of the American Society of Photogrammetry and Remote Sensing Conference, April, 2002. Washington, DC.

McKerrow, A.J., S. G. Williams, J. A. Collazo. In prep. The North Carolina Gap Analysis Project: Final Report. North Carolina Cooperative Fish and Wildlife Research Unit. Submitted to: The National Gap Analysis Program. U.S. Geological Survey, Biological Resources Division.

N.C. Natural Heritage Program (NCNHP). 2001. Descriptions of the biological themes of North Carolina, 2nd edition. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, 3rd approximation. N.C. Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.